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DEPARTMENT OF MINES

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

GEOLOGICAL SURVEY

W. H. COLLINS, DIRECTOR

Summary Report, 1926, Part C

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1927

No. 2136

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SUMMARY REPORT, 1926, PART C

WAKOMATA[1] LAKE MAP-AREA, ALGOMA DISTRICT, ONTARIO

By R. C. Emmons

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Illustrations

LOCATION AND ACCESSIBILITY

This map-area lies north of lake Huron and immediately south of Mississagi forest reserve. It extends from Blind River map-area (Map No. 1970, Memoir 143) to Bruce Mines map-area (Map No. 1969, Memoir 143). It is 31 miles long, and 15½ miles from north to south, and occupies 480 square miles.

The entire area is most conveniently reached from Dean Lake on the Canadian Pacific railway or from Ironbridge on the north shore highway. Well-gravelled roads made and used by the operating lumber companies run north of these villages, one up Mississagi river into Berth 3F, one up White river into Berth 1A, and one branching from White River road in the northeast part of Berth 175 leads north to lake Kirkpatrick (Blue lake). These roads are the sole means of ingress for lumber company supplies; there is a rather regular truck service along them. During the summer months many tourists enter the district by car, some coming from long distances to enjoy the superb scenery, the fishing, or the shooting.

ACKNOWLEDGMENTS

Many courtesies were extended to the field parties by the J. J. McFadden Lumber Company, and by the field officers of the Ontario Forestry Department. Able assistance was rendered in the field by R. A. Shatford, D. H. Ellis, and J. T. Fisher.

TOPOGRAPHY AND DRAINAGE

The area, once well wooded, but now lumbered and extensively burnt, is losing even its soil covering except in places where hardwood patches have survived the fires. The percentage of rock outcrop is exceptionally

[1] Generally known as Clear lake.

high, but there are many large Pleistocene sand-plains. In the smaller valley bottoms, too, deposits of glacial drift are very common, so that the hills, especially toward the south, rise abruptly from flat lands. The courses of the streams and rivers consist, in an increasing degree southward, of meanders in the sand-plains, which are broken by rock ridges and projections cut by gorges of rare beauty. The many large and picturesque waterfalls are for the most part due to the same rocky projections.

Two main rivers drain the area, each having its origin outside of the map limits; they are the Mississagi and its tributary the White. Each of these flows in a wide valley, progressively wider southward, and each is fed by many tributaries, some of which drain considerable areas. The old broken dams and overgrown tote roads along the smaller streams mark the use that was made of these lesser streams during lumbering operation. Some of the larger streams are still used to tap reservoir lakes, and the main dams on them are kept in good condition. The two large rivers, the Mississagi and the White, serve each spring for river driving in connexion with the logging operations nearer their headwaters. It is during these drives that the reservoir lakes within Wakomata Lake map-area are tapped to help flood the main rivers.

The geologic structure of the district is reflected both in the courses of the rivers and in the trends of the more persistent ridges. Many faults are marked by chains of lakes and streams. Snowshoe creek, Caribou creek, and the chain of lakes reaching to Twin lakes, lie along a fault that crosses Wakomata lake. Jobammageeshig lake, Chub lake, and Cumming lake lie along another fault. Parts of White river itself lie along faults.

Keweenawan (?) intrusives in many places form prominent ridges. The Lorrain quartzite forms high ground, much of which parallels the strike of the formation; and within this formation certain beds stand especially high.

GENERAL GEOLOGY

The rock formations of this map-area have been correlated with those of other areas along the north shore of lake Huron.

Table of Formations

Recent and Pleistocene	....	Boulder clay, laminated clay, boulder sand, stratified and unstratified sand
Keweenawan (?).....	....	Diabasic and dioritic intrusives
Cobalt series.........	Lorrain quartzite Gowganda formation	
Bruce series..........	Serpent quartzite Espanola greywacke Bruce limestone Bruce conglomerate Mississagi quartzite "Basal Mississagi"	
Pre-Huronian........	....	Granite and associated dykes, gneiss, and schist complex inclusions

These formations extend east and west through the map-area, beyond which, to the west, they are broken by a prominent fault. The entire sequence is that of the north shore province, and does not depart from it in any outstanding particular. In the pages that follow, emphasis is placed, therefore, on the local peculiarities and the departures from the general type, though some general features are considered worthy of mention, mainly to bring out their persistent character. For a more complete description of these same formations Memoir 143 by W. H. Collins may be consulted.

RELATIONSHIP TO CONTIGUOUS AREAS

It is apt to outline here the particular problem which made necessary the mapping of the link between Bruce Mines map-area and Blind River map-area.

East of Wakomata Lake map-area, in the northern part of Blind River map-area, is a large syncline of Huronian sediments involving the section from the Mississagi quartzite up to and including the Lorrain quartzite. The succession is the regular Bruce series succession. West of Wakomata Lake map-area, in Bruce Mines map-area, the Bruce series is much less completely shown, especially in the eastern part where the Gowganda formation rests directly on Mississagi quartzite which either had been eroded extensively prior to the deposition of the Gowganda or is thin at this place. But below the Mississagi quartzite, in the northern part of Bruce Mines map-area, is an extensive formation overlying the pre-Huronian granite.[1] This formation was traced eastward across Bruce Mines area and was found to become progressively thinner, disappearing entirely as a distinct formation before reaching the eastern boundary of the area—the east side of Otter township. This formation is quite distinctive in the Bruce series, but is absent in Blind River area; the desirability, therefore, of ascertaining what becomes of it in the interval and of learning more definitely, if possible, its relationship with the other Bruce series formations, is obvious.

Pre-Huronian

Granite is by far the most widely distributed pre-Huronian rock. A considerable amount of gneissic granite and banded gneiss is present and there are extensive areas of granite in which are inclusions of a highly metamorphosed basic rock. Lamprophyric dykes, and dykes of a somewhat basic, strongly porphyritic rock cut the granite.

The granite is essentially like the pre-Huronian granite described from adjacent areas. It is mostly red, coarse, highly quartzose, and massive. Pegmatite is unevenly distributed through it. Inclusions in the granite are of various sizes and are distributed with no apparent regularity. They, too, for the most part have a granitic texture, but in general are readily distinguished by their dark colour, due to the ferromagnesian minerals. The larger inclusions are in many cases schistose—a characteristic that may be original.

[1]*See* Memoir 143, pp. 32–38.

Bruce Series

MISSISSAGI QUARTZITE

Collins, who has studied this formation extensively, says:

"The Mississagi formation is mainly a feldspathic quartzite, although it also includes arkose, banded argillite, and several conglomerates of quite different characters. These minor components are all somewhat local in distribution, and, in the case of the argillite and conglomerate, recur at different horizons .... The basal member of the Mississagi is for the most part conglomeratic, but varies a great deal from place to place. In the northern Huronian area it ranges from 0 to 20 or 30 feet in thickness, except in the northern part of the Bruce Mines map-area where it is much thicker and diversified in character. It is nearly everywhere arkosic, and is as a rule more or less conglomeratic."

The name "Basal Mississagi" is applied tentatively to the exceptionally thick development of the basal strata, because although there is no evidence within Bruce Mines area of a break between this assemblage and the Mississagi quartzite proper, such a break may occur, and it would then be logical to regard the so-called basal Mississagi as a possible correlative of the Sudbury series. Furthermore, even if no pronounced break exists it may be possible to establish a correlation between these beds and the Sudbury series.

The locality in the northern part of Bruce Mines map-area where the Basal Mississagi is "much thicker and diversified in character", is one surveyed by the writer. The basal member was traced in prominent exposures from Garden river east to Otter township which abuts on Wakomata Lake map-area. The greatest thickness found by the writer amounted to 4,700 feet and was measured in northern Kehoe and Chesley Additional townships. The thickness becomes progressively less eastward, until in Otter township on the east side of Bruce Mines map-area, only the normal basal conglomerate of the Mississagi quartzite is present. To the west it was traced as far as Garden river where it is cut off by a fault, but R. G. McConnell found a similar formation west of Garden river which he called the Soo series.[1] It is reasonably certain that the Soo series which McConnell found to the west of Garden river is correlative with those deposits classed as Basal Mississagi in Bruce Mines area.

In Bruce Mines area[2],..

"In general, the basal member of the Mississagi may be divided into five distinct phases, though all of these do not persist throughout the area studied. (1) At the base is a coarse boulder conglomerate with a typical greywacke matrix in which there is an abundance of chloritized hornblende. (2) Above this is a pebble conglomerate with a dark quartzitic matrix. (3) A transition zone to the argillite above consists of interbedded quartzite, quartzitic conglomerate, and argillitic material. (4) Above this is an argillite horizon of considerable thickness. (5) A transition zone from (4) to the normal Mississagi quartzite above consists of interbedded argillite and impure quartzite."

From Bruce Mines map-area eastward as far as the present study extended, the Basal Mississagi has a decidedly different character from the above, but gives some indication of being a continuation of the unique basal development found to the west. The succession is analogous and

[1]Ont. Dept. of Mines, Ann. Rept., vol. XXXV, pt. II.
[2] Geol. Surv., Canada, Mem. 143, p. 34.

consists of an exceptionally thick argillite member underlain by a white, feldspathic quartzite in which there are relatively small lenses of the rather peculiar lithological types characterizing the lower horizons in Kehoe township. The assemblage in Wakomata Lake area appears to be distinctly basal to the Mississagi. It was recognized in Berth 169 and has been traced eastward as a rapidly thickening lens as far as Berths 157 and 1A. Its extension in the extreme west of the map-area is in doubt on account of the masking effect of strong and persistent faulting along the granite-sediment contact.

The Basal Mississagi of Wakomata Lake map-area consists of two main divisions; a white, feldspathic quartzite overlain by a banded argillite. From Endikai lake in Berth 169 eastward the quartzite increases from a thin formation with a boulder conglomerate at its base, to a thick, massive, and extensive formation covering many square miles. The overlying argillite appears to be thickest at Endikai lake. It extends eastward apparently as far as Berth 157, but becomes thinner. The quartzite is coarse-grained, as is so much of the normal Mississagi. In it are many conglomerate beds of jasper and vein-quartz pebbles. Near the base, especially in the northern part of Berth 163, are many conglomerate lenses in which the matrix is generally argillitic, either massive or banded. The pebbles are mostly granite and allied rocks well worn and abundant. Some are a foot or more in diameter. Although the lenses are never more than 100 feet, and most are much thinner, an average lens perhaps measuring 50 feet, they are outstanding features. None was found in the upper part of the quartzite member. At the northeast end of Endikai lake the conglomerate basal to this quartzite was best seen. It is nearly 100 feet thick, has a red quartzite matrix, and upwards passes gradationally by loss of pebbles into red quartzite, which in turn becomes white. Near the granite the quartzite is crowded with pebbles, but in it are a few, ill-defined beds of red quartzite. This conglomerate was not seen to the east, because of a heavy drift cover that conceals it, and beyond which the contact lies outside of the area mapped.

The argillite that overlies the lower quartzite and underlies the normal Mississagi quartzite was found on the east shore of Endikai lake and was traced, though not in continuous outcrop, as far east as Flack lake in Berth 157, where it is much less distinct, and partakes more of the nature of an impure, banded quartzite bounded on either side by quartzite. Where it is best exposed for measurement, namely 2 miles east of Endikai lake, it is approximately 600 feet thick. Elsewhere it appears to be thicker, being over 1,000 feet just east of Endikai lake, where, however, measurement was difficult and the result is not thoroughly reliable. The member is composed of highly coloured beds that range in thickness from one inch to one foot, but within all beds can be seen further lamination, especially on weathered surfaces. Mineralogically all beds appear alike and are typical argillites, the colour distinction being the main one. At both top and bottom of the argillite member there are intercalated beds of impure quartzite. These increase in size and number in a thickness of 3 to 4 feet and the member grades into the bounding pure quartzite.

The overlying quartzite is quite definitely correlated with the normal Mississagi. The underlying strata are believed to be correlatives of the so-called Basal Mississagi of the Bruce Mines area, for the following reasons: In both areas the formations lie below a quartzite known to be Mississagi and to which they exhibit analogous relations. Although the Mississagi quartzite in many places varies in thickness according to locality, this variation is not prominently displayed in these two areas. But the parts of the Basal Mississagi below the argillite member are very variable in thickness in both map-areas. The line of demarcation between the normal Mississagi and the Basal Mississagi is placed at the top of the argillite member. The argillite of Berth 169 grades into quartzite, both above and below, but the gradation is rapid, covering not more than 3 or 4 feet. In Kehoe township the gradation takes place over a much greater thickness, and the boundary is necessarily indefinite. Argillites have been found in the Mississagi quartzite, especially in Blind River map-area[1], yet none is so large as that found in the basal division in Berth 169. The lithological character of the basal quartzite in Berth 169 and eastward is comparable to that of the Basal Mississagi to the west for similar, distinctive rock types occur in both, namely, argillite-conglomerate, banded argillite, and banded argillite-conglomerate. These types occur near the base of the formation in both areas, but only to a minor extent within the quartzite in Wakomata Lake area, whereas in Kehoe township they are prominent members. A reconnaissance traverse north of Berth 163 revealed the presence of considerably more argillitic conglomerate at an horizon not far from the base of the quartzite member.

The correlation of these two Basal Mississagi members seems not unreasonable. The "basal member of the Mississagi quartzite" extends from Sault Ste. Marie east at least as far as Berth 157, a distance of 60 miles, and over all this distance nothing has been found to indicate that it is not conformably below the normal Mississagi. In many places, if the stratigraphic boundary has been correctly placed, the two formations seem definitely conformable. In some places the "basal member" is sharply divided from the Mississagi quartzite proper, as, for instance, where the gradation extends through only 3 or 4 feet; but in other places the boundary is purely arbitrary, a fact which in this district renders separation of the two members difficult and perhaps inadvisable.

The main Mississagi quartzite does not differ in any outstanding particular from the normal Mississagi as described by Collins. It is a white or light grey, or pink, arkosic quartzite, usually massive or faintly bedded, but in places noticeably bedded. In cliff faces the bedding is apt to stand out prominently by reason of the development of bedding joints. In Wakomata Lake area there seems to be a greater amount of pebbly quartzite than is usual in the Mississagi. On account of persistent faulting near the sediment-granite contact it is impossible in some places, especially in Berth 176, to determine whether outcrops of basal conglomerate and quartzite belong to the main Mississagi or to the "basal member". Those found in the western part of the map-area have been assigned to the normal

[1]Geol. Surv., Canada, Mem. 143.

Mississagi because the quartzite of the lower member occurs mainly east of Endikai lake and was observed to thin westward.

West of Endikai lake exposures of Mississagi are quite poor, and the formation is faulted out entirely over considerable areas. In Berth 182 north of Caribou creek is a patch of quartzite that is quite low in the Mississagi, as is indicated by its nearness to the granite and its position north of the Caribou Creek fault. This quartzite is hard, very feldspathic, and contains many thin, irregularly distributed argillite beds.

The basal conglomerate is not prominently developed in the western half of the map-area. At some places it is definitely known to be absent, at others it is very thin, and on the average is probably less than 10 feet thick. It is in general a greywacke-conglomerate with granite boulders predominating. A considerable amount of argillite is present in the matrix, not in beds, but in irregular patches or fragments. These seem more abundant in the part of the conglomerate closest to the granite and are particularly abundant in the conglomerate that fills pockets in the granite surface. This condition is especially well exemplified on the north shore of Castra lake in Berth 176. In Berth 169, southeast of the junction of the two branches of White river, is a prominent development of the Mississagi conglomerate over 50 feet thick, with abundant pebbles in a red, greywacke matrix. In the extreme west of the map-area, along Snowshoe creek and Mississagi river, are more exposures at or near this horizon. At these places were seen dark, arkosic quartzite with argillaceous bands; and also coarse boulder conglomerate with a greywacke matrix. It was impossible to determine definitely the stratigraphic horizons, as the rocks occur in isolated outcrops in extensive sand-plains, but it seems reasonable to conclude that the Basal Mississagi quartzite in the western half of Berth 188 consists of a boulder conglomerate with a greywacke matrix in the lower part, overlain by impure arkosic quartzite traversed by argillaceous bands. The conglomerate, in most places, passes up rather sharply into quartzite.

The granite surface on which the Mississagi rests is very difficult to study over large areas because of faulting along and near the contact; but details are clearly expressed in various places. In Berth 176, alongside the road at the crossing of the creek between Twin lakes, the conglomerate fills sharp, comparatively deep depressions in the granite surface, and the contact is sharp. On the north shore of Castra lake, at the east end, is a steeply sloping surface of granite on which are patches of conglomerate. The patches are thin and numerous; the whole surface over its exposed length of 100 yards is generally smooth.

The Mississagi quartzite formation has been traced from near Sault Ste. Marie east for about 60 miles to Berth 157. Over this entire distance it maintains many of the characteristics of the Mississagi formation and its correlation is nowhere in doubt. Below rocks here called normal Mississagi there occur in two separate areas prominent developments of sediments with attitudes almost identical with those of the overlying Mississagi. The two underlying sedimentary groups, though lithologically distinct, yet resemble one another in many important features. One of these developments occurs in Bruce Mines map-area, the other in Wakomata Lake map-area. The development in Bruce Mines map-area thins in an easterly direction and is absent from Otter township, which borders Wakomata Lake map-area, but thickens progressively westward to Garden river. A formation, apparently a westward continuation, was traced beyond Garden river by R. G. McConnell. Within Wakomata Lake map-area, east of Otter township and of this first lens, the Mississagi is almost absent because of faulting for a distance of 20 miles, beyond which the second development of underlying strata was found and traced east beyond the limits of Wakomata Lake map-area. Its thickness is not definitely known, but is very great, and is apparently increasing easterly. No evidence was found of an unconformity between the "normal Mississagi" and the underlying sediments.

The stratigraphic and lithologic similarities between the Sudbury series of Coleman and the Basal Mississagi raise the question of a correlation between these two, especially since the positive position of a large part of the Sudbury series is still in doubt. The interest centres on the relationships between the Mississagi and the underlying sediments. Although no stratigraphic break was found between these two Mississagi members, it must be admitted that such a break may occur without being evident even over such a distance as the 60 miles between Sault Ste. Marie and Berth 157. But if such a break exists, it is remarkable that no manifestation of it has been found, and, further, it is likely in these circumstances to be relatively unimportant. If later field study tends to sustain the correlation here suggested between the Sudbury series and the "basal" Mississagi quartzite, then the results of this study favour the inclusion of much of the Sudbury series with the Huronian sediments rather than with the pre-Huronian.

BRUCE CONGLOMERATE

This formation does not outcrop in Berth 182 or 188. In Berth 176 it is well exposed on the northwest side of Skunk lake. Near the base it is bedded and holds argillitic bands as thick as 6 inches, but higher in the formation the matrix is a massive greywacke and the very abundant pebbles and boulders are irregularly distributed. The upper contact is not exposed in Berth 176; the lower contact is well shown on Skunk lake. There it is quite sharp; the underlying Mississagi quartzites grade within 1 foot into fine argillitic material; this, in the space of another foot, becomes coarser and banded and above this the bands become fainter and pebbles more numerous. The change is complete in 3 to 4 feet.

In Berth 169 the Bruce conglomerate is better exposed, especially near the bridge crossing White river east of Endikai lake. At this locality the formation is not more than 50 feet thick and in several places is thinner. It is the characteristic boulder conglomerate with a dark quartzite or greywacke matrix. The underlying Mississagi quartzite passes quickly into a conglomerate with pebbles as large as 6 inches—the gradation occupying in places not more than 2 feet. The matrix near the quartzite formation is an impure quartzite, but this passes into a dark greywacke within 6 feet. The main body of the formation is a greywacke-conglomerate as described by Collins. In the upper part the boulders are smaller and fewer and the matrix takes on the appearance of Bruce limestone.

BRUCE LIMESTONE

For some time this formation has been regarded as the key formation of the Bruce series and also of the entire Huronian sediments in some districts. It is such in this map-area and accordingly has been mapped with care. Fortunately the Bruce limestone outcrops clearly both in cliff faces where it appears to be exposed by virtue of its lack of resistance to erosion as compared with its capping, and also in isolated outcrops where its ability to withstand erosion compares favourably with other "more resistant" rocks—an anomaly for which no satisfactory explanation has been offered. For instance, along the road between Twin lakes in Berth 176, the limestone forms small, isolated prominences. In the extreme western part of the berth it again shows the peculiar ability to resist erosion and forms high ground west of Castra lake. In the same berth on the south shores of some of the lakes, it forms prominent cliff faces capped by younger formations. As a general rule if the limestone occurs in a district, it can be found in outcrop.

The lithological characteristics have been adequately discussed by Collins in Memoir 143 and elsewhere. Throughout the limestone, thin, argillitic bands persist, usually much crenulated and contorted. Beds of pure limestone lacking such bands and more than a foot thick are rare. The lower part of the limestone is very poorly exposed and little has been learned about it in this district. The central part contains various amounts of argillite, everywhere in narrow bands. Some ferruginous limestone occurs, but at what horizon could not be determined—it appears to be below the middle of the formation. Toward the top of the limestone the proportion of argillite increases. At the top is a 1-foot bed that has been recognized over a distance of 6 miles. This bed is a dark, calcareous argillite containing red spots which appear to be weathered feldspars. It is very uniform and persistent, for it appears again in the eastern part of the area beyond a region of no outcrops of limestone and here (Berth 163) it has the same lithological appearance. Above this bed is usually a massive argillite—a part of the Espanola greywacke formation.

The thickness of the Bruce limestone is estimated at 150 feet, but the structure of the formation at the place where it is best exposed (eastern Berth 169) precludes making a reliable measurement.

ESPANOLA GREYWACKE

This formation is mainly of argillite both massive and banded; most of the bands are narrow. Although argillite is the characteristic rock, greywacke also occurs in the lower part of the formation. The best displays of greywacke are at the west end of Castra lake and south of the east end of the lake.

The succession within the formation commonly is toward the bottom a well-banded, calcareous argillite overlying a rather massive bed of argillite seldom more than 10 feet thick; above this a rather massive, greywacke-like rock; and higher still a thick, banded argillite constituting more than half the formation. Very commonly the lower, banded argillite is strongly brecciated in the manner described by Collins in

Memoir 143. An excellent example of this may be seen on the ridge southeast of Ellis lake in Berth 176.

Pebble-bearing zones are rare. One such zone is exposed just south of the White River bridge in the east part of Berth 169. The pebbles are of granite, about 1 to 2 inches in diameter, not plentiful, and confined to a 10-foot zone lying on the Bruce limestone. North of the bridge the usual succession occurs, but the lower part of the greywacke is remarkably siliceous, being very largely a dark red quartzite with intercalated argillite bands. This zone is about 100 feet thick.

At no place within the area can a reliable estimate be made of the thickness of the formation for it is folded and faulted. It appears to be about 400 feet thick in the eastern part of Berth 163.

ESPANOLA LIMESTONE

Above the Espanola greywacke in the central part of Berth 163 there is considerable limestone with intercalated argillite beds. The exposures are not good, but as limestone appears to constitute more than half of the rock at this place, the assemblage has been mapped as Espanola limestone. It is conformably above the Espanola greywacke. The formation, apparently, is lithologically identical with the Bruce limestone. Only the lower 20 to 25 feet were seen. Considerable iron carbonate is present, as is shown by the abundant limonite on weathered outcrops. The total thickness and the relationships to the Serpent quartzite are unknown.

SERPENT QUARTZITE

This is a white or grey, massive or finely banded, arkosic quartzite not well exposed in this area. In the western part it lies on the Espanola greywacke, but only in patches, for it was largely eroded during the Bruce-Cobalt interval.

In Berth 163 the exposures are fair and the quartzite is well developed. The Espanola greywacke underlies it and in a thickness of 20 to 25 feet grades upwards through a dark arkose into quartzite, above which is coarse arkosic quartzite faintly bedded. The main formation is massive, arkosic quartzite, though on the weathered surface fine lamination may be seen in many places. This lamination, where present, forms an outstanding lithological difference between the Serpent and Mississagi quartzites.

In the western part of Berth 163 there is, at the bottom of the formation, a quartzite-conglomerate of considerable thickness, which grades down into the Espanola greywacke. The pebbles are mainly quartzite and are confined to lenticular beds, in most of which they are sparsely distributed. The thickness of the quartzite-conglomerate is nearly 100 feet. It merges, by the disappearance of pebbles, upward into quartzite.

Cobalt Series

These rocks are extensively developed within the area mapped, but for the most part are inclined at only a small angle and, therefore, the lithological succession is not well displayed.

GOWGANDA FORMATION

The Gowganda formation is mainly a boulder conglomerate, lacking bedding and commonly having a fine, greywacke matrix. In places the matrix is a dark quartzite, in others a red quartzite, and in a few places a banded argillite. Quite commonly the quartzitic phases are not conglomeratic. Boulders vary greatly in size, but not in composition—granite predominates. In most places the boulders are not assorted according to size, though quite commonly bedding is made evident by the concentration of pebbles in some beds and in the massive conglomerate bedding is disclosed in many places by the development of bedding joints in cliff faces. In many places, and as well shown in the eastern part of Berth 176, very thick beds of massive conglomerate are separated by thin beds of argillite. Toward the top of the Gowganda, especially in Berth 169, the formation becomes a red quartzite carrying pebbles that upwards decrease in amount and are absent at the top of the formation.

In Berth 188 and Gould township there is a distinctive member at the top of the Gowganda. It is a very finely banded argillite, non-conglomeratic, and with strongly crenulated bands. The bands are narrow, and mostly thin. The full extent of this member has not been explored, and the nature of its contact with the boulder conglomerate below is unknown. The upper contact with the Lorrain quartzite is well exposed. In a thickness of 30 feet the argillite becomes a dark quartzite and this grades upward into coarser and lighter Lorrain quartzite.

LORRAIN QUARTZITE

The Lorrain quartzite is exposed especially well in Berths 188 and 182. It extends into Berth 176, occurs in Berths 169 and 163, and extends southward. The rock is characteristically a white quartzite, commonly carrying pebbles of white quartz and jasper. It is in general coarsely bedded and in many cases is crossbedded, the bedding planes being faintly shown, except where marked by a concentration of quartz pebbles within a layer. There seems to be a fair amount of pebbly quartzite throughout the Lorrain, and a notable development of such strata outcrops on the high hilltops east of Wakomata lake. These beds are believed to lie in the upper half of the formation, but owing to the presence of a large fault to the north, coupled with the fact that the top of the formation was not found, the determination of the stratigraphical position of the horizon was not possible. Characteristic pebbly beds near the bottom of the Lorrain were seen in the western part of Berth 176.

In the southwestern part of Berth 163, there is a member that is quite distinct lithologically. It occurs between two quartzite masses and at a height above the bottom of the lower one such as to suggest that it is the stratigraphic equivalent of the central part of the Lorrain quartzite about Wakomata lake. The member is notably uniform from the bottom to the top. It is a dark, cherty quartzite and is finely banded, many of the bands being crenulated. On fresh surfaces the bedding is faintly evident, but is brought out clearly on weathered surfaces. Above and below it passes gradationally within 6 or 8 feet into white quartzite. South of lake Elizabeth in Berth 163 this member outcrops in a prominent cliff face, capped by the upper quartzite. East of this lake it also occurs, mainly on steeply sloping ground, but to a less extent in precipitous slopes.

Keweenawan (?) Intrusives

Here as elsewhere along the north shore are intrusives of dioritic to gabbroic composition, and fine to coarse, granitic, or diabasic texture. These rocks are commonly referred to in the district as "diabase". They form dykes and sills, as well as large, irregular, intrusive masses (conoliths). Ore deposition on the north shore quite commonly has an apparent connexion with the diabase, but it is usually within them, in veins or disseminated around veins, that mineral values are found.

No example of extensive contact metamorphism adjacent to the diabase was found in Wakomata Lake map-area; not even limestone associated with the diabase, as it is in many places, is much metamorphosed. In fact inclusions of limestone in the diabase appear to have resisted alteration to a remarkable degree. The largest amount of contact action seen is in the western part of Berth 163, where the Espanola greywacke is cut by diabase. On both sides of the diabase mass the greywacke is altered, over a width of 25 to 30 feet, to a spotted contact rock in which some beds have been much more altered than others. Considerable magnetite and some sulphide of iron occur in the contact metamorphosed rock.

Pegmatitic and aplitic material may be seen in definite dykes or indefinitely bounded masses in many of the larger intrusives, and especially in the higher parts of sills.

Pleistocene Deposits

These are most noticeable in the form of sand-plains, formerly lake beds and river flood-plains, along the present rivers. White river and its tributaries have several such sand-plains and they reach even north of the area along the valley floors.

Along the sides of the valleys, especially the steeper ones, prominent accumulations of glacial boulders mark the lateral moraines of ice tongues. One of these tongues apparently dammed the outlet of White lake, forming a deep lake, part of whose bottom still remains on the west side as a large, flat plain, more than 100 feet above the present lake-level.

Glacial gouging, striæ, and such markings occur on innumerable rock surfaces.

The present rivers meander through the glacial deposits, interrupted in many places by waterfalls where degradation has resulted in the rivers being superimposed on once concealed rock spurs around which the pre-Glacial streams flowed. Where the river courses are confined between rock walls, as is excellently illustrated by White River gorge in Berth 169, the river bottom is composed of large glacial boulders.

Structure

The Huronian strata lie in two broad, synclinal structures of which only the northern parts are included in Wakomata Lake map-area. The two main structures have an east-west trend and merge into one another in the vicinity of White river. The western syncline strikes south of east from Mississagi river to White river; the eastern syncline strikes north of east from White river to the east boundary of the map-area. The central parts of the synclines are occupied by Cobalt strata; the Bruce series outcrops along the northern margins with a structure locally modified by minor folds and faults. Some of the distinct minor folds are not clearly apparent on the accompanying map because the nature of the relief is not also indicated, and for the same reason the map in several places presents a fictitious appearance of folding.

The larger folds trend parallel to the general structure of the north shore and are integral parts of this structure. The minor folds and faults appear to be only local expressions of the major structures, except so far as they may be related to local intrusive masses.

The folding is, in general, moderate, the angles of dip being commonly less than 20 degrees, and in many places the strata are essentially horizontal. Lower dips more commonly prevail in the quartzite and steeper dips in the argillitic and calcareous formations. In the two western berths the dips almost everywhere are gentle. In the eastern part of Berth 176 steep local dips are common, but the general dip is still low. In Berth 169 the dips are as a rule less than 30 degrees, but in this berth along the east-west White River fault local folding in places is so intense that the strata are overturned. In the southeastern part of Berth 163 the regional dip is generally steeper than elsewhere. In the southwestern part of Berth 163 the gentle dips outline a synclinal trough. Topographic relief in this part of the area, coupled with exceptionally extensive exposures, causes the structure to stand out prominently when viewed from any of the neighbouring hill-tops. In the northern part of Berth 163, and southern part of 1B, the regional dip is gently south-southeast, decreasing in angle to the north. Much of the structure was discernible by the writer in an aeroplane flight made over the area at an elevation of 2,500 to 3,000 feet.

Several major faults within the area are clearly indicated. Undoubtedly there are many more faults than were mapped, but their presence cannot be proved in the extensive areas of quartzite and conglomerate, where considerable displacement is possible without bringing noticeably different horizons into juxtaposition at the surface.

The most prominent fault has been traced from Mississagi river at the junction with Snowshoe creek, across Wakomata lake, up Caribou creek, and into Berth 176 where it was no longer traceable. Either the same fault, or others that are regarded as expressing the same disturbance, continues eastward into Berth 169. Another fault extends from Snowshoe creek southeast into Gould township. This fault brings the lower strata of the Gowganda formation into contact with the upper strata of the same formation.

In Berth 169 there are several faults of considerable importance, closely associated with minor folds and intrusions of diabase. One prominent fault extends along White River valley in a southwesterly direction; it appears to stop just north of the southward turn of the river in Berth 169. Another extends eastward just north of the river in the same berth, and on the south side of the river are several small faults in the sediments abutting against diabase.

ECONOMIC GEOLOGY

Within the limits of Wakomata Lake map-area, no well-developed mineral deposits have been found, although the area has been well combed by prospectors. A lull in prospecting, which has lasted for the past few years, closed late in the summer of 1926 when some prospecting parties entered the district. Previous prospecting has been confined largely to three parts of the area: (1) the west-central part of Berth 163 and east-central part of Berth 169; (2) the northeastern part of Berth 188; (3) the northern part of Gould township.

In Berths 163 and 169, south of White river, a large diabase dyke intrudes Huronian sediments. Mention has been made of the contact metamorphism of the sediments at places along the border of the intrusive. Along the contact are small bodies of sulphide, oxide, and carbonate—largely pyrite and chalcopyrite, magnetite, and calcite with siderite. The deposits are very patchy, as is so characteristic of contact metamorphic ore-bodies, but within the diabase they have more nearly vein-like forms. Small open-pits have been dug on some of them, but no large ore-bodies have been proved. The locality, however, merits further attention by prospectors. The entire locality was once staked, but the claims have lapsed.

North of Wakomata lake is another diabase dyke on which claims have been located, but these, too, have lapsed. The workings have been grown over and were not found.

The third area, in Gould township, is the one that has received most attention. In concession V, lots 7 and 8, is a small diabase dyke cutting Gowganda conglomerate. The dyke strikes easterly and dips very steeply; it follows a narrow shear zone. Along the shear zone and in the dyke is vein material consisting of pyrite and chalcopyrite in a matrix of quartz, calcite, and chlorite. Beside the road is a shaft, from which considerable vein matter has been taken and now forms a dump. The material on the dump is of rather uniform composition. For a distance of half a mile west of the shaft, trenches cross the shear zone and show it to be quite persistent, although very little sulphide appears beyond a point 100 yards from the road. It is some time since any work has been done on this property.

APPENDIX: TIMBER BERTH 195

In Bruce Mines map-area, a conglomerate of considerable proportions was found at the base of the Bruce series. In Otter township, in the same map-area, outliers of this formation cap some of the granite hills. A report to the effect that more of this conglomerate was to be found in Berth 195 led the writer to make a search for it. The area was traversed in sufficient detail to prove definitely that no large mass of conglomerate is present, but, possibly, an occasional, very small, outlier may occur as a capping to some of the hills.

Most of the township is underlain by granite and gneiss, both containing in many places rather abundant inclusions of more basic rock. The granite is typical of the variety found in the general district below the

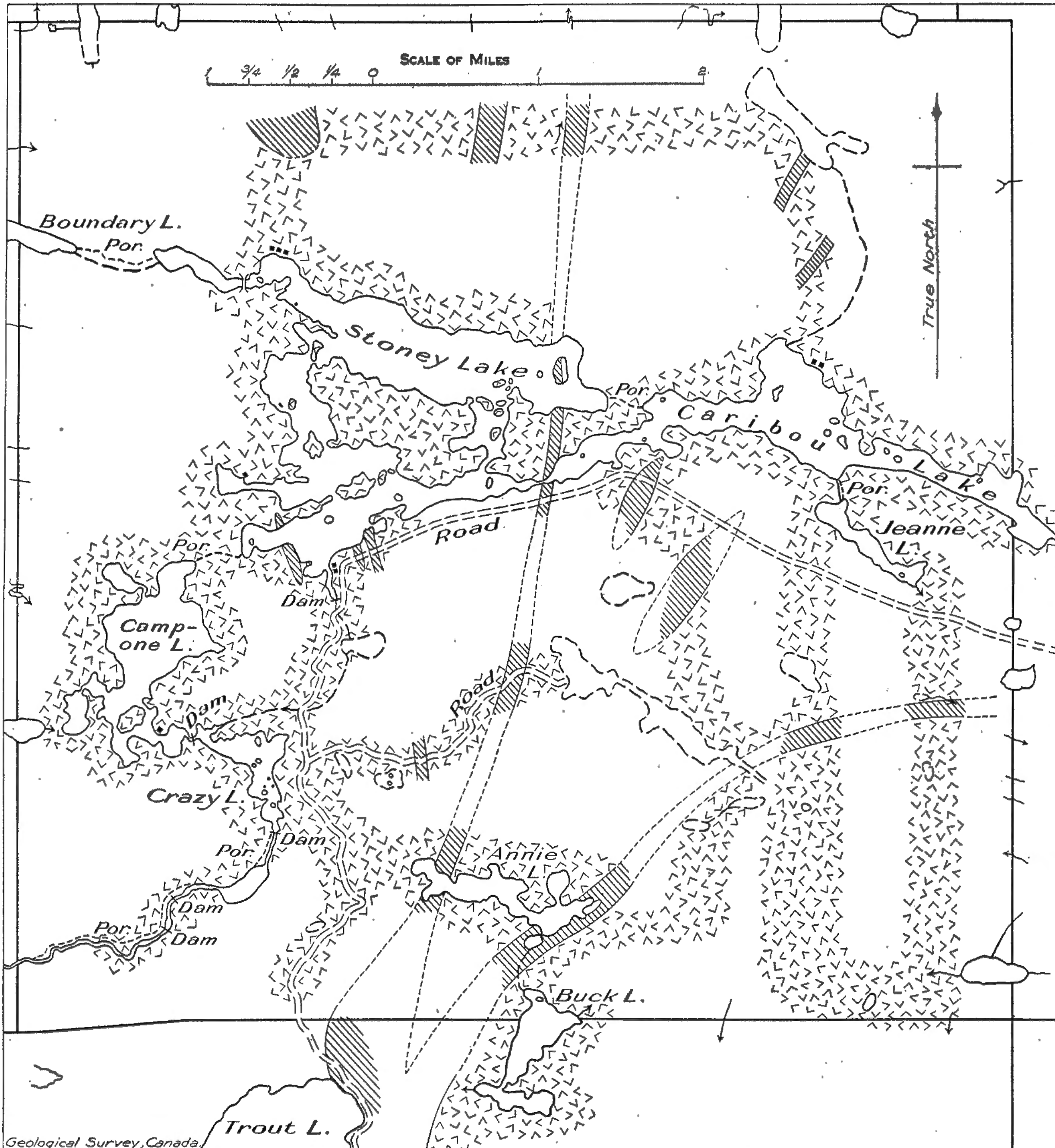

Figure 1. Township 195, Algoma district, Ontario; pre-Huronian granite, gneiss, and schistose inclusions shown by angle pattern; Keweenawan diabase and diorite by ruling pattern.

Huronian and most of it is believed confidently to be pre-Huronian. The gneiss is most extensively developed in a wide band extending slightly north of west across the centre of the berth. It is in this band that Caribou and Stoney lakes occur. Contacts of the gneiss and granite, wherever seen, show that the granite is younger than the gneiss. One granite dyke that cuts across the largest island in Stoney lake has an entirely different appearance from that of the main granite of the district, it is coarser, more quartzose, and much fresher looking. How much younger this granite is than the main granite of the district cannot be said. This dyke is the only such mass seen.

Diabase is not extensive in Berth 195, but two fairly large masses cut granite south of Caribou lake. A large diabase dyke in Otter township appears to branch into two narrow, persistent dykes that extend across Berth 195. Apparently coincident with the small extent of the diabase in the berth, prospecting activity has been very limited.

THE MESOZOIC AND PLEISTOCENE DEPOSITS OF THE LOWER MISSINAIBI, OPAZATIKA, AND MATTAGAMI RIVERS, ONTARIO

By F. H. McLearn

CONTENTS

Illustrations

INTRODUCTION

An examination of the Mesozoic and Pleistocene deposits of Missinaibi, Opazatika, and Mattagami rivers, on the James Bay slope, north of the area of Precambrian outcrop, occupied about eight weeks in the summer of 1926. Particular attention was given to the lignite and peat beds, the presence of which has been known for nearly fifty years. Plants were found in the Mesozoic deposits which make possible a more accurate dating of them than hitherto obtained. As interglacial deposits, the peat beds are of particular interest because of their northern location.

Co-operation with a party from the Ontario Department of Mines, consisting of Professor R. J. Montgomery, in charge, and R. J. Watson, was most satisfactory and helpful. The main object of this party was to study the Mesozoic clay deposits, just as that of the Geological Survey party was to examine the lignite and peat deposits. Without Professor Montgomery's advice, the measurements made and the tests performed by him, and without access to the pits opened up, the description below of the mottled clay facies of the Mattagami series would have been much restricted. The Ontario Government's party also shared in the discovery and collecting of fossil plants from the Mattagami series.

The fuel analyses were made in the Fuel Testing Laboratories of the Mines Branch, R. E. Gilmore, Superintendent, and were reported upon by C. B. Mohr. Important advice in the office has been given by W. A. Johnston. The fossil plants have been studied by W. A. Bell and the plant material in the peat by V. Auer (*See* Appendix).

In the field, beds in numerous exposures were measured, plotted as columnar sections, and compared. Vertical measurements were made to river-level. The aneroid was used to measure the elevation of thicker beds, e.g., zones of gravel, boulder clay, etc., but a tape was used to measure details of lignite and peat layers and beds adjacent to them.

Descriptions of localities may differ in detail from those of earlier observers, because of the different exposure now as compared with the past. The difference of exposure may arise from landslide, shifting of stream course, or different (seasonal) water-level. All distances along a river or brook are given as in a straight line, not as around the bends. Right and left bank are used in the sense of facing downstream.

Among those who have described this area, or parts of it, are Robert Bell[1], E. B. Borron[2], J. Mackintosh Bell[3], M. B. Baker[4], M. Y. Williams[5], J. Keele[6], J. G. Cross[7], and E. M. Kindle[8].

PHYSIOGRAPHY

The principal physical feature of the region is a plain, the coastal plain, sloping up from south to north and separated from the higher plain of the clay belt on the south by a low escarpment[9]. The rivers are deeply entrenched in this plain: to a depth of about 120 feet on Missinaibi river below Coal brook; to a depth of 65 feet on Opazatika river; to a depth of about 90 feet on Mattagami river near the Great bend; and to a depth of about 30 feet near the confluence of Mattagami and Missinaibi rivers. Most of the incising has been in the Pleistocene deposits. But, in a few places, the upper part of the Mesozoic clays and sands has been cut into, and at Grand rapids on the Mattagami a part of the Devonian has been laid bare.

Spruce and poplar line the river banks and to some extent are on the plain above, but much of the plain is covered by muskeg, the area of which increases northward.

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[1]Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. C, pp. 1-5 (1879).
[2]Report on the Basin of Moose River, Etc., pp. 62-69 (1890).
[3]Ont. Dept. of Mines, vol. XIII, pt. I, pp. 161-175 (1904).
[4]Ont. Dept. of Mines, vol. XX, pt. I, pp. 214-246 (1911).
[5]Geol. Surv., Canada, Sum. Rept. 1919, pt. G, pp. 1-12 (1920).
Ont. Dept. of Mines, vol. XXIX, pt. II, pp. 19-30 (1920).
Geol. Surv., Canada, Sum. Rept. 1919, pt. G, pp. 13-19 (1920).
Ont. Dept. of Mines, vol. XXIX, pt. II, pp. 31-55 (1920).
Roy. Soc., Canada, vol. XV, sec. IV, pp. 25-45 (1921).
[7]Ont. Dept. of Mines, vol. XXIX, pt. II, pp. 1-18 (1920).
[8]Geol. Surv., Canada, Sum. Rept. 1923, pt. C I, pp. 21-41 (1924).
[9]Kindle, E. M.: Geol. Surv., Canada, Sum. Rept. 1923, pt. C I, pp. 23-29 (1924).

STRATIGRAPHY

Table of Formations

	System	Series or formation		Thickness in feet	Lithology
	Recent				Sand, gravel, etc.
Cainozoic	Pleistocene	Marine Champlainian		5–25	Sand, clay
		Glacial till, etc.		120	Boulder clay, gravel, sand, clay, interglacial peat, and carbonaceous silt, etc.
Mesozoic	Late Jurassic or Early Cretaceous	Mattagami series	Grey clay or lignitic facies	125	Lignite-bearing, grey, black, etc., fire-clays, quartz sands, micaceous silts
			Mottled clay facies	25	Buff, cream, etc., and mottled fire-clay. Kaolin-bearing quartz sands
Palæozoic	Devonian	Long Rapids		2	Shale, nodular limestone
		Abitibi River		60	Coral, limestone, etc.
Precambrian					Syenite gneiss, greywacke, schist, etc.

Precambrian

The northernmost outcrop of the Precambrian on Missinaibi river is at a rapid nearly 2 miles north of the south boundary line of Burstall township. There the rocks consist of dark, finely banded greywacke schist and more massive layers of the same composition, all intruded by aplite dykes nearly parallel to the bedding. The strike is east-west and the dip 80 degrees north.

The northernmost outcrop of the Precambrian on Opazatika river is on the right or south bank about three-quarters of a mile below Breakneck falls and about one-quarter mile north of the north boundary line of Bradley township. There the rock is a garnetiferous biotite gneiss striking north 85 degrees west and about vertical; it is cut by pegmatite dykes, $\frac{1}{8}$ inch to 2 feet wide, nearly parallel to the banding. At Breakneck falls farther upstream the rock is more massive and about a syenite in composition.

The northernmost Precambrian outcrop on Mattagami river is at the lower end of Long rapids, where a thick basic dyke is intrusive into syenite gneiss.

Palæozoic

The Middle Devonian Abitibi River limestone and the Upper Devonian Long Rapids shale and limestone have been described or commented

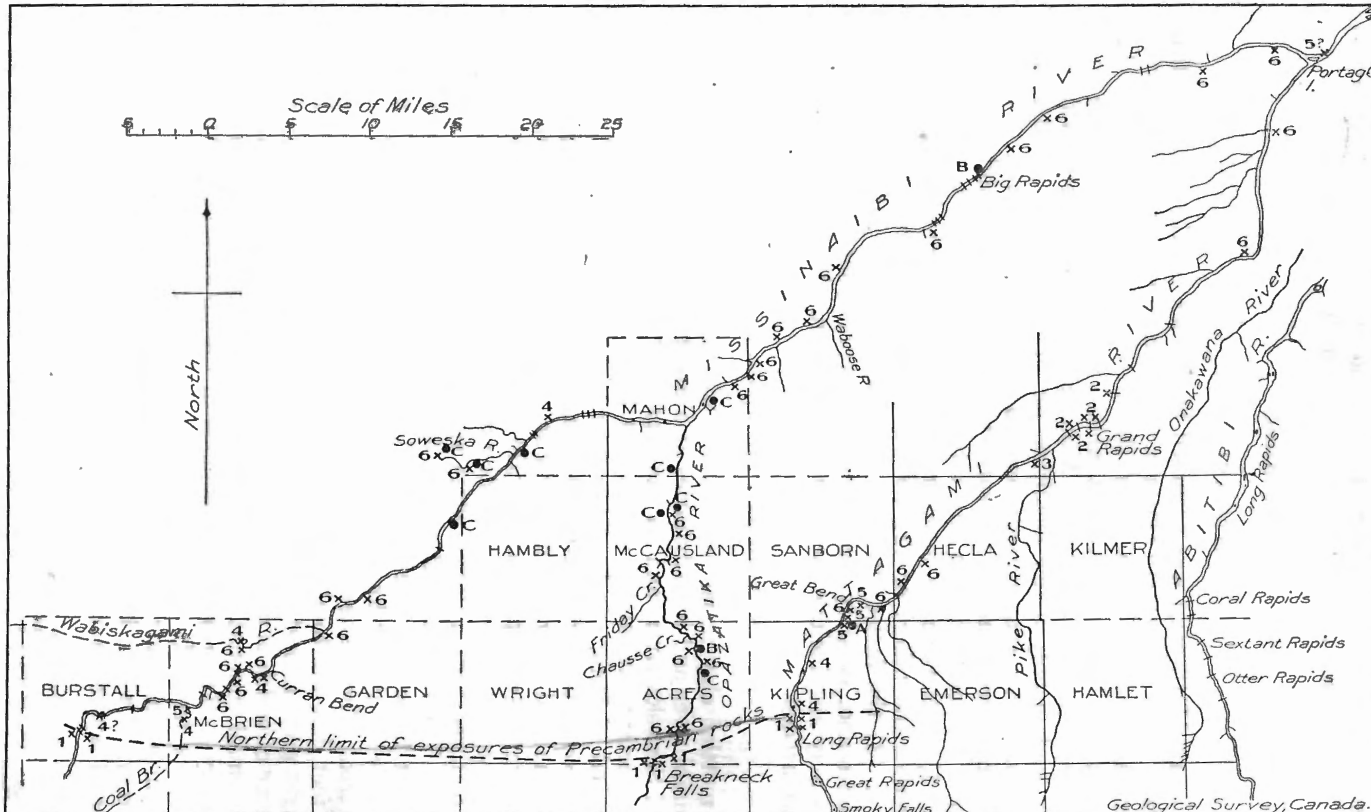

Figure 2. Parts of Missinaibi, Opazatika, and Mattagami rivers. Position of observed outcrops, except those of lignite and peat, are indicated by crosses with attached numbers respectively signifying: 1, Precambrian syenite gneiss, etc.; 2, Devonian, Abitibi River formation; 3, Devonian, Long Rapids formation; 4, Upper Jurassic or Lower Cretaceous, mottled clay; 5, Upper Jurassic or Lower Cretaceous, grey clay; 6, Pleistocene, marine (Champlain) deposits. Outcrops of lignite and peat are indicated by solid black circles with attached letters respectively signifying: A, Upper Jurassic or Lower Cretaceous lignite; B, Pleistocene alluvial lignite; C, interglacial peat.

on by former writers.[1] No further study was made of them in 1926, other than to sample the Abitibi River limestone in one of the cliffs at Grand rapids. The analysis of the sample is given under "Limestone."

Mesozoic

MATTAGAMI SERIES

The name Mattagami was proposed by Keele[2] for the Mesozoic fire-clay-bearing series of northern Ontario. In the area examined the deposits of this series appear with two facies, the mottled clay and the grey clay or lignitic facies. Both outcrop at about river-level and for the most part can be seen only at low water. Although distributed over a wide area they are found in only a few localities, for in most places boulder clay, sand, or other Pleistocene deposits extend down to river-level. The two facies were nowhere found in the same section or locality and, therefore, the relation of one facies to the other is unsolved. It is not known whether: (1) each facies is a separate and distinct member and, if so, which overlies the other; or (2) the two facies grade laterally into one another; or (3) the facies alternate, in vertical section, with one another several times and, possibly, grade into and replace one another laterally. The series may also include facies as yet unknown. Reliable records from drilling are needed.

Mottled Clay Facies

The mottled clay facies has a fairly wide distribution, being exposed on Missinaibi river and its tributaries at a number of places between Coal brook and Soweska river, and on Mattagami river below Long rapids.

An important exposure is on the east bank of Mattagami river below the lower end of Long rapids. It commences about 1,500 feet below the rapids and continues downstream for more than 4,000 feet, being exposed in pits and natural outcrops and rising in one place to a height of 14 feet above low water (of September 9, 1926). Much of it is covered at high water. In the upstream 2,600-foot stretch, Montgomery's studies show the presence of three beds, a lower white sand, a middle clay, and an upper white sand. The maximum thickness of the lower sand in Montgomery's pits is 4 feet 6 inches. The downward extension of this lower sand and what underlies it are not known. It is a medium coarse sand with kaolin in the matrix. The greatest thickness of the middle clay in Montgomery's pits is 9 feet, but the total thickness must be nearly twice this. It consists of light grey, almost white, yellow, cream, or buff fire-clay, or impure kaolin, some of which is mottled with brown and red patches; as impurities there are small amounts of quartz, mica, undecomposed feldspar, etc. (Montgomery). The maximum thickness of the upper sand in Montgomery's pits is 9 feet. It is a very coarse and angular sand with almost white kaolin in the matrix. Most of this sand consists of quartz, a very small amount of which is stained with iron; a little mica is present. In the two sand layers Montgomery obtained 10 to 20 per cent kaolin. This

[1]Williams M.Y.: Geol. Surv., Canada, Sum. Rept. 1919, pt. G, pp. 7-9 (1920).
Kindle, E. M.: Geol. Surv., Canada, Sum. Rept. 1923, pt. C I, pp. 30-36 (1924).
[2]Keele, J.: Ont. Dept. of Mines, vol. XXIX, pt. II, p. 47 (1920).

upstream part of the deposit is overlain by Pleistocene sand, gravel, bluish green clay, or boulder clay slide. The structure is a very low arch with gentle slopes upstream and down.

The downstream 1,400 feet of this deposit was not explored as thoroughly as the upstream part. Near river-level there are a few feet of cream, mottled cream, and yellow, etc., fire-clay, and in one place a 1-foot bed of black clay with lignite fragments. About 2 feet of the upper sand layer is exposed. The overlying Pleistocene bluish green clay in one place rests on the fire-clay layer and in another on the sand layer.

There is probably another deposit of this facies farther downstream, about two-thirds of a mile below the second island, where white sand outcrops at low river-level and fire-clay is said to be present in a pit now filled with water.

Deposits of this facies are also found on Missinaibi river, and its tributaries. On the left bank of Coal brook, about one mile above its mouth, greenish grey clay is exposed at river-level and is overlain by 4 feet of mottled buff and green, and yellow and red clay. This clay contains a considerable proportion of undecomposed material, some of which is probably feldspathic (Montgomery). This clay is non-calcareous.

Along the right bank of Missinaibi river, at Curran bend, a deposit of this facies is exposed in pits and natural outcrops for nearly one-half mile. There are two layers, a sand below and a clay above. No second upper sand is visible as in the deposit on Mattagami river. The sand is at least 20 feet thick, but how much thicker and what underlies it are not known. It consists chiefly of angular, clear, milky, and smoky, and a small proportion of iron-stained, quartz grains. A little mica is present. The proportion of kaolin in the matrix is less than the Mattagami deposit, about 3½ to 9½ per cent (Montgomery). The greatest thickness of the clay layer exposed is 11 feet, but is much less in parts of the deposit. The clay layer consists of light grey or almost white, and mottled white, red, and buff fire-clay or impure kaolin. A little mica and quartz are present and show in the sieve tests (Montgomery). The light grey or white clay patches tend to be higher in quartz. The deposit is overlain by Pleistocene boulder clay and gravel. A peculiarity of this deposit is its presence at different levels, 11 to 60 feet above low river-level, in different parts of the area of outcrop, the result of slumping or more likely of glacial transportation.

Another deposit of this facies is on the right bank of Wabiskagami river, about 2½ miles north of the above deposit. It extends along the bank of a low flat for about ⅙ mile and rises to a height of 13 or 14 feet above river-level. As in the deposit at Curran bend, only two layers are present, a sand below and a clay above. One of Montgomery's pits contains, in ascending order: 3½ feet of mottled white, red, and yellow fire-clay or impure kaolin; 1½ feet of light grey quartzose fire-clay; and 1 foot of yellow and white fire-clay. Another pit contains 6 feet of white sand overlain by 4 feet of mottled white, yellow, and red fire-clay. At the downstream end white sand outcrops along the bank. On the opposite and left bank of the river 2 feet of white sand, at river-level, is overlain by boulder clay. Upstream and down from this locality the Pleistocene deposits extend to river-level.

Yet another occurrence of this facies is on the left bank of Mattagami river 3 miles below the mouth of the Soweska and continues along the low shore or on the river bottom for about 500 feet (Montgomery). Five feet of almost white fire-clay or impure kaolin with patches of red and greenish brown, are exposed in a pit. No sand layer is visible.

A search for deposits of this facies on Opazatika river proved unfruitful. The river has probably not cut down deeply enough to expose deposits of this age.

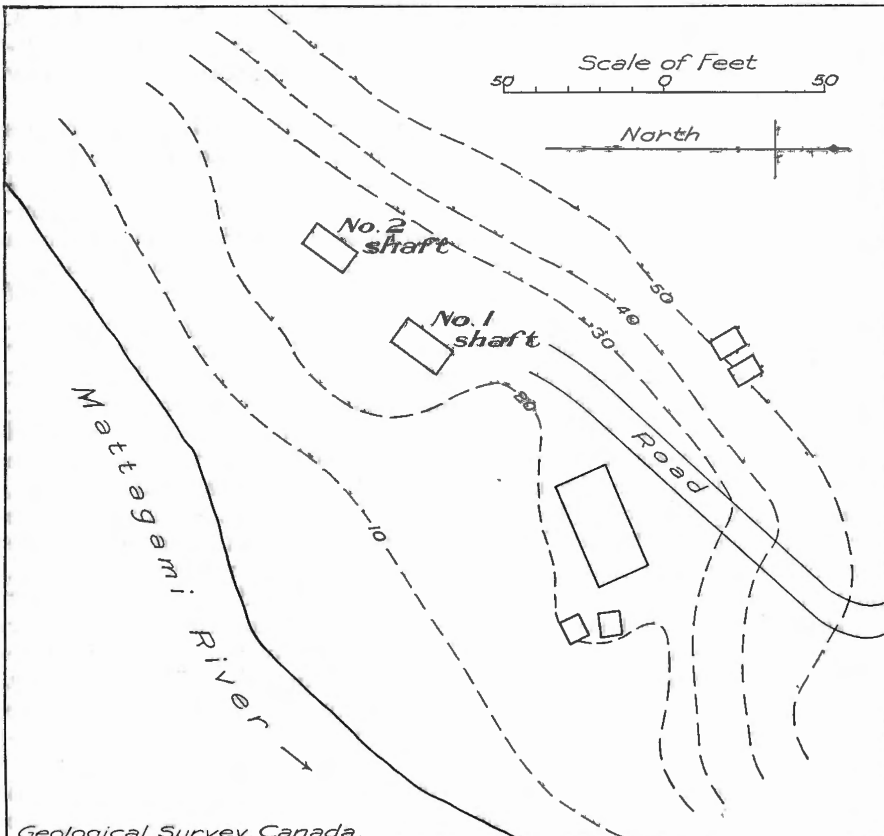

Figure 3. McCarthy shafts, Mattagami river. Elevations, in feet, above river-level, September 10, 1926.

Grey Clay or Lignitic Facies

Deposits of the Grey clay facies are distributed over a wide area, being known on Mattagami river at the Great bend, on Coal brook, a tributary of the Missinaibi, on Moose river, and probably at Blacksmith rapids on Abitibi river. None was found on Opazatika river.

The most instructive section of a deposit of this facies was one exposed in No. 2 McCarthy shaft on the left bank of Mattagami river, one-fourth mile south of the boundary between Kipling and Sanborn townships and at the beginning of the Great bend. Unfortunately at the time of the writer's visit, this shaft was full of water, so that observations were necessarily confined to the dump. Professor Montgomery, however, had visited the workings from time to time after the level of about 65 feet had been reached and the writer is indebted to him for information. The shaft was started at an elevation of 20 feet above low water-level and at a distance of 65 feet from the river (*See* Figure 3). It was carried to a depth of 87 feet and from there a bore-hole was drilled 50 feet, giving a total penetration of 137 feet. The shaft begins in boulder clay and the fire-clay series appears to have been reached at a depth of about 12 feet and to have continued to the bottom of the hole. It follows, if the structure is flat, that 125 feet of the grey clay facies are revealed in shaft and bore-hole. Below the boulder clay there appear to have been first grey and black clay and then a thick bed of sand to a depth of 60 feet in the shaft. From about 60 to 65 feet there was a bed of black clay and to the bottom of the shaft, at 87 feet, dark brown to black carbonaceous clay and also light-coloured clay. In the bore-hole, from 87 feet to 122 feet, there were black and dark brown carbonaceous, and grey, clays. From 122 to 127 feet there was silt, and from 127 to 137 feet there was sand. The bottom of the drill is said to have penetrated solid rock, but as no specimen was obtained its nature is not known. Lignitized, flattened tree trunks of various sizes were found through nearly all the clays. Many were collected and stored in a box for fuel. Some of these are 2 feet long and over 6 inches wide. A study of the dump adds to our knowledge of this section. Black clay is fairly common on the dump and in part probably came from the bed at 65 feet; it is very dark grey, or dark brown, or black, and contains pieces of lignitized wood in the form of stems, sticks, and flattened trunks of small trees; it contains also numerous "chips" of mineral charcoal and also much fine mineral charcoal as revealed under the microscope. Indeed most of this black clay is fairly carbonaceous. But all of it contains a large amount of clay that is very plastic when wet and is non-calcareous. Light grey clay is more common and varies in intensity of colour and in proportion of lignitized wood, stems, mineral charcoal, and other organic matter; it also is very plastic when wet and non-calcareous. A small proportion of the clay on the dump is harder, more indurated, and less plastic. Most of the clay is massive with little or no banding. Some of the clays contain very small sericite mica flakes. There is also a fairly well indurated and somewhat laminated, micaceous, non-plastic, and non-calcareous silt; mica flakes are very small, but in large proportion; powdered, it is seen under the microscope to consist mainly of sericite mica flakes and very small quartz grains. One specimen of hard, indurated clay contains some impressions of indeterminate conifer branches and fern fronds.

An actual surface exposure of a deposit of this facies occurs in the opposite or right bank of the river, both to the north and south of the Kipling-Sanborn line (*See* Figure 4). About 1,000 feet south of the line, 8 feet of fine, micaceous sand and some clay is exposed at low water-level and is apparently flat lying. The micaceous sand consists chiefly of small quartz grains and small flakes of sericite mica. In it are hardened or cemented areas of the same material, forming concretionary masses. These indurated parts carry wood fragments and large fronds of the cycad genus *Nilsonia*. At the same locality, at low water-level and below it, are boulders or concretions of hard sandstone with wood remains. What these are is not known. About 250 feet downstream or 750 feet south of the Kipling-Sanborn line, and a few inches above low water-level, there is grey fire-clay with a lignite seam striking parallel to the bank and dipping 80 degrees east. This seam is described later under Mesozoic lignite. Downstream there is no outcrop for 850 feet, but 100 feet north of the line a few inches of lignite outcrops just above low river-level and dips eastward into the bank. Farther downstream there is no outcrop for 80 feet, where about 4½ feet of grey fire-clay enclosing a thin lignite seam appears. The strike is north 25 degrees east and the dip 45 degrees east. The fire-clay and

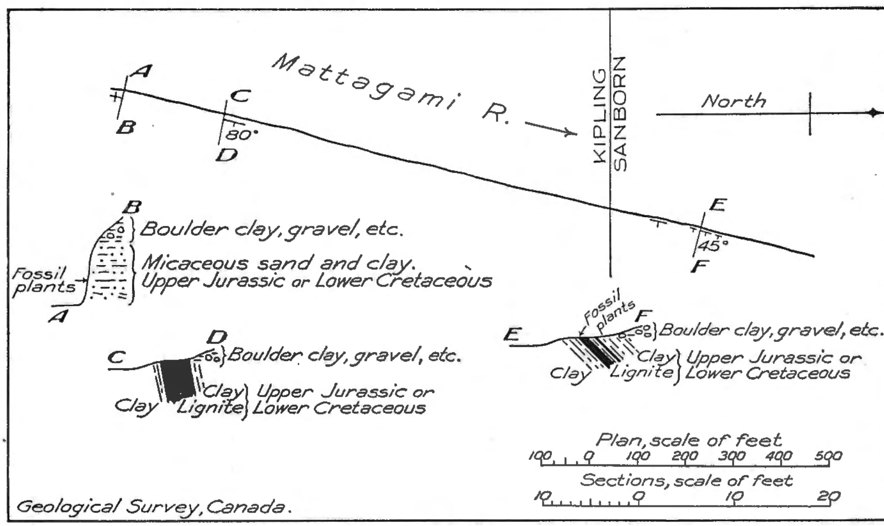

Figure 4. Lignite outcrops and sections of strata on east bank of Mattagami river at crossing of boundary between Sanborn and Kipling townships.

lignite are overlain by black boulder clay with fragments of lignitized wood and small striated boulders. The high attitude of this deposit is probably the result of scouring and ploughing by a glacier as explained by Baker[1] years ago.

Nearly a mile downstream on the same bank, and well around the Great bend, there is grey fire-clay with lignitized wood fragments just beneath the gravel on the shore and a few inches above low river-level. Boulder clay overlies it in the river bank. A mile and a half yet farther downstream, on the same bank, and at the mouth of a stream entering from the south about one mile west of the Sanborn-Hecla line, there are 5 feet of black, plastic boulder clay with lignitized wood fragments at river-level; the clay may, possibly, be underlain by a deposit of the grey clay facies.

[1]Baker, M. B.: Ont. Dept. of Mines, vol. XX, pt. I, p. 236 (1911).

In Missinaibi River basin this facies is known only on Coal brook. There, at a distance of 1,200 feet from the mouth, is an outcrop, partly submerged, in the bed of the brook. It consists of dark grey, almost black fire-clay, with lignitized wood fragments, light grey fire-clay, and pinkish grey fire-clay. A 20-foot hole was put down at the downstream end of this outcrop. The following section is supplied through the courtesy of Mr. R. P. McGregor:

	Feet	Inches
Pinkish grey clay	1	0
Brown clay	0	6
Black clay	3	0
Gravel, sand, clay, or till	2	0
Black clay	3	0
Brownish clay	1	0
Black clay	2	0
Brownish grey clay, pebbles up to 1½ inches, a boulder clay	2	0
Brownish grey clay	1	0
Greenish clay with pebbles, a boulder clay	2	6
Black clay	1	6

The mixture of Mesozoic fire-clay and boulder clay in this hole shows that the strata are thoroughly disorganized as a result of disturbances due to glacial action. Downstream there are no more exposures in the bed of the brook. In the high river banks only Pleistocene boulder clay, gravel, etc., are seen and they extend not only to river-level but below it, as several bore-holes show. The sole location at which a deposit of the fire-clay series could exist in the cliff is directly west of the exposure in the brook, where a recent landslide conceals the lower part of the cliff; as this is not far from the locality where both Bell and Borron observed a lignite seam in the river bank many years ago it will be discussed further under Mesozoic lignite.

A deposit of this facies may be exposed on Moose river below Portage island, for specimens of lignite and dark grey fire-clay were seen at Portage island and were said to have come from Moose river. The deposit at Blacksmith rapids on Abitibi river may be of this facies of the Mattagami series, but was not visited by the writer.

Age

The earlier explorers did not separate the lignite-fire-clay bearing sediments from the Pleistocene deposits, considering them all to be Pleistocene. Keele was the first to recognize that they were distinct from the Pleistocene deposits and of much earlier age. He collected a few obscure plant remains and referred them "to the Palæobotanists of the United States Geological Survey" who reported that "the material....transmitted is so fragmentary that with the few specimens in hand it is impossible to determine even the genera with certainty. However, most of the large fragments belong to a leaf of Taeniopteroid aspect. The nervation suggests some of the later types, such as are found in the older Mesozoic. It is almost certain that the beds are not younger than Kootenay and they are surely not older than Permian"[1]. The collections made this year admit

[1]Keele, J.: Geol. Surv., Canada, Sum. Rept. 1919, pt. G, p. 17 (1920).

of a more accurate dating. The thin lignite bed on the east bank of Mattagami river, north of the Kipling-Sanborn line, contains in its matrix of matted, lignitized vegetation the following species, identified by W. A. Bell:

Brachyphyllum mclearni W. A. Bell
Cladophlebis cf. *albertsii* (Dunker)
Pityophyllum cf. *graminaefolium* (Knowlton)
Onychiopsis? sp.

The micaceous sand, which outcrops on the right bank of Mattagami river 1,000 feet south of the Kipling-Sanborn line, carries *Nilsonia* cf. *densinerve* (Fontaine). This last locality is probably the one from which Keele collected his plants " of Taeniopteroid aspect ". A specimen of hard, indurated clay from the No. 2 McCarthy shaft contains some impressions of indeterminate conifer branches and fern or cycad fronds. The age of the above flora, as interpreted by W. A. Bell, is late Upper Jurassic or early Lower Cretaceous. This, of course, dates the grey clay facies of the Mattagami series at the Great bend on Mattagami river. No fossils were found in the mottled clay facies.

Origin of Facies

A thorough study of the origin of the sediments of the Mattagami series, involving as it does many mechanical and chemical tests, is quite beyond the scope of this report and has not been attempted.

The Precambrian terranes to the south, from which the Mesozoic sediments presumably came, include biotite-granite and syenite gneisses, garnetiferous biotite gneisses, greywacke schist, pegmatite dykes, etc. The sediments of both facies of the Mattagami series consist chiefly of the end products of chemical erosion of such rocks and the minerals resistant to chemical erosion, i.e., of kaolin, sericite, quartz, etc. Minerals of the Precambrian rocks, such as feldspar, biotite, and hornblende, which are readily altered by chemical erosion, are present in only very small proportions or not at all. The proportion of undecomposed or only partly decomposed feldspathic rock varies and is appreciable only in the clays of the mottled clay facies on Coal brook, 1 mile above its mouth. Very few grains of garnet have been found in the sediments of the Mattagami series, but as heavy minerals they would be concentrated in pockets or lenses and not disseminated through the sands. The same climatic and topographic conditions[1] can be inferred for both facies, a moist, equable, not cold, climate, a covering of vegetation, and a not too high gradient, probably that of one of the later stages of the erosion cycle. The presence of coarse grains in some of the sands does not necessarily indicate a very steep gradient. They may have been transported in times of flood and probably did not travel very far anyway.

An important difference between the two facies is the large amount of plant debris in the one and its rarity in the other. The sediments of the grey clay facies must have been laid down on a site receiving drifting, or infalling, or in situ, tree and other plant material, and in sufficiently stag-

[1]*See also* Keele, J.: Geol. Surv., Canada, Sum. Rept. 1919, pt. G, p. 18 (1920).

nant and toxic water of swamp, shallow lake, or alluvial plain to arrest decay. The sediments of the mottled clay facies, on the other hand, were deposited on lake or alluvial plain sites not receiving plant accumulations or, if receiving them, in water sufficiently aerated to promote decay, or aeration was promoted by seasonal drying. The dominant grey to black colours of the clays of the grey clay facies are due largely to the presence of plant matter. The yellow, buff, and red colours of the mottled clay facies are, probably, due to the presence of ferric compounds.[1] No plant matter was present to reduce the ferric compounds or to give grey and black colours.

The presence of kaolin in the matrix of the sands of the mottled clay facies requires explanation. The coarse sand grains and the very fine kaolin could not have been deposited at the same time. It is not a residual deposit. Certainly the upper sand in the deposit below Long rapids cannot be so regarded, for it rests on a clay layer and must have been transported. The quartz and kaolin may have been laid down separately, the quartz in time of flood and the kaolin in time of quiet subsiding water, sinking down between the quartz grains and filling the interstices. Or partly kaolinized grains of feldspar were transported and deposited with the quartz grains and completion of kaolinization took place after deposition.

All the known sediments of the Mattagami series are probably of non-marine origin. Plant debris is very abundant in the grey clay facies and no marine fossils have been found in either facies.

Thickness and Erosion

That the Mattagami series has suffered considerable erosion is demonstrated by the following: (1) in the deposit below Long rapids on the Mattagami, the Pleistocene deposits rest partly on the upper sand and partly on the middle clay; (2) there are in places in the Pleistocene deposits what appear to be reworked sands and clays of the Mattagami series; (3) there are waterworn lignite fragments in sand of Pleistocene age; (4) there are lignite boulders in the boulder clay; (5) some of the beds are disturbed and upturned, apparently by glacial action; (6) no deposits of this facies have been found on the limestone at Grand rapids and if ever present there have been removed by erosion. That some of the erosion was fluviatile or fluvioglacial is shown by (2) and (3). That some was glacial is shown by (4) and (5).

In our present state of knowledge it does not seem profitable to draw any inferences as to the thickness of this series. As most of it lies below river-level, boring is the only means of determining the thickness. In the McCarthy bore-hole and No. 2 shaft the thickness of the grey clay facies is at least 125 feet.

Cainozoic

PLEISTOCENE

The Pleistocene deposits are exposed in the cliffs along the rivers, occupying, except where the Mattagami series in a few places appropriates the lower few feet, all of the cliff section and extending below it. They are

[1]McCarthy, G. R.: Am. Jour. Sci., July, 1926, pp. 21–24.

subjected considerably to slumping and in many places the lower parts of the cliffs are hidden by slide and wash, so that the best sections exposed are in the upper parts of the cliffs.

Marine Champlainian

The marine *Saxicava* beds are the latest of the Pleistocene deposits, overlying all others, and are found in the very highest parts of the cliffs, just underneath the recent alluvial deposits or soil. They are present on all rivers examined, from near their mouths southward almost to the area of Precambrian outcrop. The most southerly occurrence observed on Missinaibi river[1] is on the right bank about 2⅛ miles below Coal brook. The most southerly occurrence observed on Opazatika river is on the right bank 2 miles north of the south boundary of Acres township and 1¾ miles below the northernmost Precambrian outcrop. The southernmost occurrence observed on Mattagami river is on the right bank 7 miles below the north end of Long portage. The marine beds are thus known to extend to within 1¾ miles of the area of Precambrian outcrop. They were not found closer and were not seen in the Precambrian area, although no special search was made for them there. The Precambrian escarpment may well have served as a southern barrier to this sea, whose southernmost shoreline may have extended along its front.

The marine beds on the upper part of Missinaibi river between Coal brook and Soweska river consist of massive clay or thinly banded light and dark clay, the bands being about ½ inch thick. On Opazatika river they are more sandy and vary from place to place. At the southernmost exposure on this river and 1¾ miles below the northernmost Precambrian outcrop the marine section is as follows:

	Feet	Inches
Concealed, to top of bank	5	0
Thin-bedded sand and clay with shells	3	0
Massive clay with shells	2	6
Sandy clay with small boulders and shells	2	0
Mottled clay without shells	1	6
Sand		

Another section 5½ miles downstream from the above is as follows:

	Feet	Inches
Top of bank		
Sand—alluvial	2	0
Clay and sand in 2-inch to 6-inch layers with shells	7	0

On Missinaibi river below the Opazatika the marine section consists chiefly of clay or clay overlain by sand. On Mattagami river the marine beds observed are of clay. The section was nowhere observed to be sand overlain by clay.

The thickness is difficult to obtain in most localities, because of the concealment of top and bottom boundaries. Measurements where both are known vary from 5 to 25 feet. The marine beds rest chiefly on boulder clay, but are also found on sand, gravel, etc. The marine deposit rises to the north, like the surface of the plain.

[1]Kindle observed occurrences as far south as the mouth of the Wabiskagami.

The marine Champlainian fauna in this area is abundant in number of specimens, but sparse in species. Collections were made at only a few places. A list with localities is given below. *Macoma calcarea* and *Saxicava rugosa* are the most common. *Cardium islandicum* is less common and was found only on the Opazatika and on the Missinaibi below the Opazatika. *Mya truncata* was seen only on the Soweska.

List of Marine Pleistocene Shells

	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
Saxicava rugosa............	x	x	x	x	x	x	x	x		x				x	x
Macoma calcarea...... . . .		x	x			x	x	x	x	x	x		x	x	x
Cardium islandicum... . . .							x	x	x			x			
Mya truncata.....						x									

a. Right bank Missinaibi river, $2\frac{1}{3}$ miles below Coal brook
b. Left bank Missinaibi river, west arm of Curran bend
c. Right bank Wabiskagami river, lower end of big bend
d. Right bank Missinaibi river, opposite mouth of Wabiskagami
e. Left bank Missinaibi river, 2 miles below Wabiskagami
f. Left bank Soweska river, north side of Ells bend
g. Right bank Opazatika river, 2 miles north of south boundary Acres township
h. Right bank Opazatika river, about $\frac{3}{4}$ mile above Chausse creek
i. Left bank Opazatika river, $\frac{1}{2}$ mile below Friday creek
j. Right bank Missinaibi river, $3\frac{1}{2}$ miles below Opazatika river
k. Right bank Missinaibi river, 5 miles below Opazatika river
l. Right bank Missinaibi river, just south of second rapid above Big rapid
m. Right bank Missinaibi river, 7 miles above Portage island
n. Right bank Mattagami river, opposite island 5 miles above mouth
o. Right bank Mattagami river, 3 miles below east boundary of Sanborn township

Till and Gravel

Below the marine beds and above river-level, or above the deposit of the Mattagami series, where present, are beds of till, gravel, sand, clay, and, in places, peats and silts of interglacial age. Unsorted drift or till is the most common deposit. In some cliffs it occupies most of the exposed section. Much of it is fairly plastic when wet and contains small boulders, *i.e.* is a boulder clay. Some of it is less plastic and has a coarser matrix. Large boulders are not common, but are scattered through all the till and in a few places are abundant. Lenses of gravel and sand occur in the till and in some sections there are thinly bedded deposits of boulder clay, gravel, and sand, in layers 6 inches to 2 feet thick. Larger deposits of gravel and sand are also found. Bluish green clay, partly noncalcareous, is also found. Yellowish sands, consisting of yellow stained quartz grains and with small lenses of clay are found in a few places near or overlying deposits of the Mattagami series. They have probably resulted from reworking of the Mattagami sands in early Pleistocene time.

Two drifts at least are present in this area, but only where the interglacial peat deposits are exposed has it so far been possible to distinguish one from the other. Where known the later drift is from 20 to 40 feet thick, whereas the earlier drift is known to be at least 80 feet thick in places.

Interglacial Deposits. On the right bank of Missinaibi river, 6 miles above the mouth of Soweska river, a peat bed occurs about 85 feet above river-level. With it are other interglacial deposits as follows (Section 7):

	Feet	Inches
Concealed to level of plain, about	30	0
Boulder clay	2	0
Thinly banded sand and clay	2	0
Carbonaceous fine banded silt	1	6
Impure peat	1	0
Carbonaceous silt with gritty lenses	2	6
Gravel and sand	9	0
Boulder clay		

The surface of the plain is here about 120 feet above river-level, so that the above interglacial beds are overlain by about 30 feet of concealed deposits of the upper drift. Much of this is probably boulder clay, for an examination of the upstream end of the cliff shows that boulder clay extends nearly to the top, but the interglacial deposits are there concealed by slide from the upper drift. Downstream the peat layer extends for about 500 feet, to the lower end of the exposure. It is brown to almost black, compacted, fissile but not banded, and rather fine textured. It contains much silt and a few pieces of flattened stems and trunks, 2 to 3 inches wide, which are little altered beyond the woody stage, but are partly stained brown and black on the outside. Auer (*See* Appendix) identifies in this peat principally, *Hypnum* moss, *Carex* or sedge, and pollen of *Picea* or spruce. The overlying 1-foot 6-inch layer consists of somewhat compacted silt in very thin (a few mm.), light and dark brown layers; the dark colour is due to the presence of fine plant debris; the silt is in the form of very fine quartz grains. The silt below the peat is somewhat compacted and contains much fine plant detritus and also some flattened sticks; the grit lenses contain plant debris, sticks, and pebbles.

On the left bank of Soweska river, interglacial deposits are exposed at Ells bend, about 3¼ miles west of its mouth. At the west or upstream end of this outcrop the section is as follows (Section 2):

	Feet	Inches
Concealed to top of bank	10	0
Boulder clay	4	0
Glacial lake clay	1	6
Somewhat carbonaceous, very thinly banded silt	1	0
Peat	3	0
Carbonaceous, somewhat indurated silt	1	0
Peat	4	0
Brown-stained boulder clay	2	0
Boulder clay	3	0
Concealed		

The lower, or 4-inch, bed of peat contains numerous pieces of twigs and wood, small chips of charcoal, stems, moss, and disseminated microscopic quartz grains. Auer identifies chiefly *Hypnum* moss, twigs, pieces of pine wood, and also *Salix* or willow, *Carex* or sedge, and spruce pollen.

The overlying 1-foot bed is a somewhat indurated silt and consists of very fine quartz grains and fine, comminuted plant matter, irregularly disseminated so as to give a mottled appearance. The upper or 3-inch peat bed is a dark brown, laminated, fine-textured peat in which only *Carex* or sedge is visible. Under the microscope Auer finds also spruce pollen. Some very fine quartz grains are disseminated through this peat bed. The overlying 1 foot of silt consists of very fine quartz grains and is banded in thin, light and dark layers, a few mm. thick, the dark layers containing fine plant detritus. The varved or glacial lake clay contains small altered pebbles and the lines of stratification are much disturbed; it is 4 feet thick in one place, but a few feet distant is only 2½ feet thick and is overlain by boulder clay. About 800 feet downstream and near the lower end of this outcrop the section (3) is as follows:

	Feet	Inches
Carbonaceous, thinly banded silt	1	2
Peat	1	3
Brown, carbonaceous silt	1	2
Peat	2	2
Clay with freshwater fauna	2	3
Boulder clay	1	0
Concealed		

The lower peat does not here, as at the upstream end of the exposure, rest directly on boulder clay, but is separated from it by a clay containing small shells of freshwater mollusks, *Gyraulus,* young of *Stagnicola palustris?, Sphaerium*[1], etc., which has been deposited in a pond or quiet stream. The lower peat is much thicker here than at the upstream end and has a greater variety of plant material. Besides twigs and a few flattened tree trunks or branches, Auer identifies in this peat principally, *Hypnum* moss, *Carex* or sedge, *Equisetum* or horsetail, pollen of spruce, and spores of *Sphagnum* moss. There is also some disseminated silt in the form of very fine quartz grains. The overlying carbonaceous silt has more plant detritus than in the section upstream, but contains also much admixed silt in the form of very fine quartz grains; most of the plant detritus in this bed is too fine to identify. The upper 1-foot 3-inch peat layer contains *Carex,* other plant material, and a small proportion of silt. The thinly bedded, somewhat indurated, carbonaceous silt at the top of this section is like that in section 2 at the upstream end of this exposure.

This Soweska River exposure records an interesting sequence of events. An earlier epoch of glaciation is recorded by the lower boulder clay. The retreat of the glacier is marked by the clay with the freshwater fauna. A retreating glacier would leave an uneven surface on which the drainage system would be disorganized and on which many shallow lakes and ponds would form; in them at first freshwater mollusks would live. With the growth of vegetation from the shore, bogs would form and gradually close over and fill the shallow lakes. The lower peat bed represents such a bog or an accumulation of vegetation which has fallen or drifted in from nearby bogs on the lake border and has been laid down with silt washed in from the sides or carried in by entering streams. An increase in the volume and transporting power of entering streams due to climatic change or

[1] Identified by F. C. Baker

change in the drainage system would result in a silting up of the bog and the formation of the lower layer of carbonaceous silt. On this site a bog again formed, or infallen and drifted vegetation from a nearby bog accumulated, together with silt brought in by streams, and formed the upper peat layer. Again, there was a flooding by a silt-laden stream and another layer of carbonaceous silt was formed. Finally, the beginning of the later glaciation is heralded by the glacial lake clay, which was laid down in a lake formed by the ponding of northward flowing waters by an advancing glacier. The lake clay was finally overridden by the glacier which disturbed and partly destroyed it and deposited boulder clay.

About 1 mile downstream, on the right bank, a bed of peat 5 inches thick is exposed at about the same elevation as the peat beds upstream, and is underlain and overlain by boulder clay. Upstream and west of Ells bend the peat has been traced by Mackintosh Bell, whose observations are summarized in a later paragraph under " Economic Geology."

This deposit resembles that on Missinaibi river in having peat overlain by very thinly banded, carbonaceous silt. It differs in having two peat layers.

Interglacial deposits are also found on the right bank of Missinaibi river, about three-quarters of a mile below Soweska river. At present this exposure is as described below. At the upstream end and about 50 feet above low river-level there are 2 inches of peat. Downstream 500 feet, the section is as follows (Section 8):

	Feet	Inches
Impure peat	1	4
Finely banded carbonaceous silt	1	3
Impure peat	0	6
Hard boulder clay	3	0

The upper peat layer contains *Hypnum* moss, pollen of spruce (*See* Appendix), and disseminated, fine, microscopic quartz grains. Downstream 200 feet there is a better section (9):

	Feet	Inches
Impure peat	0	5
Finely banded carbonaceous silt	2	4
Impure peat	1	0
Brown carbonaceous silt	1	3
Hard boulder clay	2	0

The lower silt bed consists of very fine quartz grains and very finely comminuted plant debris. The lower peat is impure, with a large admixture of microscopic quartz grains; small charcoal fragments are present and Auer identifies, as important plant constituents, *Hypnum* moss and pollen of spruce and pine. The upper carbonaceous silt is finely layered or banded (a few mm.) in light and dark layers, the latter being coloured dark brown by plant detritus; the silt is high in proportion and consists chiefly of microscopic quartz grains. The upper peat layer is also impure and contains disseminated fine silt; Auer identifies in this peat *Hypnum* moss and pollen of spruce and pine. All of this top peat layer is not exposed.

The above deposit differs from that at Ells bend on the Soweska and from that 6 miles above the Soweska on the Missinaibi, in having a peat layer above the finely banded carbonaceous silt.

Interglacial deposits are also found on Opazatika river. On the east bank, about 8 miles below Breakneck falls at low water-level, the following section (3) is exposed.

	Feet	Inches
Banded arenaceous clay	1	0
Impure peat	0	9
Dark clay	1	0

The peat bed includes much plant detritus, moss, twigs, and small sticks. There are also a few pieces of flattened tree trunks or branches 2 inches across, stained brown on the outside. There is much admixture of silt in the form of very fine quartz grains. As the bank is very low the deposits directly overlying these interglacial beds are not known. The nearest exposure is about one-third mile downstream, where the section is as follows:

	Feet	Inches
Concealed at top of hill	3	0
Finely banded sand with marine fauna	2	0
Rudely banded sandy clay with marine fauna	1	6
Hard boulder clay	20	0
Concealed	10	0
Fine yellow sand with some thin bluish clay bands	4	0
Concealed	8	0
Sand and clay	2	0
Concealed	15	0

It is probable that the peat described above underlies the boulder clay and sand of this section.

The following section (4) is exposed at low water-level on the left bank of the Opazatika about 5½ miles above its mouth:

	Feet	Inches
Peat	0	9
Carbonaceous silt	0	4
Green clay	1	0
Concealed to river-level	8	0

The peat layer is cut off above by boulder clay slide and may be thicker than 9 inches. Much plant matter, twigs, small "chips" of charcoal, and much silt, are present.

A little farther downstream and near river-level on the right bank, about 5 miles above the mouth, there is a long exposure of an interglacial deposit. A section (5) near the middle of the outcrop is as follows:

	Feet	Inches
Finely banded silt	1	7
Carbonaceous silt	0	8
Peat	0	8
Carbonaceous silt	1	7
Concealed to river-level	15	0

The lower carbonaceous silt consists chiefly of very fine quartz grains, mixed with finely comminuted plant detritus. In the peat layer Auer identifies a fairly large flora, including *Hypnum* and *Sphagnum* mosses, cotton grass, willow, twigs, pine wood, and pollen of spruce and pine. It is a relatively pure peat as compared with others in the area, but even so there is a considerable amount of disseminated silt present. Downstream 75 feet the section (6) is somewhat different, there being two peat layers instead of one:

	Feet	Inches
Banded silt	2	0
Carbonaceous silt	0	6
Peat	0	10
Carbonaceous silt	0	5
Impure peat	0	6
Silt	1	0
Concealed to river-level	15	0

The lower peat bed consists of silt and plant detritus both macroscopic and microscopic; the proportion of silt is high. The 10-inch or upper peat layer is lower in silt. The plant matter present includes *Carex* or sedge. Between the two above exposures of the interglacial beds there is one showing the boulder clay, etc., of the later drift which here overlies the peat and other interglacial beds. The section is as follows:

	Feet
Sand with marine fauna	1
Concealed	5
Boulder clay	10
Concealed to river-level	45

Downstream 300 feet there is boulder clay 20 feet above river-level:

	Feet
Boulder clay	10
Concealed to river-level	20

At both the up and downstream ends of this exposure the peat thins to 2 or 4 inches and at the downstream end it is overlain by boulder clay. Glacial erosion may account for the thinning here.

Farther downstream, on the left bank 3 miles above the mouth of the river, a section of the interglacial deposits is as follows:

	Feet	Inches
Impure peat	0	6
Carbonaceous silt	1	2
Concealed to river-level	7	0

Higher in the cliff there is boulder clay.

It is assumed that the peat deposits on the Opazatika are of the same interglacial epoch as those on Missinaibi river. They outcrop much nearer to river-level than on the other rivers, but this is because the Opazatika has not cut so deep a valley. The drift over the interglacial deposits on this river is somewhat thicker than that on the Soweska.

Wherever the two drifts can be distinguished the later is thinner than the earlier. But the later glaciation was effective enough to disturb and remove some of the glacial lake clay, to destroy some of the interglacial deposits, and to compress the peat.

From the plants identified by Auer, and, as he points out, it may be inferred that the climate of this interglacial epoch was not unlike that in the same region today, the flora is that of a northern bog. There is no evidence of a warm climate similar to that recorded by a part of the interglacial deposits at Toronto. No trees 17 inches in diameter of *Populus*, *Abies*, or any other genus were seen in the interglacial deposits. The largest flattened tree trunk observed was 4 or 5 inches in diameter. The thick trees recorded and figured by Baker[1] came from the Mesozoic Mattagami series, the deposits of which were once thought to be of interglacial age. Until thicker trees are found in undoubted interglacial deposits no inferences as to climate or duration of interglacial time, based on them, should be made. Neither wood nor pollen of *Populus* and no wood of *Abies* were found. A few pollen grains of *Abies* were observed by Auer, who concludes that *Picea* or spruce was the most common tree, as it is at the present time, and that *Pinus* or pine was next in importance, although not so common.

No marine shells were found in the interglacial deposits in the area examined last summer. If any marine invasion did occur in interglacial time it apparently did not extend this far south.

A few deposits of carbonaceous silt, etc., were observed on Mattagami river, between Long rapids and the Great bend and may be of interglacial age, but were not studied.

The degree of alteration, analyses, and economic possibilities are treated in later paragraphs under "Economic Geology, Pleistocene Peat".

ECONOMIC GEOLOGY

Three kinds of deposit have been called coal or lignite in this area: the Mesozoic lignite; the Pleistocene sand layers containing boulders of lignite; and the Pleistocene interglacial peat.

MESOZOIC LIGNITE

The lignite occurs in the grey clay facies of the Mattagami series, the sediments, origin, and age of which have been described in preceding sections. Analyses of the lignite are given in the following table, as on a dry basis; were the moisture considered, all figures, including the B.T.U., and excepting only the fuel ratio, would be much lower.

Sample No.	Ash	Vol. M.	F.C.	S.	B.T.U.	Fuel ratio
1	21·9	38·5	39·5	0·4	9020	1·00
2	7·2	47·0	45·8	0·8	11160	0·97
3	57·1	26·8	16·1	0·5	3830	0·60
4	3·8	47·6	48·6	0·8	11570	1·00
5	21·2	42·3	36·5	0·7	8420	0·86

1. A sample across the 3-foot seam on the east bank of Mattagami river about 750 feet south of the Kipling-Sanborn line.
2. Lignitized tree trunks in the 0·6-foot "seam" on the east bank of Mattagami river, about 180 feet north of the Kipling-Sanborn line.
3. Matted, lignitized vegetation in the above "seam".
4. Lignitized tree trunks from clays in No. 2 McCarthy shaft.
5. Float lignite on lower part of Coal brook.

[1]Baker, M. B.: Ont. Dept. of Mines, vol. XX, pt. I, p. 236, text figure 25 (1911).

The seam on the east bank of Mattagami river, about 750 feet upstream from the Kipling-Sanborn line, is 3 feet thick. It outcrops near river-level and can be seen only at low water. It dips about 80 degrees east and has grey fire-clay walls. A representative sample was taken across this seam and the analysis is recorded in the above table as sample 1. The coal consists of large slabs of lignite, formed of flattened, lignitized tree trunks, in a matrix of small pieces of mineral charcoal 7 mm. and less long, set in a yet finer matrix. This finer matrix was seen under the microscope to consist chiefly of small particles or shreds of mineral charcoal, subordinately of small particles of lignitized wood and other plant material, of quartz grains, crystals of selenite (?), and a very fine, dense matrix, probably of clay and fine organic detritus. The large, flattened tree trunks are dark brown and of woody texture on fractures along the grain, but are black and shiny on all other fractures, which are conchoidal.

The seam in the same bank, but more than 900 feet downstream and about 180 feet north of the Kipling-Sanborn line, outcrops at river-level at low water for a distance of about 50 feet. It strikes north 25 degrees east and dips 45 degrees east. Compared with the 3-foot seam upstream it is thinner, has a different matrix, and much clay irregularly through it. It is impossible to say whether or not it is a continuation of the 3-foot seam and, from an economic standpoint, very doubtful whether it should be called a seam at all. The main part varies in thickness from 0·5 to 0·8 of a foot, but even this includes some irregular clay bands and lenses. The best part of the section is as follows:

	Feet
Grey clay with some scattered lignite pieces	2·5
Lignite	0·15
Grey clay	0·50
Lignite with some clay	0·60
Grey clay with small lignite fragments	0·80

The 0·60-foot "seam" consists of flattened, lignitized tree trunks up to 2 feet long, lying parallel to the bedding, and also many small pieces or chips of mineral charcoal up to 2 inches long, resting in clay and in a matrix of a matted accumulation of twigs, leaves, and cones of the conifer *Brachyphyllum,* small problematical leaves (*Pityophyllum*), rarer fronds of the fern *Cladophlebis,* and some lignitized twigs and stems. There is a little clay and much quartz sand through this matted accumulation. The large pieces of flattened, lignitized tree trunks are brownish and woody on some fractures which follow the original grain, and black and shiny on all other fractures, which are conchoidal. The smaller sticks and branches are lignitized also and are dark brown or black and shiny on their conchoidal fractures. The conifer twigs, leaves, and cones, and the fern fronds are carbonized, are indeed remarkably well preserved, and can be separated merely by immersing in water. A sample of the lignitized tree trunks in this seam gives the analysis recorded in the above table as sample 2. The matted vegetation in the matrix of this seam gives the analysis recorded above as sample 3. Compared with sample 2 the fuel ratio is much lower and the ash much higher. The latter, of course, is due to the presence of much sand or silt. The lower fuel ratio means that the conifer twigs, fern fronds, etc., have not reached as advanced a stage of carbonization as the tree trunks in the same seam. In spite of the very fair quality of the lignitized tree trunks contained in this bed, it can hardly be considered a seam in the economic sense, nor of other than purely scientific interest. The importance of the matted and extraordinarily preserved vegetation in the determination of the age of the series has already been noted.

It is probable that the first of the two above localities is the one described by Baker[1] fifteen years ago. He evidently had the advantage of better exposure, partly artificial, as he did considerable digging and some drilling. He found two seams, a 6-foot above and a 1-foot below. He noted their irregularity in thickness. The 3-foot seam exposed at low water last summer may be a narrow part of his upper, or an expanded part of his lower, seam.

On the west bank of Mattagami river, nearly opposite the above occurrence and about ¼ mile south of the Kipling-Sanborn line, is the McCarthy camp where two shafts, side by side, were put down. The most reliable information at hand is of the No. 2 shaft. The location, depth, geological section, and rocks on the dump are described in a preceding section on grey clay facies. To the writer's knowledge no coal seam was found in this shaft. Lignite in the form of flattened tree trunks, stems, and branches, and mineral charcoal, was found scattered through much of the clay in the shaft. The larger pieces of flattened tree trunks were collected and stored in a box for fuel. An average sample was taken from the box, the analysis of which is given in the above table as No. 4. Like the similar "slabs" of lignite in the seams on the opposite bank they are low in ash and high in B.T.U. No material that would correspond to the matrix of the seams on the opposite bank was seen, however. The clays on the dump carry lignitized wood fragments of all sizes and also fragments or chips of mineral charcoal. The black clay, described under grey clay facies, with its abundant lignitized wood and mineral charcoal, is an interesting sediment. Although it has all the constituents of a seam like the 3-foot one across the river, it has much too great an admixture of clay, so that it may be better considered as a carbonaceous clay bed than a seam of coal. The 3-foot seam on the opposite side of the river either never extended this far or is above or below the horizons penetrated by the shaft and bore-hole.

On Coal brook, a tributary of Missinaibi river, a search was made for a 3-foot bed of lignite seen by Bell[2] and Borron[3] many years ago. It does not show now. As previously described under grey clay facies, all that now remains exposed of the Mattagami clays at the bend where Bell and Borron made their observations is a small outcrop in the bed of the brook. It consists of black clay, with pieces of lignite through it, and some lighter coloured clays. The section of a bore-hole put down on this outcrop is described under grey clay facies; no lignite was encountered in it. On the banks along the brook, only the Pleistocene boulder clays and gravel are seen. Downstream the boulder clay, etc., extends below river-level,

[1]Baker, M. B.: Ont. Dept. of Mines, vol. XX, pt. 1, p. 236 (1911).
[2]Bell, R.: Geol. Surv., Canada, Rept. of Prog. 1877–78, pt. C, p. 4 (1879).
[3]Borron, E. B.: "Rept. on the Basin of Moose River, Etc.," p. 65, Toronto, 1890.

as bore-holes prove. Along the bed of the stream and below the outcrop of fire-clay, float lignite occurs and was sampled. An analysis is given in the table above as sample 5. The sample included some of the usual matrix material as well as fragments of lignitized wood, which accounts for the high ash and low B.T.U.

A comparison of the map (Figure 5) made this summer with that published by Borron[1] explains why the seam observed by Bell and himself was not found last summer and why most of the holes put down along

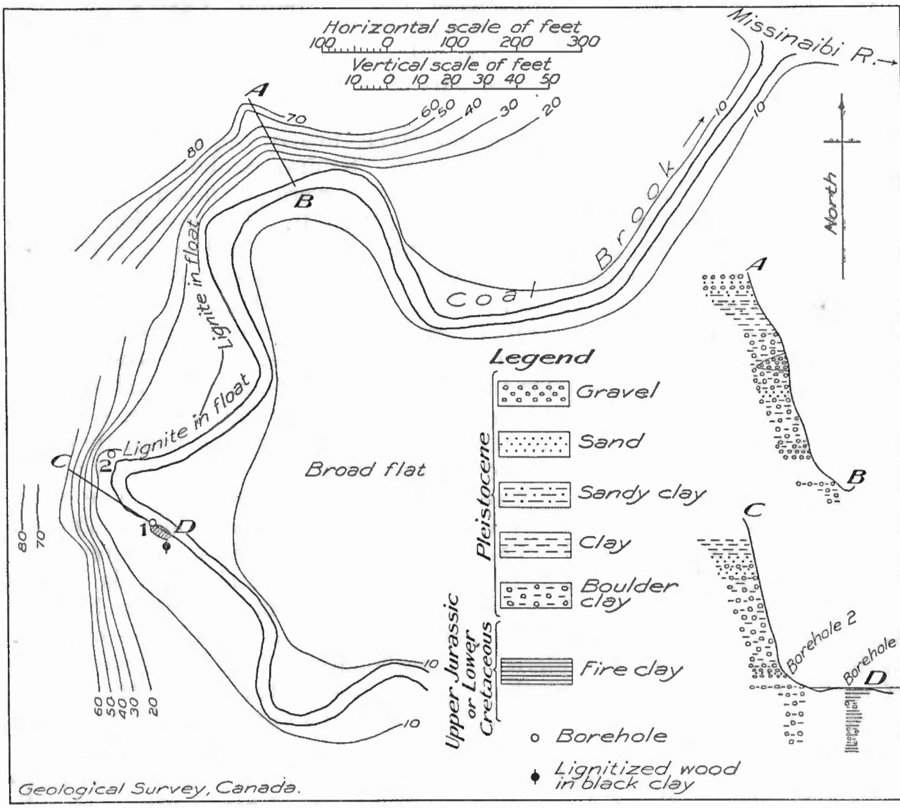

Figure 5. Lower part of Coal brook showing outcrop of fire-clay, etc.

the brook did not penetrate to the fire-clays. The stream has changed its course in thirty-six years. There is no island now, the bend has migrated downstream, and the site of the seam is now covered by stream deposit and by slide from the bank. The area tested by Borron, in which he encountered fire-clay and lignite, lies chiefly to the south of the present bend in the river. Indeed the present outcrop in the brook bottom appears to be the disturbed northern border of a mass of the fire-clay series, cut

[1]Borron, E. B.: "Report on the Basin of Moose River, Etc.," p. 64, Toronto, 1890.

off to the north by glacial erosion and replaced by glacial deposits. Borron found fire-clay, lignite, and clay with lignite in his bore-holes. It may be pointed out here that cores of holes apparently showing lignite seams should be carefully examined, as black clay containing much lignitized wood, mineral charcoal, and other coaly material may be mistaken for a seam.

Some idea of the composition of the coal in the Mattagami series can be gained from an examination of the lignite boulders in the Pleistocene sands. They are described in the next section and apparently have been derived from the erosion of seams like the 3-foot on Mattagami river. This, therefore, was a common type of seam in the Mattagami series, a seam containing large pieces of flattened, lignitized wood, much mineral charcoal, and some sediment. Under greater pressure and advanced to the stage of a bituminous coal, these Mattagami coals would consist chiefly of bands of bright coal and mineral charcoal.

The known seams, including the two observed last summer and those described by other observers, are not very thick and do not represent a very great accumulation of plant matter. The irregularity, the relatively small accumulation of plant material (in the known seams), and the presence of silt in the matrix are compatible with a drift theory of origin. They do not prove it, however, and the alternative theory of an accumulation in situ cannot, in our present state of knowledge, be rejected. Whatever the origin, the plant material has not travelled very far, probably not more than from one part of a swamp or shallow flood-plain lake to another in time of flood, for there is no sign of wear, and as W. A. Bell points out, the delicate ends of fern fronds are preserved.

If analyses of the flattened tree trunks or slabs alone are made, very good results are obtained; the percentage of ash is low, 3·8 and 7·2 in two samples, and the B.T.U. is high, 11,570 and 11,160 in the same two samples. The favourable analyses which, from time to time, have been reported from this area are probably thus to be explained. If, however, the entire seam is sampled with the matrix included, the ash is higher and the B.T.U. lower. Thus the 3-foot seam on the east bank of the Mattagami has 21·9 per cent ash and a B.T.U. of 9,020. Even in this sample, however, the B.T.U. is fairly high. The high calorific value of these coals must not be too much emphasized; rather it is the fuel ratio, which in the samples collected varies from 0·60 to 1·00, by which the coal must be judged. The volatile matter is high and the more important fixed carbon low. In spite of their very fair calorific value, these coals of the Mattagami series are, after all, only lignites.

When pieces of this coal are first taken from an excavation, they contain much moisture and are tough and difficult to break. They soon begin to dry. Slacking, however, had not proceeded very far in some pieces exposed to the air for several months. In a dry room a lump soon slacks and breaks into small pieces. No tests for moisture, or of the effect of drying, were made. Analyses of freshly mined material would probably yield a fairly high percentage of moisture and, compared with analyses on a dry basis, lower percentages of other constituents.

Only one true solid seam was seen this summer in the area examined. It is only 3 feet thick and its extent could not be determined. The small bed of lignite north of the Kipling-Sanborn line on Mattagami river can hardly be called a seam in the economic sense. All other occurrences observed are merely of lignite slabs or flattened tree trunks, and other lignite pieces scattered through the clay, and are of no economic value. It is true that other seams have been observed in the area and are now concealed; but in one locality the irregularity or thinness has been commented on[1]. In another locality, on Coal brook, the seam has not been visible and not studied in recent years. Until thicker and more regular beds are found and their continuity over a sufficiently large area to make mining profitable is proved, these deposits cannot be regarded as of economic importance. Of course, it must be remembered that the Mattagami series is distributed, perhaps discontinuously, over a large area, all of which has not been examined, *e.g.* the deposits on Moose river; that most of it is below river-level, hidden from observation; that the thickness is not known; and that little exploration by drilling has been done.

PLEISTOCENE LIGNITIC SANDS

An unusual type of deposit is that of worn pieces of lignite in a matrix of sand. It occurs at two localities in the area, in both places under boulder clay, and is apparently of Pleistocene age.

The "coal" bed at Big rapids on Missinaibi river is one of these deposits. It can be seen on the left bank just below the rapids. The section there taken from the top of the bank down to river-level is as follows:

	Feet	Inches
Fine sand with recent freshwater fauna	3	0
Gravel	1	0
Boulder clay	3	7
Mixed gravel, sand, lumps of boulder clay	1	6
Sand and scattered and rounded lignite fragments	1	6
Closely packed and rounded lignite fragments in a sand matrix	0	5
Sand	0	2
Closely packed and rounded lignite fragments in a sand matrix	0	4
Sand	0	2
Packed, rounded, lignite fragments in a sand matrix which 100 feet downstream is 10 inches thick	0	7½
Sand	1	0
Lens of packed, rounded lignite in sand	0	4
Sand	0	4
Lens of packed, rounded lignite in a sand matrix	0	5
Sand	0	5
Concealed to river-level	5	0

The above measurements were made at low water; some of this section would be concealed at high water-level. The lignite fragments are well worn and their corners are rounded. They have evidently been derived from erosion of the grey clay facies of the Mattagami series. They have been transported and laid down in stream courses and in a sense might be considered as lignite gravels. They underlie boulder clay, but what they rest on is not known. It is not possible in our present state of knowledge to say whether they are of early Pleistocene or interglacial

[1]Baker, M. B.: Ont. Dept. of Mines, vol. XX, pt. I, p. 236 (1911).

age. The lignite varies in composition. Some of the fragments are of lignitized, flattened tree trunks, like the "slabs" in the fire-clays of the Mattagami series and in the seams at the Kipling-Sanborn line on Mattagami river. Other pieces consist of mineral charcoal chips embedded in a fine-grained mass of mixed mineral charcoal, clay, sand, etc., like the matrix of the 3-foot seam at the Kipling-Sanborn line on Mattagami river. The presence of the matrix material indicates that these alluvial lignite beds are derived in part at least from erosion of seams in the Mattagami series, although some of the material may have come from scattered lignite in clay of the same series.

This bed was known to Robert Bell[1] and its secondary origin was recognized by J. Mackintosh Bell.[2]

A similar deposit occurs on the east bank of Opazatika river, a little more than three-quarters of a mile above Chausse creek. The section there from the top of the bank down is as follows:

	Feet	Inches
Sand	2	0
Sand and clay in 2 to 6-inch layers with *Saxicava* fauna	7	0
Boulder clay	2	0
Concealed	18	0
Sand	15	0
Boulder clay	2	0
Concealed	20	0
Sand	1	0
Layer of worn lignite fragments in sand	0	2
Sand	1	0
Layer of worn lignite fragments in sand	0	6
Sand	1	0
Concealed	2	0

Like the deposit at Big rapids on Missinaibi river this one is under boulder clay. It occurs at about the same level as the interglacial peat deposits on the same river, but is not close enough to a peat exposure to determine its relative age. Being under boulder clay it is certainly not post-Glacial and the age is probably like that of the deposit at Big rapids, either interglacial or early Pleistocene. Compared with the deposit at Big rapids it is much thinner. It consists of worn fragments of lignite, with the corners and edges rounded. The origin is no doubt like that of the layer at Big rapids.

These deposits cannot be called coal seams. Nothing is known of their extent, but they are probably very irregular and probably not very continuous. The layers are too thin and there is too great an admixture of sand for profitable mining. Moreover, they would have to be mined in the unconsolidated Pleistocene deposits. Removal of the overburden of Pleistocene deposits is not practical. These deposits of lignite cannot be favourably considered from the standpoint of mining on a large scale.

PLEISTOCENE PEAT

Detailed sections of the peat beds have been given above under "Interglacial Deposits." Their relations to other Pleistocene deposits have been described and their bearing on the conditions of interglacial time discussed.

[1]Geol. Surv., Canada, Rept. of Prog. 1877–78, pt. C, p. 4 (1879).
[2]Ont. Dept. of Mines, Ann. Rept., vol. XIII, p. 162 (1904).

There now remains a consideration of them as possible fuels. Analyses of the samples collected are given below, on a dry basis:

Sample No.	Ash	Vol. M.	F.C.	S.	N.	B.T.U.	Fuel ratio
6	52·1	34·3	13·6	0·3	....	....	0·40
7	35·1	44·6	20·3	0·3	1·2	6400	0·45
8	57·3	28·8	13·9	....	....	....	0·48
9	26·9	48·0	25·1	....	....	....	0·52
10	56·4	33·8	9·8	....	....	....	0·29
11	67·8	23·4	8·8	....	....	....	0·38
12	60·5	29·1	10·4	....	....	....	0·36
13	66·4	25·0	8·6	....	....	....	0·34
14	59·0	29·3	11·7	0·2	0·8	4060	0·40
15	52·7	31·6	15·7	....	....	....	0·50
16	20·3	54·3	25·4	0·3	....	8330	0·47

6. River bank, Missinaibi river, 6 miles above Soweska, 1 foot 0 inches thick.
7. Left bank Soweska river, 3¼ miles west of mouth, lower peat, 2 feet 2 inches.
8. Left bank Soweska river, 3¼ miles west of mouth, carbonaceous silt, 1 foot 2 inches.
9. Left bank Soweska river, 3¼ miles west of mouth, upper peat, 0 feet 3 inches.
10. Right bank Missinaibi river, ¾ mile below Soweska, upper impure peat, 1 foot 4 inches thick.
11. Right bank Missinaibi river, ¾ mile below Soweska, lower carbonaceous silt, 1 foot 3 inches thick.
12. Right bank Missinaibi river, ¾ mile below Soweska, lower impure peat, 1 foot 0 inches thick.
13. Right bank Missinaibi river, ¾ mile below Soweska, upper carbonaceous silt, 2 feet 4 inches thick.
14. Right bank Opazatika river, 5 miles above mouth, carbonaceous silt, 1 foot 7 inches thick.
15. Right bank Opazatika river, 5 miles above mouth, lower impure peat, 0 foot 6 inches thick.
16. Right bank Opazatika river, 5 miles above mouth, upper peat, 0 feet 10 inches thick.

It is evident from the above analyses of these layers that they are merely peats and not lignites, for their fuel ratios vary from 0·29 to 0·50. They have advanced little, or not at all, beyond the peat stage. No separate analyses were made of flattened tree trunks occasionally found in the peats. They show little alteration, except where stained brown or black, chiefly on the outside. Both the peat and carbonaceous silt have been compressed and somewhat indurated, and sticks and tree trunks have been flattened by the weight of the overlying drift of the later glaciation and probably also by the weight of the glacier itself. Otherwise, the peat beds have been little changed since their deposition and humification.

The samples analysed, both of peat and carbonaceous silt, are all high in ash, the lowest being 20·3 per cent and some over 50 per cent. The high ash is due to the presence of a large amount of silt in the form of very fine quartz grains, mostly below 0·05 mm. diameter. There is a gradation between what is here called peat through impure peat to carbonaceous silt. The moisture has not been determined.

In the deposit on Missinaibi river, 6 miles above the Soweska, the peat layer is only 1 foot thick and contains 52·1 per cent ash.

In the peat deposit at Ells bend on Soweska river the lower peat varies in thickness from 4 inches to 2 feet 2 inches in a distance of 800 feet; where sampled this peat layer has 35·1 per cent ash and a calorific value of 6,400 B.T.U. The overlying carbonaceous silt in the same length of exposure varies in thickness from 1 foot to 1 foot 2 inches, and where sampled contains 57·3 per cent ash. The upper peat layer is 3 inches thick and contains 26·9 per cent ash. The upper carbonaceous silt was not considered worth sampling. At this locality the overburden of boulder clay, clay, etc., is over 20 feet. One mile downstream, on the right bank, where the peat is again exposed, it is only 5 inches thick, showing a thinning downstream. Westward or upstream, Mackintosh Bell traced this deposit intermittently for 4 miles along the river. He found it to thicken and thin and vary considerably in quality. His measured sections include much that he qualified as "argillaceous," "impure," or "poor". The total thickness recorded by him varies commonly between 2 and 5 feet and probably includes what in the above recorded sections, 1 and 2, are called peat and carbonaceous silt. The ash in the analyses recorded by him varies from 10·88 to 31·04 in the undried samples. In spite of the continuity of this deposit, it is irregular in thickness, is not anywhere very thick, contains impure layers of carbonaceous silt, and even the best peat layers are not low in ash. The overburden is from 20 to 25 feet.

In the deposit on the right bank of Missinaibi river, below the Soweska (sections 8 and 9), the total thickness of impure peat and carbonaceous silt varies between 3 feet 1 inch and 5 feet in 200 feet of the best part. All of the section, however, is not exposed at any one place. The lower carbonaceous silt is 1 foot 3 inches thick and contains 67·8 per cent ash. The lower impure peat varies from 6+inches to 1 foot in the 200 feet and where sampled has 60·5 per cent ash. The upper carbonaceous silt varies from 1 foot 3 inches to 2 feet 4 inches and, where sampled, has 66·4 per cent ash. The upper impure peat varies from 1 foot 4 inches to 5 inches in thickness, but the top is eroded in both sections; where sampled the ash is 56·4 per cent. Five hundred feet upstream the entire deposit thins to 2 inches. The overburden of clay, boulder clay, etc., is more than 20 feet. At the time Robert Bell visited this locality 6 feet of deposit was exposed.[1] J. Mackintosh Bell[2] saw 3 feet 6 inches. The exposure was apparently best in Robert Bell's time and has been since obscured by slide. The deposit is irregular and the ash high.

The 9-inch bed of impure peat on the right bank of Opazatika river, 8 miles below Breakneck falls (section 3), is not important. Nor does the 9-inch bed on the left bank 5½ miles above the mouth (section 4) merit much consideration, although digging might reveal a better section.

The deposit on the right bank, about 5½ miles above the mouth of this river, is only a few inches thick at the upper end, where it is overlain by boulder clay. Downstream there is (section 5) 1 foot 7 inches of carbonaceous silt, containing 59 per cent ash and having a calorific value of 4060 B.T.U., overlain by 8 inches of peat and 8 inches of carbonaceous silt. Downstream 75 feet (section 6) there are two peat beds; the lower and 6-inch peat layer is impure, having 52·7 per cent ash; above this are 5 inches of carbonaceous silt and the upper peat layer, which is 10 inches thick, contains 20·3 per cent ash and has a calorific value of 8330 B.T.U.; at the top are 6 inches of carbonaceous silt. About 725 feet downstream and at the lower end of the exposure only 4 inches of peat remain and are overlain

[1]Geol. Surv., Canada, Rept. of Prog. 1877-78, pt. C, p. 44 (1879).
[2]Ont. Dept. of Mines, Ann. Rept., vol. XIII, p. 162 (1904).

by boulder clay. Although this deposit has one fairly good layer of peat it contains also impure layers, is not very thick, and is irregular. The overburden is about 35 feet.

The peat deposit on the left bank farther downstream and 3 miles above the mouth is 1 foot 4 inches thick, but includes much silt.

Although much of the peat in the deposits described above will burn, the greater part of it is high in ash. The deposits are irregular in thickness and are nowhere very thick. Moreover, they are merely peats and not lignites. The overburden is heavy in proportion to the thickness of the peat layers, 20 to 35 feet, so that stripping is not practical. Although at some time they may have a very restricted local use, they cannot be favourably regarded from the standpoint of large-scale mining.

LIMESTONE

A 25-foot cliff of limestone of the Abitibi River formation, on the left bank of Mattagami river at Grand rapids, was sampled, care being taken to include all beds. The sample gave the following analysis:

	Per cent
CaO	48·40
MgO	5·21
Insol	1·40
Fe_2O_3	0·36
Al_2O_3	0·04

This is a good limestone, which should be suitable for use in the pulp and other industries of northern Ontario. The insoluble matter is particularly low. Compared with analyses[1] of limestone obtained by breaking fragments from fossil specimens, collected on Abitibi river by E. M. Kindle, this is very similar. The MgO, however, is higher and the CaO, Fe_2O_3, and Al_2O_3 a little lower. But this sample is a general one, representing all kinds of limestone layers, whereas Malcolm's samples are selected, i.e., representative of the fossiliferous layers. They would naturally differ a little.

IRON ORE

No special study was made of the iron ore deposits at Grand rapids, as they have been described in previous reports. One of the small orebodies was sampled and gave the following analysis:

	Per cent
Fe	26·13
Insol	45·20

[1]Malcolm, W.: Geol. Surv., Canada, Sum. Rept. 1924, pt. C, p. 96 (1926).

APPENDIX: BOTANY OF THE INTERGLACIAL PEAT BEDS OF MOOSE RIVER BASIN[1]

By Vaino Auer

In the summer of 1926 McLearn collected, for the Geological Survey, Canada, a number of samples from the interglacial peat deposits of Soweska, Opazatika, and Missinaibi rivers, on James Bay slope. These samples were submitted to the writer, who was asked to determine their geobotanic nature. Sections of the deposits from which these samples were obtained are described in the foregoing report by McLearn.

FLORA

As the peat is partly indurated, much difficulty has been experienced in the separation of its plant constituents. Only in the less compacted peat has a satisfactory separation been effected. The results obtained, therefore, are not quantitatively accurate. Samples for study were treated with nitric acid, washed with a special washing apparatus, and all microscopical constituents separated and mounted on slides. Another method was particularly suitable for the preparation of tissue, pollen, leaf spores, etc.; the powdered peat was boiled in a solution of potassium hydroxide and mounted on slides with glycerine and distilled water. Siliceous samples were treated with hydrofluoric acid. By the use of the centrifuge the greatest possible concentration was obtained.

In section 1 at Ells bend on Soweska river, the lower peat layer contains *Hypnum*, twigs, pieces of wood (*Pinus*), and a considerable amount of silt. Recognizable parts of plants are *Salix* and *Carex*. There are also some interesting small, round, black, spherical bodies which are probably mushrooms, and are called, in the literature of peat geology, *Coenococcum geophilum*. Under the microscope pollen of *Picea* and *Pinus* (3 grains) was determined. An allochtonic origin is inferred. The upper peat layer contains, as megascopical constituents, only *Carex*, and as microscopical, only pollen grains of *Picea;* an allochtonic or limnaestic origin is inferred.

In section 2 at Ells bend the lower peat layer contains abundant *Hypnum*, twigs, pieces of wood, *Carex*, *Equisetum*, leaf fragments, stalks, probably of the family Umbellifera, *Sphagnum*, and some part of the stem of *Eriophorum*. Under the microscope pollen grains of *Picea* and spores of *Sphagnum* were observed. The flora of this peat layer is extraordinarily rich in species like those of present day flourishing bogs, overgrown with shrubs. In the upper peat layer only *Carex*, coal, and some twigs were seen and the microscope showed only pollen grains of *Pinus*.

In section 3 on Opazatika river the peat layer contains much silt and is of allochtonic origin. The peat layer in section 4 is similar.

In section 5 on Opazatika river the peat bed contains *Hypnum*, *Sphagnum*, *Eriophorum*, *Salix*, twigs, and pieces of wood (*Pinus*). A slide 8 by 8 mm. gave under the microscope: 20 pollen grains of *Pinus;* 60 of

[1]The original report, as received from Doctor Auer, has been considerably abbreviated and recast in the form presented. There has, however, been no reduction of the part dealing with the flora of the peat. Where possible the diction of the original manuscript has been preserved.

Picea; 2 of *Betula;* 2 of *Abies;* 2 of *Ericaceae;* and 2 spores of plants of the family *Polypodiaceae.* Thus there has been a luxuriant flora similar to that of northern bogs, especially those moistened by spring water.

In section 6 on the Opazatika the lower peat layer consists chiefly of pure lake-mud and the upper peat layer contains *Carex, Scheuchzeria,* and mud.

In section 7 on Missinaibi river the bottom layer has been a lake-mud, the sedimentary nature of which is obvious. Overlying it is a mixed peat in which are found *Hypnum,* a very large species of *Carex,* and twigs. The principal constituents seen under the microscope are pollen of *Picea;* pollen of *Pinus, Abies,* and *Ericaceae* are also present. There has evidently been a particularly luxuriant flora and an autochtonic or in situ origin is inferred. The mud shows that there has been an ancient lake which has been overgrown by a flourishing bog, advancing from its border.

In section 8, on Missinaibi river below Soweska river, the peat layer consists of *Hypnum* mixed with fine silt and pollen grains of *Picea.*

In section 9, on Missinaibi river below Soweska river, the lower peat consists of mud and much *Hypnum* detritus. The microscopical test shows per slide: pollen of *Picea* 50; of *Pinus* 10; *Abies* 1; and spores of Polypodiaceae 2. The upper peat layer consists also of mud and much *Hypnum* and the following pollen per slide: *Picea* 50; *Pinus* 4; and *Betula* 1.

INTERPRETATION

The compactness of the peat and the flattening of all wood fragments within it show that all the peat layers have been compressed and are much thinner now than originally. Most of the peat beds are of allochtonic origin and only in a few places can an autochtonic origin be inferred. That these deposits are largely the result of fluviatile processes is shown by the presence of beds of silt interbedded with them. A lower silt bed, where present, may indicate a flood period consequent upon the melting of the retiring ice; and the uppermost one a flood period consequent upon the approach of a new advance of ice. When the ice retired, because of increasing warmth, the waters subsided along the river channels and bogs began to grow. The composition of the peat shows that here and there small lakes arose in which mud accumulated and from whose borders bogs advanced by growth of *Hypnum* and particularly of *Sphagnum.* Other bogs were formed by osiers overgrown with *Carex.* Others consisted of a luxuriant growth of reed and grass, covered with *Picea* and *Pinus* (*Pinus Banksiana* ?) where certainly the influence of spring water was great. The oncoming of glacial conditions is marked by flooding along the river courses, silt is deposited on the bogs, and peat-bearing sediment is transported and deposited. Thus arose the silty layers that are between and upon the peat layers. Finally, the approaching continental ice-sheet buried all and in retreating left behind a thick morainic mass.

At the present time the pollen method, with some exceptions, is the most exact and reliable method of analysis. *Picea* pollen is the most common, *Pinus* pollen less common, and *Betula* and *Abies* pollen are rare.

Picea was undoubtedly the most important member of the flora and followed closely on the recession of the ice-field. Later came *Pinus* (*P. Banksiana* ?) and then *Betula*. *Abies* scarcely grew there at that time; the presence of its pollen is probably to be attributed to transportation by wind.

Particular attention should be directed to the unusual poverty of species, which, however, is quite in conformity with the northern situation. The conditions of interglacial time in this region were probably much like those of the present. Its duration was probably not great.

ON THE ORIGIN OF THE COPPER ORES OF ROUYN DISTRICT, QUEBEC

By H. C. Cooke

Illustration

In the spring of 1926 the writer was instructed to revise and complete the geologic mapping of the district north of Rouyn, Quebec, prior to reissuing the Opasatika and Duparquet map-sheets. Accordingly, an area extending from somewhat south of the town of Rouyn to the centre line of Duprat and Dufresnoy townships, and from Osisko and Dufault lakes to the Duprat-Montbray boundary, was examined in considerable detail. When the first mapping was done in 1922 this area was difficult of access and covered with dense bush. It is now traversed by numerous roads and trails, mining camps have been established at many points, and fire has removed the forest cover from the northern half. It was, consequently, possible to secure much information previously unavailable.

The general geology of the region was described in detail in 1922[1], and some revisions made in 1923[2] and 1925[3], so that it is unnecessary to discuss it here. Last summer, however, a number of observations were made bearing directly on the origin of the copper ores, and the possible extension of the copper-bearing field, which are worthy of immediate description.

In the report for 1925 certain facts were noted as indicating that the copper deposits might be genetically related to the granodiorite masses. Of these masses two are known, one around lake Dufault in Dufresnoy township, the other around Flavrian lake in Duprat and Boischatel townships. These masses were, therefore, studied with particular care.

The Dufault granodiorite mass is of very irregular outline, some 6 miles in greatest width from east to west, and about the same in length from north to south. On the west side the rock varies from diorite to very basic diorite. The most basic phases consist of about equal parts of greenish hornblende and labradorite feldspar, $Ab_{50}An_{50}$, with a few grains of quartz and magnetite and occasionally a little pyrite. Rock of this composition, however, forms a band only a few feet wide around the edge of the mass, and the average basic phase is composed of some 25 to 35 per cent of hornblende, 55 to 65 per cent of feldspar which varies in composition, in different specimens, from $Ab_{50}An_{50}$ to $Ab_{75}An_{25}$, and quartz varying in amount from a few grains up to perhaps 10 per cent. The texture is granitoid and moderately coarse, 2 to 3 mm. on the average, but very

[1]Cooke, H. C.: "Opasatika Map-area"; Geol. Surv., Canada, Sum. Rept. 1922, pt. D, p. 19.
[2]Cooke, H. C.: "Some Gold Deposits of Western Quebec"; Geol. Surv., Canada, Sum. Rept. 1923, pt. C I, p. 76.
[3]Cooke, H. C.: "Gold and Copper Deposits of Western Quebec"; Geol. Surv., Canada, Sum. Rept. 1925, pt. C, p. 28.

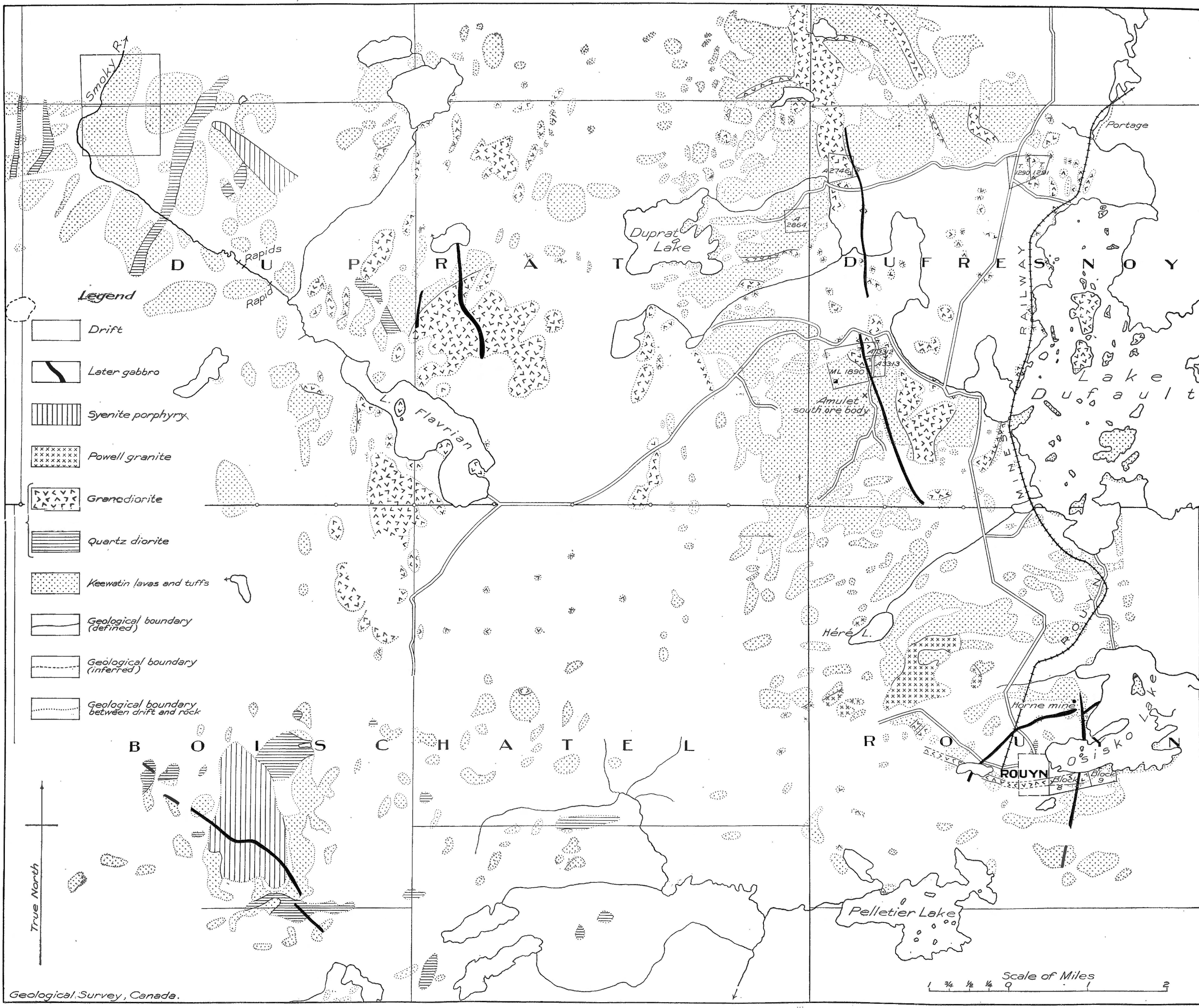

Figure 6. Geology of parts of Dufresnoy, Rouyn, Duprat, and Boischatel townships, northwestern Quebec. Many small rock outcrops that were observed are not represented.

coarse pegmatitic phases occur here and there with crystals up to 2 or 3 inches in length. The basic phase forms a border perhaps half a mile wide along the west side of the mass.

Toward the east the rock gradually becomes less hornblendic and more siliceous, finally passing into a highly siliceous granite. Unfortunately for purposes of accurate determination it is rather badly altered even in specimens taken from deep railway cuts. It can be observed, however, that the proportion of quartz increases to a maximum of about 40 per cent in specimens from the east side of lake Dufault, and that of hornblende correspondingly decreases to 1 or 2 per cent, represented by badly chloritized shreds. At the same time the feldspar changes in composition, becoming gradually more sodic until it is pure albite. The severe alteration made it impossible to determine, in the thin sections at the writer's disposal, whether any orthoclase is present in the more siliceous types, but it is probable that some is present as it is found in the acid parts of the Lake Flavrian mass.

These variations in composition suggested that the mass had differentiated after coming into its present position; and, as the west side is basic and the acid parts are to the east, that the mass might be flat and sill-like, dipping gently eastward. The conclusion was rendered more plausible from the fact that the granodiorite mass lies directly across the broad summit of an anticline in the Keewatin series, an area where the lava flows lie almost flat with a general slight dip to the east. Accordingly, careful attention was given to contacts between the granodiorite and the Keewatin, to obtain dips, if possible, by direct observation. It was found difficult to get such data, as the contacts are as a rule covered by drift even where outcrops are almost continuous; but in two places clean contacts were obtained. In the northeast corner of M.L. 1890, near where the Keewatin-granodiorite contact runs off into drift on the north, the contact where exposed for 50 or 60 feet dips east at an angle of 22 degrees. Again, in the northwest corner of the southwest quarter of Dufresnoy, and the northeast corner of claim A 2746, the dip is seen to be even lower, in the neighbourhood of 10 degrees, so that the trace of the outcrop (*See* Figure 6) swings around the corner of the hill to the northeast, changing direction from nearly north-south to east-southeast. Two facts indicate that to the east of this point the upper surface of the granodiorite must be almost flat. The contact follows the contour line at the junction of the high ridge on the north and the low swamp on the south as far as the Makamik road, then, still following the same contour line, swings north around the end of the hill. Such a relation between topography and outcrop is almost invariably characteristic of flat bedding. Again, in the area northwest of lake Dufault, there are numerous outcrops of Keewatin lavas dotting the granodiorite surface. These masses are bits of the original roof of the intrusive not yet completely removed by erosion; and as the topography here is low and flat, it is evident that the roof here must have likewise been flat and close above the present surface.

It may be concluded, therefore, that the Dufault granodiorite mass is a rather flat sill, dipping gently to the east in the western half of the area underlain by it. The writer did not study the eastern boundaries of the mass to determine the dip there, and must, therefore, confine himself to noting that there are two possibilities. The intrusive may reverse its dip on the east and thus form a saucer-shaped mass; or the eastward dip may continue so that the mass passes on the east beneath a cover of Keewatin rocks. In the first case the eastern part of the intrusive mass would be a broad band of basic diorite, as on the west; in the second, highly acid differentiates would be found right up to the contact, and the country rock would probably be highly silicified and recrystallized.

It is impossible to determine the thickness of the intrusive sill, as there are no data at hand from which the dip can be determined. In any case the dip undoubtedly varies a good deal from place to place, since, as already mentioned, the dip on the western edge is 20 to 25 degrees, passing to nearly flat for 1½ miles or 2 miles along the edge of the ridge northwest of lake Dufault. If the mass had a uniform dip of 5 degrees east over its whole width of 6 miles, the thickness would be approximately 3,000 feet; a figure which the writer is inclined to regard as probably greater than that of the real thickness.

A highly characteristic feature of the more basic parts of the granodiorite mass is a sort of acid veining. The rock is cut by numerous joints, the very narrow cracks now filled with some sort of vein material, and the rock for distances up to an inch on each side of the crack bleached to a lighter tint. This veining is so invariably present as to become a diagnostic feature of the rock; its importance will be discussed later in the report.

The granodiorite mass around Flavrian lake is of roughly oval shape, some 7 miles in length from north to south, and about 4½ miles in greatest width from east to west. At one point, south of Duprat lake, it is only three-quarters of a mile from the westernmost extension of the Dufault sill. The Flavrian mass differs from the Dufault sill in being composed almost entirely of highly siliceous granitic rocks, like the highly siliceous phases forming the central and eastern parts of the Dufault sill; and it was with difficulty that more basic phases were found, near Keewatin contacts, sufficient in number, size, composition, and in the gradational character of their relationships from basic to acid types, to convince the writer that the Flavrian mass is essentially the same rock as the Dufault body. The following description makes it clear that the two are essentially identical.

Two miles north of the Duprat-Boischatel boundary and a few chains west of the Duprat centre line running north and south, there is a prominent contact breccia composed of large fragments of Keewatin lavas and quartz diorite in a matrix of granodiorite. The fragments are sharp-angled and have clean-cut edges, entirely without evidences of digestion by the granodiorite. The granodiorite itself, however, is strongly chilled near the larger fragments over widths of 6 inches to a foot, and the chilled parts are much more basic than the parts farther away, into which they grade. Although the general body of the granodiorite is highly siliceous, the chilled parts near the contact resemble in composition and texture the basic parts of the Dufault sill. The chilled parts near the fragments, therefore, evidently represent the composition of the intrusive at the time it was first injected, as these were solidified immediately after intrusion and could, therefore, not alter their composition; whereas the still liquid parts were subjected to the differentiating processes and became more acid.

A thin section of one of the basic chilled parts near an inclusion consists of some 10 per cent of quartz, 30 per cent of greenish hornblende, a few flakes of biotite, and the remainder, feldspar about $Ab_{85}An_{15}$. The composition is thus identical with that of a moderately basic specimen from the Dufault sill. The acid material into which the basic passes within a few feet contains nearly 50 per cent of quartz, a few shreds of biotite, and about 50 per cent of badly sericitized feldspar, apparently all albite. In composition this rock is, therefore, very like the most siliceous specimen collected from the Dufault sill.

There is no wide basic edge exposed along any contact of the Flavrian mass, as in the case of the Dufault sill, and it is necessary, therefore, to conclude either that the mass is not a sill, or that if it is a sill it is very flat-lying and dips on all sides beneath a roof of Keewatin rocks. There is no way of determining whether or not the mass is a sill, although from analogy to the Dufault body it may be supposed to be sill-like; but the upper surface at least was certainly almost flat at the time of intrusion. This is indicated by the fact that a large remnant of the original roof, consisting of highly altered Keewatin rocks, extends almost completely across the middle of the mass, forming a hilly area whose general level is somewhat above that of the areas north and south; and also by the fact that on all sides, but particularly on the southeast, there is a wide belt of badly altered Keewatin rocks, suggesting the presence of the granodiorite not far beneath.

The alteration of the Keewatin rocks in the neighbourhood of the siliceous granodiorite has been severe, consisting of both recrystallization and addition of quartz and feldspar. Over large areas the Keewatin rocks have been converted into light grey to pure white, finely crystalline rocks, easily mistaken for the granodiorite itself by one who has not traced the alteration throughout its various stages. One diagnostic characteristic of the altered rocks, by which they can always be differentiated from the granodiorite, is the presence in them of numerous needle-like crystals of black hornblende, varying from one-eighth to one-half inch in length.

RELATIONS BETWEEN THE GRANODIORITE AND THE OLDER GABBRO

In former reports a rock was described, somewhat erroneously, under the name of older gabbro. The original description in the Summary Report for 1922, part D, reads as follows:

> "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 0·7 mm. diameter. The quartz is not secondary, as it also forms graphic intergrowths with the feldspar, which constitutes 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 rocks, 60 to 75 per cent, consists of greenish hornblende in crystals averaging 1 mm. in 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 name older gabbro, applied originally as a roughly descriptive field term, was, therefore, retained temporarily in the report until the primary nature of the hornblende could be definitely and finally determined. The examination of many more thin sections has made it evident that the above description is undoubtedly correct; and also that the feldspar, undetermined in 1922, is labradorite, about $Ab_{50}An_{50}$. The rock is, therefore, a quartz diorite rather than a gabbro, and in future this name, rather than older gabbro, will be applied to it.

The descriptions also show that the ordinary quartz diorite has essentially the same composition as the basic phases of the Dufault and Flavrian granodiorites. In addition there are other pronounced similarities. The quartz diorite, even in dykes, exhibits a tendency to differentiate readily; and thus forms segregations more siliceous than the average dyke matter, and identical in composition and texture with the more acid phases of the granodiorites. Many of these segregations are of the very coarse pegmatite, with hornblende crystals up to 2 or 3 inches in length, such as have been already mentioned in the description of the granodiorites. Again, the acid veining described on page 50 as characteristic of the basic phases of the granodiorite is also found almost universally in the quartz diorite. Petrographically, therefore, the two rocks are very closely related.

The age of the quartz diorite was fairly definitely determined in 1922 and later years as younger than the Keewatin and Timiskaming series, probably later than the great folding movement that deformed these series, and older than the syenite porphyry and the later gabbro, since both these intrusives cut it. Since the petrographic similarities suggest that the granodiorite may be identical with the quartz diorite, a careful search was made for data to fix the age of the granodiorite. The granodiorite was easily proved to be older than the later gabbro, since a large dyke of the gabbro cuts completely across the western side of the Dufault sill, and another runs through the central part of the Lake Flavrian mass. Syenite porphyry, unfortunately, is extremely rare in the area, and in spite of the fact that the granodiorite outcrops have been burnt clean and are excellently exposed, only one small dyke of it could be found. This dyke cuts the granodiorite on the south boundary of claim A 3312, about 6 chains east of post No. 3, and about three-quarters of a mile east of the Duprat-Dufresnoy boundary. It is 6 to 10 inches wide, strikes north 43 degrees east with a vertical dip, and is a dark grey rock weathering to a light grey. It is composed of numerous equidimensional phenocrysts of white feldspar up to 5 mm. in diameter, embedded in a microcrystalline, dark grey matrix. The microscope shows the phenocrysts to be too much altered for determination, but they probably consisted of albite or orthoclase and albite as they lie in a matrix composed of approximately 40 per cent chlorite and 60 per cent of a sodic feldspar very close to albite in composition. The porphyry is thus similar in composition to the grey syenite porphyries of the region, of which the Lake Fortune dykes are an example.

The granodiorite cuts the Keewatin series, but there is no indication of its relation to the Timiskaming. On Opasatika lake, however, there is a small sill described in the Summary Report for 1922 (page 50 D) under the name of amphibolite, the composition and differentiation of which is identical with that of the Dufault granodiorite. As no other rock in the region has the same composition or a similar differentiation, there can be little doubt that this is a small sill of granodiorite, the age of which is, therefore, post-Timiskaming. As nearly as can be determined, therefore, the ages of the granodiorite and the quartz diorite are nearly the same.

Some interesting relations were found northeast of Flavrian lake. The belt of altered Keewatin lava running across the granodiorite is cut by a thick, flat sill of quartz diorite striking northwest and dipping northeast at a low angle. At the southern contact the very siliceous granodiorite cuts off both the lavas and the quartz diorite, forming an intrusive breccia of large fragments of both in a granitic matrix. The quartz diorite is, hence, somewhat older than the siliceous granodiorite.

A wide dyke of quartz diorite runs through the bed of Noranda lake and eastward through Rouyn townsite to disappear under the bed of Osisko lake. Around Noranda lake and eastward to the townsite the dyke is bordered on the north side by a band of highly siliceous rock identical with the very acid type of the granodiorite. The contact between the two is never sharp, always gradational, and it was considered at first that the two bands might have been formed by differentiation in place. Toward the east end of the outcrop, however, the siliceous band leaves the north side of the dyke and cuts across it to the south side. The contacts are still gradational, although the gradation is rather rapid, taking place within 3 or 4 inches. It is evident, therefore, that the basic quartz diorite must have been intruded first, must have solidified, and then have been intruded by the acid material; but the gradational contacts indicate that the intrusions succeeded each other closely, and that the acid magma was injected before the basic rock was cold.

Attention may also be called to the dykes which radiate from the Dufault mass of granodiorite. Four of these, on the west, cut the lavas beneath the sill, whereas the one on the north cuts the lavas above the sill. All these dykes are of quartz diorite, and their arrangement suggests that they are all parts of the same magma. In every case, unfortunately, outcrops were absent near the critical point of junction between the dykes and the sill, so that it was impossible to prove by observation whether any break is present or not.

The facts cited, however, prove fairly definitely that there is a very close relationship between the quartz diorite and the granodiorite; in other words, that both types originated from the same underlying reservoir of fluid magma. The quartz diorite masses were apparently intruded first, the granodiorite a little later.

Large masses of quartz diorite are scattered throughout the whole area between Rouyn and the Interprovincial Boundary, and are also found east of Rouyn, though much more sparsely. If, therefore, it can be proved that the granodiorite is the source of the Rouyn copper ores, it is evident that other copper deposits might have been formed by the sub-surface differentiation of the underlying reservoir of magma, and hence that such deposits may be found anywhere within the region where the quartz diorite appears. That this conclusion is true is evident from the discoveries already reported from Montbray township. Thus the field of possibly productive prospecting is very greatly enlarged.

RELATIONSHIPS BETWEEN THE GRANODIORITE OR QUARTZ DIORITE AND THE COPPER ORES

In the Summary Report for 1925 a few facts were noted suggesting that the granodiorite was the source of the copper ores. A few more facts supporting this hypothesis were obtained during the field work of 1926, but the hypothesis must still be regarded as unproved until further work is done.

In the 1925 report attention was called to the spacing of the known ore-bodies around the margin of the intrusive mass. Today this is even more evident. The detailed mapping of the area shows that the Waite-Montgomery discovery, the four different discoveries on the Amulet property, and some minor discoveries to the south, are all spaced close to the boundary, and commonly less than half a mile from it. This summer's work also brings out the fact that these discoveries, which are all of heavy sulphides with little or none of the ordinary gangue materials, all lie *beneath the base of the intrusive sill,* a fact that the writer believes to be of significance.

Another type of deposit has been found in the large remnant of Keewatin roof overlying the central part of the Lake Flavrian granodiorite. One of the best examples is about half a mile northwest of the 2-mile post of the north-south centre line of Duprat, in the northwest corner of claim A 9626. It is a vein or lens varying from a few inches to 3 feet in width, and lying in a small fault. It strikes north 35 degrees east, and dips about 80 degrees south. The vein material consists of quartz and chalcopyrite in about equal parts, together with a little specularite and pyrite.

It will be noted that this vein differs from the Horne and other deposits to the east in two important particulars. The sulphides, pyrite, pyrrhotite, and sphalerite, which form so large a part of the eastern deposits, are almost entirely absent; and quartz, almost absent in the eastern deposits, here forms 50 per cent or more of the vein. Also, chalcopyrite, which in the eastern deposits appears to have come in somewhat later, replacing the other earlier-formed sulphides, is here deposited contemporaneously with the quartz.

A considerable number of veins of this type have been found east of the Flavrian mass in the southwest corner of Duprat township and the adjoining part of Dufresnoy township. They are all of the same type, rather narrow, filling fault fissures, and composed mainly of quartz and chalcopyrite in varying proportions.

It will be noted that all the veins of this second, quartz-chalcopyrite type, have been found *above and close to the highly siliceous top of the granodiorite mass;* whereas, as already mentioned, the heavy sulphide deposits lie stratigraphically beneath the basic bottom of the Dufault sill. Such relations strongly suggest the conclusion that the heavy sulphide bodies are basic segregations that separated in some way, perhaps by sinking, during the early stages of cooling of the magma; whereas the quartz-chalcopyrite veins represent the other end of the differentiation process, and were given off in the final stages of cooling, together with water and other volatile constituents.

Direct evidence that the diorite and granodiorite have given rise to the sulphide bodies is not plentiful as yet. In the Summary Report for 1925 it was mentioned that north of lake Dufault, in the northeast corner of claim No. T 1290, there are numerous fragments of glassy rhyolite in the granodiorite, and these fragments of rhyolite are filled with splashes of chalcopyrite, although the rhyolite a few feet farther from the contact contains no chalcopyrite. The only explanation for the presence of the chalcopyrite in the fragments thus seems to be that it was introduced by emanations from the cooling granodiorite.

Again, toward the east end of claim Block 9 on the south shore of Osisko lake, the acid granodiorite dyke that cuts across the basic diorite dyke is filled with a network of veinlets composed mainly of sulphides. A sample weighing 15 or 20 pounds was crushed and the sulphides separated and assayed. They contained 0·94 per cent of copper, so that the sulphides present consist of approximately 97·2 per cent pyrite and 2·8 per cent of chalcopyrite. The network of sulphide veinlets is entirely confined to the acid granodiorite, and hence it is difficult to avoid the conclusion that the sulphide is a product of the differentiation of the granodiorite.

Again, mention has been made of the acid veining universally characteristic of the quartz diorite and the basic parts of the granodiorite. A railway cut on the north side of the Horne property, claim Block 15, cuts through certain quartz diorite dykes, and makes it possible to see that at the centre of each such acid band is a narrow veinlet carrying a considerable amount of pyrite together with gangue minerals. The gangue minerals accompanying the pyrite are epidote with a certain amount of quartz and chlorite apparently secondary after hornblende. These veinlets occur so uniformly throughout the diorite and basic granodiorite that it seems necessary to conclude that they have formed by differentiation from the cooling magmas themselves.

These facts, therefore, all suggest that there is some close connexion existing between the sulphite bodies and the granodiorite-quartz diorite masses, but it is equally evident that much yet remains to be done toward working out the exact nature of this connexion and the conditions under which the different sulphides, pyrite, pyrrhotite, chalcopyrite, and sphalerite, respectively, are formed.

FIEDMONT AND DUBUISSON MAP-AREAS, ABITIBI COUNTY, QUEBEC

By W. F. James and J. B. Mawdsley

CONTENTS

Illustrations

INTRODUCTION

The following report deals with recent developments in the upper part of Harricanaw River basin, and is chiefly concerned with some of the mining properties which have been opened or further explored since the investigations of H. C. Cooke in 1923[1]. Although some other general geological information is included, the report does not contain a discussion of the geology of the Dubuisson and Fiedmont map-areas, geologically surveyed in 1926. The maps resulting from this geological survey are now in the course of preparation on a publication scale of 1 inch to 1 mile.

During the field season, the writers were assisted by Messrs. W. F. Baker, William Gerrie, S. H. Ross, J. A. Retty, G. F. Flaherty, J. Satterly, H. W. McGerrigle, D. G. Baird, and A. M. Bell, who rendered very efficient field assistance. To the numerous operators of properties within the map-areas, the writers are indebted for much courteous assistance.

The upper basin of Harricanaw river is reached by an excellent water route from Amos, on the Canadian National railway. At Amos, supplies of all sorts may be obtained. The water route permits the operation of small steamboats over a distance of about 70 miles above Amos. During part of the last season, a regular passenger and freight service was maintained between Amos and points upstream. At Amos, boats for private use may always be chartered without difficulty. Winter roads permit easy travel to most points within the area after the close of navigation. In the vicinity of the railway, settlement is fairly well advanced. Good roads lead to all localities in which farming is being carried on and in most of the villages automobiles may be hired. Small stores are located in Barraute

[1]Geol. Surv., Canada, Sum. Rept. 1923, pt. C.

and Landrienne villages. A considerable number of farms are now being worked in Landrienne and Barraute townships, and in Fiedmont township during the last year a number of new settlers followed the good roads into the areas more remote from the lake and main river. Farming suffers from early frosts, but the country should be well adapted to provide such

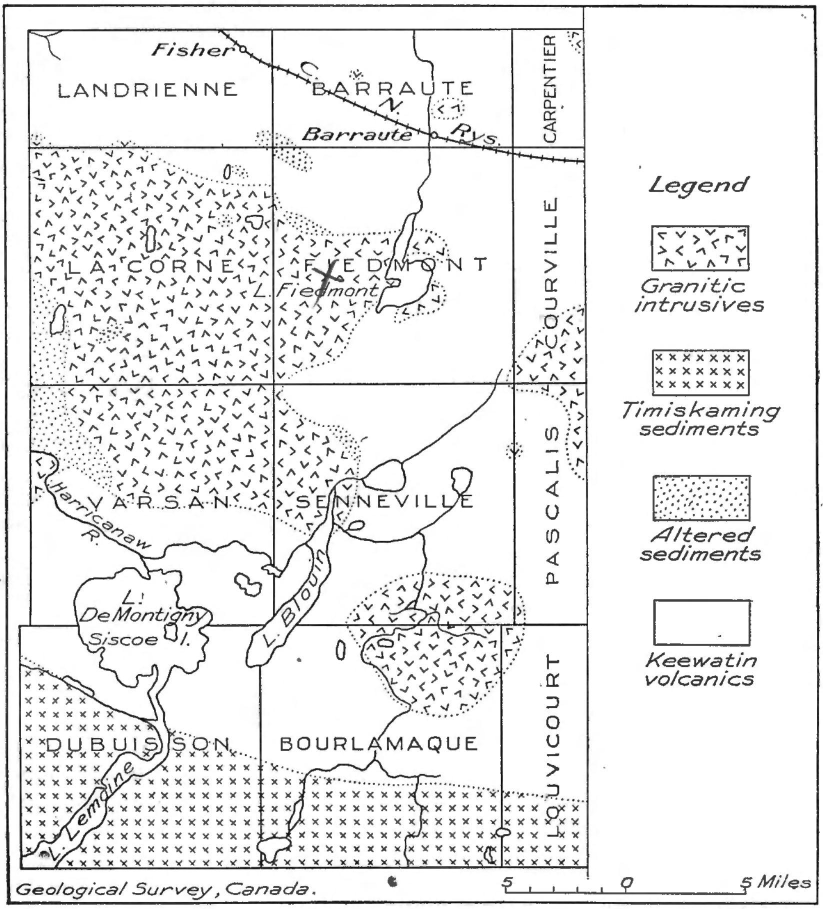

Figure 7. Sketch map of geology of Fiedmont and Dubuisson map-areas, Abitibi county, Quebec.

products as hay, potatoes, some of the hardy cereals, and, eventually, dairy products for which the new mining district of Rouyn would provide a convenient market.

Geologically, Fiedmont and Dubuisson map-areas are similar to those mapped to the west. The following are the areas in which outcrops are extremely few: Fiedmont, Carpentier, and Courville townships; Senneville township, except in the northwestern corner; the southern part of Varsan; the southern parts of Dubuisson and Louvicourt; and the western part of

Bourlamaque township. The sediments mapped as Timiskaming swing to the south, so that the greater part of the areas is underlain by Keewatin volcanics and intrusive bodies. Granite underlies almost the whole of LaCorne township, the northern part of Varsan, and the western part of Fiedmont, townships. Some molybdenite occurs in the western acid edge of this granite and in a small area of similar composition in the northeast of the mass. No molybdenite can be expected in the central part of the mass.

It was noted that molybdenite occurrences are associated with sheared sedimentary rocks within a pegmatitic phase of certain granite masses. Similar conditions were noted to the west in the vicinity of Kewagama lake. Most of these schist areas have been mapped, but other small areas may yet be found. It is suggested that prospecting for molybdenite be confined first to a search for pegmatitic granite which encloses such schist bodies, and then to close examination of such areas as may have been found.

An important geological feature is the presence of more basic intrusive masses, with the general composition of granodiorites. They occur in Dubuisson township and form large bodies in Bourlamaque township. The gold deposits in the vicinity of Demontigny lake appear to be connected in origin with the magma that produced these intrusives, and in Bourlamaque township the rather widespread occurrence of chalcopyrite near the borders of the main granodiorite mass gives reason for the expectation that copper deposits may be of importance in the locality. Prospecting for copper has not been given sufficient attention and it is thought that the locality merits further investigation.

The granodiorite outcropping on Bourlamaque river was found to extend eastward into Louvicourt and northward into Senneville and Pascalis townships, a mass about 6 miles from north to south and 7 miles from east to west. It is a coarse, granitic rock, pink to grey in colour, with prominent feldspar crystals and less prominent hornblendes, and marked in most localities by coarse, opalescent quartz eyes. Its contact with the Keewatin lavas that it intrudes is seen in very few places, but there is no doubt of its intrusive relations to the Keewatin volcanics. Near it and locally cutting it are narrow dykes of a porphyritic rock of nearly similar composition. These dykes, though obviously later than the granodiorite, were probably derived from the same magma, are considered to be of the same general age, and probably were localized by faulting that occurred during or following the intrusion of the granodiorite.

A magnetic attraction that may be of significance as indicating the presence of a magnetic mineral deposit, was noted in Senneville township. Compass lines run eastward from the west shore of Blouin lake, in the southern part of Senneville township, showed a tendency to converge to a point on the centre line of the township, about 1½ miles north of the southern boundary. The area just west of this point of convergence should be prospected with a dip-needle for the purpose of localizing the area underlain by the body responsible for the attraction. The presence of granodiorite intrusive into the greenstones in the vicinity renders it possible that such a deposit does occur. Outcrops in the general locality are scarce.

Prospecting in Harricanaw River basin began during the construction of the Canadian National railway through the district. Work on some gold discoveries in the vicinity of DeMontigny lake has gone on intermittently ever since, with the result that surface work has exposed large areas of bedrock on some of the properties; and complete mining equipment has been installed and considerable underground work performed on a few others. Work in the district was at its maximum during 1923 and since then relatively little has been done. During the winter of 1926-27 some underground work was done on the Siscoe property and plans have been made by various operators for further work on several of the properties.

Development work on the auriferous veins in Landrienne and Barraute townships has shown the presence of a fairly uniform type of mineralization over an extensive belt along the formational strike which is south of east. The country rocks are altered volcanics and in them shear zones and quartz veins occur. No large intrusive bodies occur within several miles of any of the now known deposits, though a number of dykes and small masses have been found. Areas of sheared zones and shatter zones are numerous. From the nature of the shearing and shattering, it is inferred that the present land surface is much higher than the underlying continuation of the upper surfaces of the large intrusive bodies exposed some miles away and hence that the veins may be expected to go to considerable depth. The saddle-like character of veins on some of the properties suggests that other veins may be found that do not outcrop. A feature quite commonly observed is that the dip of the veins is usually opposite to that of the shearing planes, though the strike of veins is about parallel to the shear planes. Ferruginous carbonate is one of the gangue minerals within the quartz veins and is evidenced in the country rock by a pronounced replacement of the original rock minerals near the veins. It appears that the rock alteration is due to the effect of the vein solutions. Pyrite and tourmaline are common vein minerals and chalcopyrite is also noted in many places. Free gold occurs on almost all properties in the district on which work has been done.

MINERAL DEPOSIT, LOTS 8 AND 9, RANGE 4, LANDRIENNE TOWNSHIP

The property, locally known as Mine d'Or Abitibi, was held at the time of examination in the name of Sinai Rousseau. The road from Landrienne runs close to the property. The areas of rock examined lie in the southern parts of lots 8 and 9, range IV, Landrienne township, just north of the cleared roadway along the line between ranges III and IV. The exposures consist of a series of whale-backed outcrops, most of which lie in lot 9, and which altogether lie within an area 400 feet by 500 feet, the exposed rock forming about 15 per cent of the surface. The largest single outcrop is about 250 feet by 75 feet. A small amount of stripping has been done and a shallow test-pit has been sunk on the northern margin of the largest outcrop. Much of the rock surface has been exposed by a fire which almost completely removed the vegetation.

The rock exposed consists of volcanic flows, chiefly andesites, but locally much altered by vein solutions. A slight shearing has been impressed on the rocks in a direction north 80 degrees east with a dip 60 degrees north. The northern part of the northwest outcrop reveals a width of 40 feet of carbonated andesite followed on the south by 50 feet of uncarbonated andesite which is succeeded to the south by a 300-foot wide band of carbonated volcanics disclosed by scattered outcrops. To the south of the larger band is another outcrop of uncarbonated rock. The strike of the boundaries between the two types of rock is about north 80 degrees east.

The chief area of mineralization is in the northern part of the 300-foot zone, and is exposed for about 350 feet from east to west and 80 feet from north to south. It is cut by a conjugate system of veins, ranging in width from ½ to 12 inches. The veins of the principal system vary in width from 2 to 5 inches, strike north 87 degrees east, and dip about 70 degrees north. The veins are regular, though slightly sinuous. A second system consists of contorted veins ½ to 12 inches wide which strike north 143 degrees east and dip 65 degrees east. A third system similar in width is composed of slightly sinuous veins that strike north 67 degrees east and dip 75 degrees north. In addition there is a large number of irregular stringers. The carbonated zone on the whole consists of from 7 per cent to 15 per cent of vein matter. All the veins are considered to be of practically the same age, though the contorted system designated as the second is cut by the other two systems and is, therefore, at least slightly older. This older vein system carries about 2 per cent of tourmaline in aggregates of needle-like crystals. Chlorite masses, a few inches in diameter, form 20 per cent to 30 per cent of the vein matter and reddish carbonates in small masses about 6 per cent. Pyrite and chalcopyrite in the proportion of 2 to 1, form about 1 per cent. The pyrite is in compact masses and the chalcopyrite in small, dendritic masses. Quartz is the other vein mineral.

In the other two vein systems mineralization is similar, except that chlorite and tourmaline are present in much smaller quantities, the chalcopyrite is in more rounded masses, and pyrite is scanty. Here again the sulphides form about 1 per cent of the vein material. The carbonated wall-rock in the vicinity of all the veins is mineralized with cubes of pyrite to about 5 per cent of its volume. Pyrite throughout the carbonated areas forms up to 2 per cent of the rock.

No values have yet been reported from the deposit. The mineralization is heavy and should the sulphides carry any considerable amount of gold the outlook for the property is good, since the extent of the mineralized area is large. No intrusive was noted close to the mineralized area, but the character of the mineralization suggests that an intrusive, probably acid in composition, cuts these older rocks but is hidden by the drift.

SULPHIDE ZONE, LOT 35, RANGE II, LANDRIENNE TOWNSHIP

In the northern part of range II, Landrienne township, in lots 32 and 35, a large outcrop rises 50 feet above the surrounding swamp and sand-plains. It is roughly circular, about half a mile in diameter, and it is composed of rhyolite and quartz porphyry flows which apparently strike east 40 degrees south and dip steeply north. The outcrop near its northern boundary is sheared in a direction of east 20 degrees south and dips 40 degrees north.

Four mineralized zones were seen in the northern part of the outcrop on lot 35. They follow the strike of the shearing and from north to south are 20 feet, 5 feet, 20 feet, and 40 feet, wide, respectively. The length of the zones is unknown, but is more than 200 feet. The country rock is sheared rhyolite. The shear zones contain little or no quartz in veins, but the rock is heavily mineralized with fine-grained pyrite. A few glassy quartz stringers were seen in the southern part of the outcrop. No acid intrusives were seen in the immediate vicinity, though it may well be that such an intrusive is present nearby under the extensive drift cover, and has produced the mineralization. The large granitic intrusion of LaCorne is about 2 miles to the south. As in the case of the mineral deposit on lots 8, 9, range IV, Landrienne township, if gold values are associated in quantity with the sulphides, mineralization is sufficiently heavy to indicate a workable deposit.

FISHER-QUEBEC PROSPECTING SYNDICATE PROPERTY, LANDRIENNE AND BARRAUTE TOWNSHIPS

The claims of the Fisher-Quebec Prospecting Syndicate, Limited, are located in the townships of Landrienne and Barraute. The following are the lots held in September, 1926:

Lot 54, range III, Landrienne tp., eastward to lot 9, Barraute tp.
Lot 48, range IV, Landrienne tp., eastward to lot 12, Barraute tp.
Lot 48, range V, Landrienne tp., eastward to lot 6, Barraute tp.
Lot 56, range VI, Landrienne tp., eastward to lot 2, Barraute tp.

The area held is thus 4 miles from north to south and at its greatest width about 4 miles from east to west.

Initial prospecting was begun in 1924 when large boulders of quartz carrying free gold were found on the property. Development work has been concentrated chiefly on lots 59 and 60, range V, Landrienne township. The work consists of shaft sinking, trenching, and diamond drilling. The shaft has reached a depth of 25 feet and is 7 feet by 9 feet. Diamond drilling to the present has amounted to about 2,000 feet. The trenching has exposed a considerable amount of rock. In some places the drift cover penetrated was 15 feet deep. The principal workings are in an area about 1,000 feet square on the western edge of a ridge largely covered with moraine and rising some 40 feet above the muskeg country that borders it on the north and west. The rock composing this outcrop is an equigranular dacite with a grain of 1 mm. The constituent minerals are 60 per cent oligoclase, 20 per cent quartz, and the remainder granular epidote, chlorite, carbonate, and pyrite which has a concentric structure and contains numerous inclusions of the rock minerals present in the dacite. Towards the north of the outcrop is a small exposure, several feet wide, of an acid carbonated volcanic which microscopic examination determined to be a tuff. It is fine grained and very high in quartz which occurs as larger grains in a fine groundmass, principally quartz.

Two zones of carbonated rock appear in the workings. The northernmost occurs in the northeast corner of the rock area and has been exposed for a length of about 50 feet, but passes beneath the drift cover in both directions. It has an approximately east-west strike. To the south of it is a width of about 300 feet of dacite that is little or not at all carbonated. The larger carbonated zone occurs south of the dacite and is at least 500 feet wide at the eastern edge of the workings. Towards the west it narrows rapidly to about 100 feet. These zones trend roughly east and west and in them the rock, now about 70 per cent carbonate with quartz, epidote, and pyrite grains, was evidently a dacite in which carbonate has completely replaced the feldspar. Within the larger carbonated mass are a number of shear zones with an east-west strike and a steep dip. They seem to be intensely sheared sections of larger zones that cannot be traced continuously across the property. The largest shear zone in the vicinity of the shaft is about 8 feet wide and within it are lenses and irregular bodies of quartz up to several feet wide and a few feet long connected by narrow stringers of quartz. The quartz carries large masses of chalcopyrite associated with pyrite. Carbonate is also a gangue mineral. The rock is intensely sheared near the edges of the quartz-bearing zone and east of it along its strike. The schist is said to carry good values in gold. Four other shear zones, narrower but similar in character, were noted in the altered dacite. In a few instances, flat-lying quartz veins, 3 inches to 12 inches wide, were noted. In the southern part of the rock area, in a rock cut, a vein forms a small saddle of which the north limb follows the schistosity and the south limb dips 35 degrees south and cuts the schistosity. As on other claims in the neighbourhood, the mineralization is later than the shearing, but tends to follow the strike, though not the dip, of the planes of shearing. The operators report values up to $14.46 in gold per ton over 3 feet of mineralized schist near the shaft, and up to $29.75 over 3·6 feet of mineralized quartz. A $50 assay is reported from a picked sample of chalcopyrite in the shaft and $27.10 per ton over a width of 2·5 feet in the bottom of the shaft.

The most easterly workings of the Syndicate are on lot 9, range III, Barraute township, just west of the Gillies workings and 1,000 feet south of the north boundary of the range. They consist of preliminary, irregular surface stripping and have disclosed areas of sheared carbonated greenstone. About 300 feet west of the east boundary of the lot is a quartz vein, designated as No. 9, which for the most part strikes and dips with the schistosity of the rock (north 15 degrees east, dip 55 degrees north), though locally it is oblique to the shearing. It has been exposed over a length of 30 feet and has a width of 10 inches to 3 feet. The vein quartz is glassy white and carries some pyrite and tourmaline. The wall-rock is highly carbonated andesite, with some pyrite mineralization. Free gold has been found in the vein. Ten feet to the south is a nearly flat-lying vein 6 inches wide. It strikes approximately north-south and dips about 10 degrees west. The vein is of glassy white quartz containing tourmaline, pyrite, and chalcopyrite. The foot-wall is slightly sheared and contains about 20 per cent of pyrite in coarse cubes. Good assays are reported from samples taken over a width of 2 feet.

Trenching in the northern parts of lots 55 and 56, range IV, has disclosed a number of quartz veins and mineralized areas. The rocks are basic volcanics, pillowed, amygdaloidal, and massive phases, cut by basaltic dykes and later porphyry. The whole area exposed is several hundred feet square, and is an area of shattering and mineralization. Shear zones and shattered zones are numerous, and adjacent to vein material the country rock has been greatly carbonated. The mineralization in these zones is presumably associated with the intrusive porphyry dykes, which are about parallel to the shearing and shattering that strike between 40 and 50 degrees south of east. The shape of the quartz masses corresponds to the shape of the shear or shatter zone in which they have been deposited. In one of the shear zones observed the vein varies in width from 3 inches to 16 inches and has fairly regular walls. Partings of tourmaline within the vein are parallel to the walls. In the same zone small, narrow stringers of quartz are parallel to the shearing. Several irregular quartz masses within shatter zones have been exposed by stripping and are from a few inches to 6 feet wide, though none has been traced for a length of more than 18 or 20 feet. A number of the masses are 3 to 4 feet wide. The quartz contains pyrite, some chalcopyrite and tourmaline, and iron-rich carbonate in good crystals. Carbonate has strongly impregnated the wall-rock near the quartz masses and has undoubtedly been an original constituent of the vein. It is reported that free gold has been found in some of these masses and that some good values have been shown by assays of the vein matter. One assay reported shows $10 a ton over a width of 3·5 feet of mineralized schist, and smaller values are said to occur in the quartz.

CONTINENTAL GOLD MINES, BARRAUTE TOWNSHIP

The claims of the Continental Gold Mines, Limited, are in Barraute township, range II. The lots on which the principal work has been done are numbers 8, 9, and 10. The country is quite low and the outcrops are low and flat, but over considerable areas the rock is covered by a relatively thin coating of drift. The area explored is about 1,500 feet square and sections between natural outcroppings have been exposed by a number of shallow trenches, aggregating more than 2,000 feet in length; most of the work has been concentrated on lot 9. The country rock is chiefly volcanics, with some acid dykes of rhyolitic composition that may be associated with the porphyry intrusions that occur in the general district, and some basic irregular dykes identical in composition and appearance with the andesite and basalt lava flows. In one locality adjacent to the largest vein the andesites are pillowed and associated with fragmental beds similar in mineral composition. The acid volcanics are rhyolitic, the bulk of them are acid porphyritic flows, but undoubtedly some of the more sheared and altered varieties are tuffaceous in origin.

The rocks are highly sheared in a general direction east 20 degrees south and dip 45 degrees north. About 80 per cent of the exposed rocks are carbonated, an alteration that has probably been contemporaneous with the injection of the quartz veins and other mineralization. The rhyolite seems to have been more extensively carbonated than the more basic volcanics. The intrusive acid dykes seem to have been little carbonated.

The veins are numerous, but most are small. The principal vein has been exposed for slightly more than 260 feet and strikes roughly east 20 degrees south and dips south across the dip of the shearing planes of the rocks, which have a parallel strike but a dip of about 35 degrees to the north. The vein is about 1 foot wide and at its western end forms a facing on the southern edge of the rock outcrop. It appears to have formed in a fault-plane parallel to the strike of the schist, but of opposite dip. A few cross stringers, 5 or 6 inches wide, extend from the vein into the country rock. The vein material is glassy white quartz, containing tourmaline, a small amount of pyrite, and some chloritized greenstone fragments. Values up to $27.50 are reported from assays of grab samples of the vein material. The wall-rock near the vein is highly carbonated and is mineralized with pyrite, some of it in cubes one-quarter inch in diameter. A short distance to the west is a 2-inch quartz-tourmaline vein that is almost flat and outcrops at intervals over an area of several hundred square feet. In the western trenches at least four veins are disclosed and range in width between 6 inches and 2 feet. These veins have been exposed only over short lengths, and from the work done, their full lengths have not been established. In addition there have been uncovered many small, narrow veins. Carbonate and sulphide mineralization on the walls of all these veins has been intense. High assays up to $127 have been reported from grab samples of vein matter and wall-rock taken at several points. Free gold is associated with some of the vein matter. None of the veins so far examined appears to constitute a deposit of workable size, but the mineralization is promising.

FOISIE CLAIM, BARRAUTE TOWNSHIP

The Foisie claim, now transferred to La Mine D'Or Venus, Ltée, consists of lots 13 and 14, range II, and lots 12, 13, 14, 15, in range I, Barraute township. The initial work on the property was begun early in the season of 1925.

The principal rock area lies about 1,000 feet south of the line between ranges II and III. The largest natural outcropping is on the northern edge of a ridge that is but thinly drift covered and on which a few natural outcrops and considerable stripping have exposed a large section of rock. The rocks are chiefly volcanics of medium to basic composition, in which some pillowing is developed. Shearing in a direction east 20 degrees south and dipping 60 degrees north has been impressed on the rocks that are locally carbonated. Some acid porphyritic rocks of doubtful origin occur within the greenstones, and are sheared to the same extent as the greenstones.

In all, seven veins were examined in the surface workings. The largest vein lies in the northern edge of the outcrop. It occurs in the form of a saddle with a strike of about east 20 degrees south, and pitches at about

15 degrees towards the east. The surface of the outcrop coincides practically with the top of the saddle, which has locally been truncated to show the north and south limbs with dip 45 degrees north and 45 degrees south, respectively. The thickness of the limbs is about 18 inches, but the crest in one place measures 4 feet. The vein has been exposed over a length of 60 feet to where, in the east, it pitches beneath the rock. The limbs diverge towards the west and their length has not been traced. The vein is composed of glassy white quartz containing tourmaline, ferruginous carbonate, pyrite, and chalcopyrite. The pyrite occurs in cubes up to one inch in size. Free gold occurs in association with the tourmaline and carbonate. The gold is very pale in colour. The country rock in the vicinity of the vein is highly carbonated and is mineralized to a considerable distance with coarse cubes of pyrite. Small quartz veinlets cut the country rock and adjacent to them have selvages of almost pure carbonate. Assay values of vein or wall-rock have not been reported. The vein has been trenched to a depth of 6 or 8 feet. South of the main vein a trench has been dug southward for about 500 feet. At 250 and 400 feet south of the main vein are two quartz veins striking with the shearing and dipping 45 degrees south, with widths of 3 and 6 inches respectively. Nearly 600 feet south of the main vein, two apparently intersecting veins occur. These have opposite dips and may be the limbs of a saddle vein similar to the main vein. The width of the veins is between 16 and 24 inches. Thirty feet farther south is another vein exposed for 60 feet. It is 14 inches thick at the western end, increasing to 3 feet in the central part, and pinching out toward the east. It strikes east 30 degrees south and dips 65 degrees south. Three hundred and fifty feet south of the last-mentioned vein are two veins striking south 20 degrees east and dipping steeply to the south. Each has a maximum width of 8 to 10 inches and the more northerly vein is exposed over a length of 30 feet. The composition of these smaller veins is in general similar to that of the main vein to the north, except that in them the proportion of ferruginous carbonate is higher. Tourmaline forms heavy masses in the vein. The mineralization of the wall-rock is similar to that observed elsewhere and there seems no doubt that the alteration of the rock is due to the action of the vein solutions.

Though considerable free gold occurs in the veins, no systematic assays have been reported. Mineralization within and near the main vein is heavy and merits investigation as a possible ore-body of economic proportions. It is significant that the veins on this property dip across the schistosity as on other properties nearby. The presence of the saddle vein suggests that other similar veins may be encountered at depth. The saddles are due to the influence of the shearing in providing for the vein solutions channels, other than the south-dipping fissures in which the veins usually lie. A series of steep, diamond-drill holes should yield considerable information concerning the nature of the mineralization of the veins at depth and would probably also indicate the presence of other veins which do not outcrop on the surface.

GILLIES CLAIM, BARRAUTE TOWNSHIP

Work on a claim on lot 10, range III, Barraute township, is being carried on by the Gillies interests. Stripping and trenching amount to about 350 feet and the workings lie north and south about 1,000 feet south of the northern boundary of lot 10. The workings at the time of examination were partly filled with water. The country rock in the trenches is greenstone, most of which is sheared parallel to a plane striking east 15 degrees south and dipping 55 degrees north. Some of the andesite shows poorly developed pillows. The rock is considerably altered to carbonate and in the vicinity of quartz veins carries large cubes of pyrite. About 800 feet north of the workings near the cabin is an outcrop of a quartz porphyry strongly sheared and similar to many seen along the railway in the vicinity. The rock is probably of volcanic origin, though its relations have not been clearly determined.

Three veins were exposed in the workings. At the north end of the property is a flat-lying vein 4 inches thick, with a slight dip towards the west. Thirty feet south is a 3-inch vein striking east and west and containing free gold; farther south again is a third vein 10 inches thick. The vein material consists of quartz, glassy white to colourless, containing pyrite, chalcopyrite, tourmaline, carbonate, and inclusions of chloritized country rock. It is reported that samples showed some values.

SISCOE GOLD MINES, LIMITED

(*See* Figure 8)

The claims of the Siscoe Mining Company comprise several hundred acres and are located on lake DeMontigny in Dubuisson and Varsan townships. The principal holding is Siscoe island, which is the largest island in DeMontigny lake and lies mostly in range X, Dubuisson township, but extends into range I, Varsan township. Some of the nearby islands are also held by the company, as well as lot 39, range I, Varsan township.

Gold was discovered on the northernmost claim, lot 39, range I, Varsan township, during the initial prospecting in 1911 and 1912, but gold showings on Siscoe island were not reported until three or four years later. For the development of the property, the Siscoe Mining Syndicate was formed and later the Siscoe Gold Mines, Limited. Extensive development work underground was done in the period beginning previous to 1919, and further work has since been done, chiefly in the way of extending the underground workings and in diamond drilling. Harricanaw river and a chain of large lakes provide an excellent water route to Amos, about 40 miles distant.

Work on Siscoe island consists of much surface stripping and trenching, most of which was done several years ago, a great deal of diamond drilling, the records of which were not available, shaft sinking, and underground work. Four shafts, called A, B, C, and D shafts, have been sunk and are located as shown on the accompanying plan (Figure 8). The principal shaft, D, is inclined about 57 degrees toward the east and reaches a vertical depth of about 75 feet. The shaft is equipped with a hoist, compressor, and other mining equipment. About 1,500 feet of underground workings have been cut and furnished with light tracking for a small tram. The A, C, and B shafts are vertical and 45, 100, and 30 feet deep respectively.

Siscoe island is flat and for the most part generally about 30 feet above the surface of the lake. It is formed chiefly of bedded lake clays, through which at intervals low, rounded knobs of rock protrude. At very

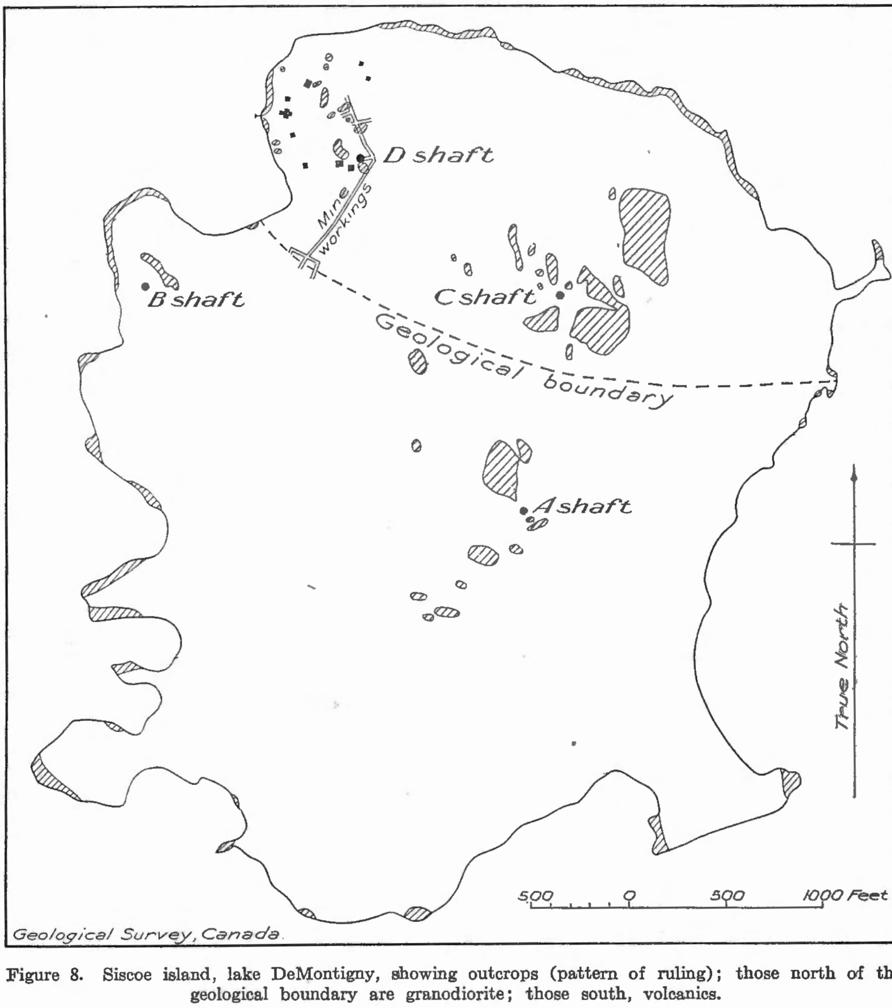

Figure 8. Siscoe island, lake DeMontigny, showing outcrops (pattern of ruling); those north of the geological boundary are granodiorite; those south, volcanics.

low water narrow outcrops appear at the water-line, but most of these are covered during periods of high water. The outcroppings form three main areas in the central and northern parts of the island, but in the whole form only a small percentage of its area. The southern part of the island is underlain by flows and tuffs of medium to basic composition. Locally small areas of the volcanics are intensely sheared. Pillow and other volcanic structures occur in many places. Some small, basic dykes, containing chlorite and serpentine, cut the lavas. The northern part of the island is underlain by a much altered intrusive mass presumably related to the granodiorite in the vicinity of lake DeMontigny. The contact of the intrusive does not appear on the surface of Siscoe island, but is to be seen on a small island to the northwest. Diamond drilling in 1926, at a point over the contact, disclosed beneath the clays that form the surface of the island a great depth of boulders, thus suggesting that a valley had been eroded in the rock surface along the line of the contact. The reason for such erosion is seen underground where a considerable area of sheared and altered rocks occurs in the contact area. The intrusive rock, as a whole, is much altered and replaced. Originally it must have been a granodiorite composed of orthoclase and albite-oligoclase, with some amphibole and biotite and large eyes of opalescent quartz. Local areas within the mass still retain some of the original characters, but the bulk of the rock has been replaced by carbonate and epidote, and according to Cooke's studies of some thin sections, in part at least by albite due to the action of the vein solutions. The ferromagnesian minerals have been largely replaced by chlorite. The grain varies from fairly fine to extremely coarse. The distribution of the coarse, opalescent quartz eyes seems to be irregular. The connexion between the intrusive and the masses of granodiorite to the east in Bourlamaque township is inferred from the occurrence of the opalescent quartz and the similarity of the feldspars.

All the rocks so far mentioned are cut by some dykes of feldspar porphyry, which attain a width of 15 feet locally. They are perhaps part of the same magma that produced the granodiorite, and only slightly later in age.

Within the volcanics and intrusives occur many veins which may be grouped into two classes. Those of the older set are small and close spaced in zones, a good example of which may be seen near the main or D shaft. Here, the veins are small, somewhat irregular, strike a few degrees east of north, and dip about 45 degrees to the east. They cannot be followed over any great length. The surface near D shaft is now largely covered by buildings and rock piles, but Bancroft in 1919 noted, within an area of 470 by 150 feet, a very large number of irregularly disposed small stringers. The stringers attain widths of 18 inches, but are generally much narrower. They contain white quartz and free gold with considerable tourmaline. The wall-rock is carbonated and carbonates occur within the vein. Some of these small veins carry only carbonates and tourmaline. The carbonate seems definitely to be of thermal origin. The veins of this type are roughly at right angles to the contact of the granodiorite and probably fill fissures that formed shortly after its intrusion. In the underground workings a large number of similar fissure veins are present. The inclined D shaft is now timbered, but it is reported that veins of this type appear in the walls and that the quartz and the adjacent country rock carry considerable sulphides and some free gold. Assaying indicates that gold is associated with these sulphides. A mill-run of about 8 tons of selected ore from this zone yielded over $39 a ton. Two large samples of rock from a lower part of the shaft yielded $2.50 and $1.85. Values have not been reported from small stringers forming a part of this zone, encountered in the lower workings, where the stringers, though of similar character, seem to be less numerous than on the surface and in the upper parts of the shaft.

These northerly striking stringers are cut on the surface by smaller stringers with a general east-west strike. The latter appear to fill fault fissures along which the older stringers have been slightly displaced. The material filling the later fissures is very rich in tourmaline. It comprises quartz, calcite, sulphides, and gold, but locally some of these veins are entirely of tourmaline. Cooke reports, also, albite as vein matter. The veins are mostly small, an inch or so wide. The veins of this sort are obviously later than the first-mentioned veins, since they lie in small faults that cut the older veins. Flat veins of this type occur on the surface and underground. The composition of the veins indicates that they are of the nature of pegmatitic emanations that began during the intrusion of the mass in which they lie. The presence of considerable carbonate in the vein solutions is reflected in the presence of calcite and other carbonates in the veins and in the strong carbonate alteration noted generally throughout the intrusive.

To the north of D shaft some old pits are now full of water, so that no adequate idea could be formed of a vein explored by these pits. At one place it seems to be about 4 feet wide, but is said to be 9 feet wide in a pit a short distance east. From the location of points designated by Mr. Siscoe, the vein has a strike of north 70 degrees east. The vein quartz is blue-grey and carries some pyrite, chalcopyrite, and free gold. A considerable fault with a strike almost parallel to that of the vein appears in the underground workings, but the connexion, if any, between vein and fault, is not known.

Near the north end of the D shaft underground workings, large veins are cut east and west of the main workings. West of the workings, at the end of a small crosscut, are a number of small, easterly-dipping quartz veins, and one vein about 2 feet thick. These veins belong to the class striking slightly east of north and dipping east. The country rock is fine-grained granodiorite, much altered and mineralized with pyrite cubes. The quartz is grey, glassy, and contains pyrite cubes. Tourmaline veins up to 3 inches thick cut veins and country rock. The latest fissures are less than one-half inch wide and filled with calcite or pyrite.

East of the main workings is an irregular drift following a vein about 2 feet thick. The general strike of the vein is about northeast, with a dip of about 60 degrees to the south. Near the eastern end of the drift the vein is cut off by a small fault whose plane strikes about north 70 degrees east and dips 73 degrees north. Later work is reported to have recovered the vein about 10 feet to the north of the drift. The vein cuts a fine-grained, silicified phase of the granodiorite, which carries pyrite in considerable amount. Good values are reported from the country rock where it is mineralized near the vein. The vein quartz is greyish and holds tourmaline and some pyrite. Free gold is said to have been noted during the work in the drift.

A vein, designated K, appears underground near the south end of the D-shaft workings. It lies within a zone of highly metamorphosed talc and chlorite schist near the contact of the intrusive and the volcanics, in a shear zone developed along the contact. On the accompanying sketch map (Figure 8) this contact zone is included within the boundary of the granodiorite mass. The dip of the vein is about vertical; and the strike, as measured by the direction of the drift, about east 27 degrees south. Where intersected by the main crosscut, it has a width of 2½ feet. Drifting has followed the vein in both directions from this point. In a southeast direction, the vein narrows within a length of 20 feet to a width of 1 foot, where it pinches out for a distance of 10 feet. It is again picked up on the same strike with a width of 4 inches, and in the remaining 40 feet of the drift attains a width of 16 inches. In a northwest direction from the main crosscut the drift follows the vein for a distance of 105 feet. West of the crosscut the vein narrows rapidly and in the face of the drift is 4 inches wide. On the southern wall of the drift, 20 feet from the face, another similar vein runs parallel to the K vein for about 40 feet. It varies in width from 3 to 9 inches. K vein is formed of glassy white quartz separated by thin seams of chloritic material into sections 1 to 2 inches wide, running parallel to the vein walls. Pyrite occurs in the white quartz, but seems to be chiefly associated with the chloritic partings. A very small amount of chalcopyrite occurs in fine fissures in the vein quartz. Some fragments of chloritized country rock occur within the vein. The country rock is the highly sheared talc and chlorite schist mentioned as being present near the contact of the dioritic intrusive and the volcanics. Near the vein the wall-rock is mineralized with coarse pyrite. Good values are reported from the vein and adjacent wall-rock, but it is not known over what widths the values occur.

Though no evidence of displacement has been detected, it appears that the band of highly altered schist is a shear zone developed in a contact fault. The vein may well be expected to be found intermittently along the length of the fault. In the crosscut to the south of K vein are found some zones of gouge and some slickensided surfaces that indicate very irregular crumpling and faulting. The intrusion of some dyke-like masses of feldspar porphyry seems to have been influenced by the lines of weakness provided by the faults.

The A vein located in the central part of the island cuts Keewatin volcanics. A vertical shaft (A shaft), reported to be 45 feet deep, has been sunk on the vein. The shaft was full of water when visited. The vein is visible on the surface for about 50 feet east of the shaft and strikes north 65 degrees east and dips 80 degrees south. It has a width of from 1 to 2 feet, is irregular, and encloses many fragments of greenstone. The vein matter is surgary quartz, with considerable coarse pyrite and tourmaline, and some chalcopyrite. The sulphide is confined chiefly to fissures in the vein quartz. This vein when sampled by Prof. Bell and Mr. J. A. Dresser showed an average value of $26.50 a ton over a width of 13 inches, the samples being taken at points 9 and 14 feet below the surface. In the shaft 34 feet below bedrock the vein has a width of 12 inches, and an indicated value of $2.80 a ton. As shown by a sample of a 9-inch width, the vein at 29 feet below surface showed values of $13.60 and $3.10 a ton.

B shaft, which was full of water at the time of the visit, has been sunk to a depth of 30 feet on a porphyry dyke adjacent to which is a 1-foot quartz vein. A sample of the dyke taken by J. A. Dresser gave 0·80 a ton in gold across 4½ feet; a sample of the country rock near the vein gave values of $2.40 a ton over a width of 4 feet.

An inclined shaft (C shaft), 100 feet deep, has been sunk on the C vein, following approximately the dip of the vein. At the time of examination of the property the shaft was full of water, but it is reported that work in the shaft has been begun. The vein cuts the coarse intrusive granodiorite, strikes a little east of north, and dips 35 degrees to the west. It probably belongs to the same group represented by the numerous small fissure veins in the vicinity of D shaft. The vein has been exposed for a length of 200 feet, is as a rule about a foot wide, and is said to be 22 inches wide at the foot of the shaft. The vein is marked by partings of tourmaline parallel to the vein walls. Sulphides are not present in any appreciable quantity. J. A. Bancroft who examined it in 1919 reports that free gold occurs in nests within the tourmaline. His sampling of the surface of the vein showed values ranging from 80 cents to $33 a ton across the width of the vein. A later complete sampling, by J. A. Dresser and John Bell, of the vein for the depth of the shaft, showed an average value of $17.50 over a width of 16·1 inches of vein material.

It seems probable that the tourmaline partings are contemporaneous with tourmaline stringers adjacent to the vein and those in the vicinity of D shaft. Cooke notes slickensided surfaces in the tourmaline fissures. Cross-fractures normal to the vein walls are filled with quartz and tourmaline.

On the strike of C vein, some 750 feet to the south, a similar white quartz vein outcrops, but occurs in the Keewatin volcanics. The vein is very short.

On the mainland north of Siscoe island a large mineralized zone has been disclosed by stripping on the lake shore on lot 39, range I, Varsan township. The country rock is a granite, somewhat porphyritic in habit, and mineralized with pyrite and carbonate. The "vein" is a zone 100 feet wide with a generally east-west strike. The occurrence lies just at lake-level and on the shoreward side is covered by a clay bank, so that very few feet of extension along the strike can be seen. Within the zone are numerous reticulated masses of glassy white quartz enclosing elongated masses of the granite. The quartz carries some pyrite, and a little free gold. Tourmaline within the quartz occurs in seams up to 3 inches wide parallel to the general strike of the zone. Small seams of carbonate locally form a selvage to the quartz masses; other veinlets are composed of tourmaline and carbonate, the carbonate being later than the tourmaline. Pyrite occurs also in the carbonate. Sufficient sampling to determine the extent of the gold values has not yet been done, though samples of small widths are said to carry good values.

The Siscoe property is of interest in that it shows quite definitely the relation of gold mineralization to the granodiorite intrusive which is of widespread occurrence in the district. There is, therefore, a possibility that zones of similar mineralization may be found in association with the intrusive, in addition to those discovered, which have already undergone some development. The present work on the Siscoe property has disclosed several small bodies of high-grade ore. The chief problems seem to be: the mining on a small scale of these high-grade sections without too much dilution of low-grade material or waste; and the economical treatment of the ore mined. If such work can be carried on profitably, there is the additional prospect that other ore-bodies may be discovered in the course of the work.

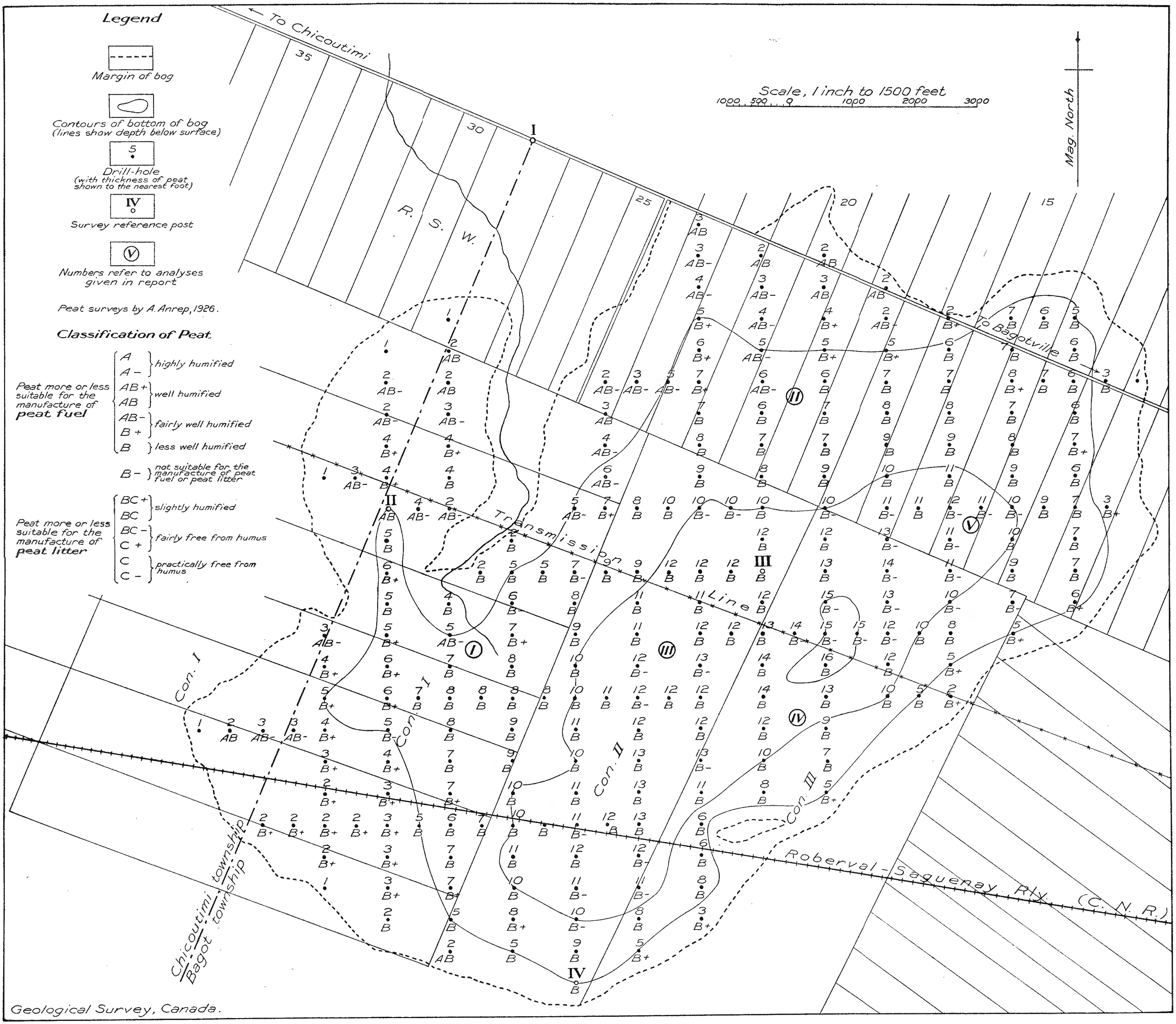

Figure 9. Chicoutimi peat fuel bog, Chicoutimi county, Quebec.

INVESTIGATION OF PEAT BOGS IN QUEBEC

By A. Anrep

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Illustrations

INTRODUCTION

Two peat bogs with a combined area of 4,098 acres were surveyed in the province of Quebec during 1926, to determine the area, depth, and qualities of peat contained in each. K. Keirstead acted very satisfactorily as field assistant.

A reconnaissance was made of areas following the headwaters of Lacolle river, about 9 miles southwest by road from Lacolle village. A few borings proved the peat bog to be shallow. Several other points were visited west of Richelieu river within a radius of 30 miles from Ile aux Noix, for instance, an area one mile south of Henrysburg and another 3 miles west of Hallerton, but drilling proved the various areas to be only shallow swamp lands.

CHICOUTIMI PEAT FUEL BOG[1]

(*See* Figure 9)

This bog is situated about 6½ miles southeast of Chicoutimi and about 4 miles northwest of Bagotville. The total area is approximately 2,748 acres. Of this area:

	Cubic yards
976 acres have a depth of less than 5 feet, with an average depth of 3 feet, and contain	4,724,000
1,114 acres have a depth of between 5 and 10 feet, with an average depth of 6 feet, and contain	10,784,000
640 acres have a depth of between 10 and 15 feet, with an average depth of 12 feet, and contain	12,390,000
18 acres have a depth of more than 15 feet, with an average depth of 15 feet, and contain	435,000

[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 fuel.

Excluding the acreage underlain by peat 5 feet or less in depth as not being of value commercially, and allowing 2 feet shrinkage in depth after draining, there is available:

	Tons
1,114 acres with an average depth of 4 feet, containing..............	718,900
640 acres with an average depth of 9 feet, containing..............	1,032,500
18 acres with an average depth of 13 feet, containing.............	37,800

The total tonnage is 1,789,200 tons, or 2,385,600 tons of peat fuel having 25 per cent moisture.

Analyses of Samples[1]

Sample	I		II		III		IV		V	
	R	D	R	D	R	D	R	D	R	D
Moisture........................	11·0	......	12·1	......	11·3	......	11·2	......	11·1	......
Ash............................	7·9	8·9	8·1	9·2	11·1	12·6	9·2	10·4	3·6	4·0
Volatile matter................	56·8	63·8	55·9	63·6	54·1	61·0	54·8	61·7	59·9	67·4
Fixed carbon...................	24·3	27·3	23·9	27·2	23·5	26·4	24·8	27·9	25·4	28·6
Sulphur[2]........................	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4	0·4
Nitrogen.......................	1·5	1·7	1·5	1·7	1·3	1·4	1·2	1·4	1·4	1·6
Calorific values in calories per gramme, gross..............	4800	5390	4600	5240	4580	5160	4640	5220	5070	5700
Calorific value in B.T.U. per lb., gross......................	8650	9710	8290	9430	8240	9280	8350	9400	9120	10260
Fuel ratio: fixed carbon to volatile matter.............	0·43		0·43		0·43		0·45		0·42	

[1]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.

[2]Average of the five samples.

The peat is fairly well humified, has high cohesive properties, is of a medium dark brown colour, and is fairly compact. It is well suited for the manufacture of machine peat fuel. The western part of the bog over a width of from 3,000 to 4,000 feet is rather shallow, but the peat is of a higher quality than elsewhere, as it is more humified and more compact. This section is too shallow for the manufacture of machine peat fuel, but could be utilized for the manufacture of hand-cut peat for local use. The remainder of the bog is deep enough for the manufacture of machine peat fuel, but the peat is lighter in texture, as the greater part of it is composed of sphagnum mosses intermixed with eriophorum, and it has a heavy surface growth of Labrador tea (*Lelum latifolium*), low-growing blueberry bushes, and various other plants.

The country surrounding the bog is level, and could be utilized as a drying ground. The surface of the bog is fairly level, with the exception of some sphagnum knolls. The whole surface of the bog is wooded with coniferous trees and rather heavily so towards the margin with spruce and alders.

The bog could be easily drained towards the north, as the country has a marked slope towards Saguenay river, 2½ miles north of the margin of the bog, and the area between the bog and the river is thoroughly drained.

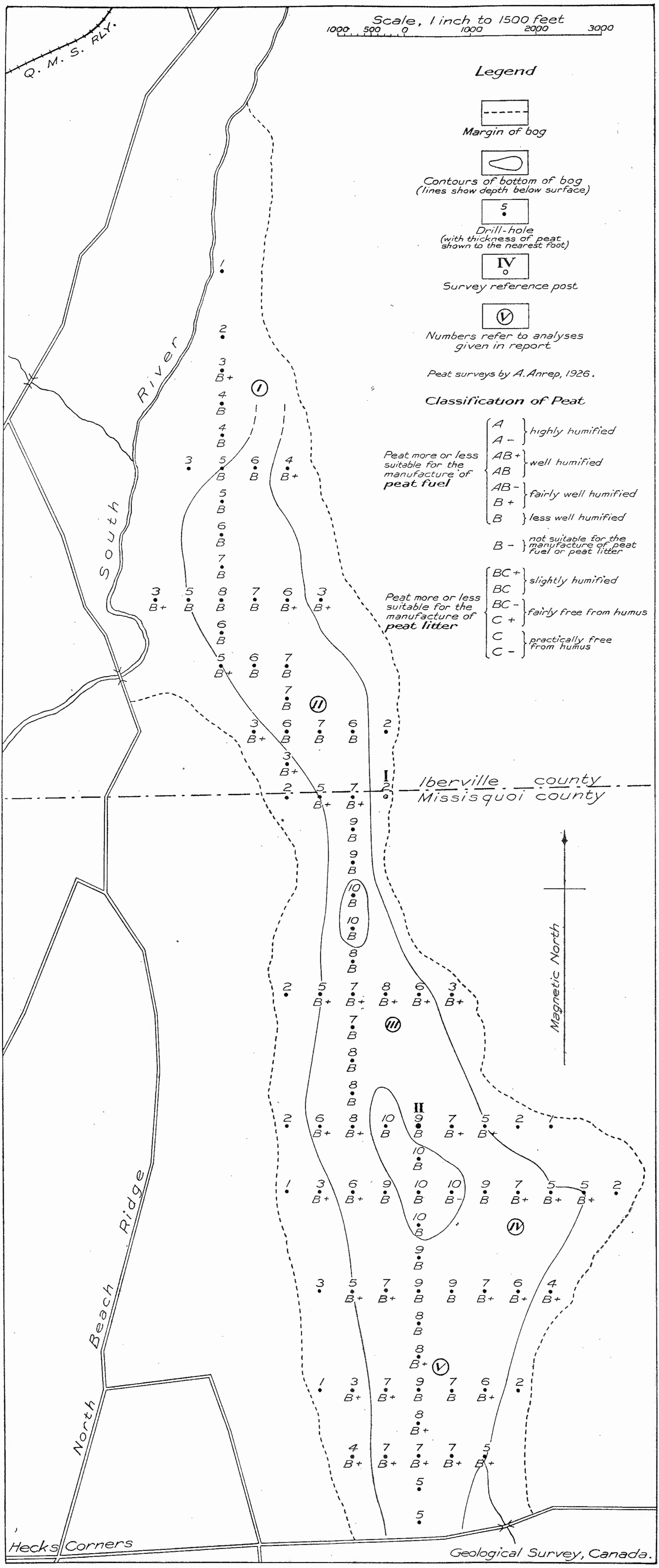

Figure 10. Part of Henryville peat bog, Iberville and Missisquoi counties, Quebec.

The peat is much intermixed with undecomposed stumps and roots which would, to a certain extent, prove a hindrance in excavating the peat. The bottom of the bog in places is composed of sand, but over most of the area is a brownish clay with large stones scattered over its surface.

This bog is very conveniently situated as regards markets. The southern part of the bog is traversed by the "Roberval and Saguenay" branch of the Canadian National railway and the bog is only a short distance from villages and towns with a combined population of between 70,000 and 80,000. Through the centre of the bog runs the Duke Price Power Company Transmission line which could easily supply power for the running of the machinery for the manufacture of peat fuel.

HENRYVILLE PEAT FUEL BOG

(*See* Figure 10)

This bog is situated about 2 miles south of Henryville station. Two parts of it remain unsurveyed, namely: a southwesterly projection along South river, and the southern part along Bloods creek.

The total area is approximately 1,350 acres. Of this area:

	Cubic yards
640 acres have a depth of less than 5 feet, with an average depth of 3 feet, and contain	3,098,000
660 acres have a depth of between 5 and 10 feet, with an average depth of 7 feet, and contain	7,454,000
50 acres have a depth of more than 10 feet, with an average depth of 10 feet, and contain	807,000

Excluding the acreage underlain by peat 5 feet or less in depth as not being of value commercially, and allowing 2 feet shrinkage in depth after drying, there is available:

	Tons
660 acres with an average depth of 5 feet, containing	532,400
50 acres with average depth of 8 feet, containing	64,500

The total tonnage is 596,900 tons, or 796,000 tons of peat fuel having 25 per cent moisture.

Analyses of Peat Samples

Sample	I		II		III		IV		V	
	R	D	R	D	R	D	R	D	R	D
Moisture	11·4	......	10·7	......	11·0	......	11·1	......	11·4	
Ash	6·7	7·5	6·2	7·0	6·5	7·3	6·6	7·4	5·2	5·9
Volatile matter	54·7	61·8	55·4	62·0	54·8	61·6	54·0	60·8	55·0	62·1
Fixed carbon	27·2	30·7	27·7	31·0	27·7	31·1	28·3	31·8	28·4	32·0
Sulphur[1]	0·5	0·6	0·5	0·6	0·5	0·6	0·5	0·6	0·5	0·6
Nitrogen	1·3	1·4	1·3	1·4	1·3	1·5	1·4	1·5	1·4	1·5
Calorific value in calories per gramme, gross	4710	5320	4790	5360	4750	5350	4740	5330	4820	5440
Calorific value in B.T.U. per lb., gross	8480	9570	8630	9650	8360	9630	8530	9600	8680	9800
Fuel ratio: fixed carbon to volatile matter	0·50		0·50		0·50		0·52		0·52	

[1]Average of the five samples.

The peat is fairly well humified, has fairly good cohesive properties, is of a medium dark brown colour, is light in texture, and is well suited for the manufacture of machine peat fuel.

The northern part of the bog is rather shallow and is gradually being put under cultivation. The remaining investigated part has a fairly satisfactory depth. The greater part of the bottom of the bog is composed of grey clay, with stumps of trees and roots resting on it.

This bog is very conveniently situated as regards markets. It is close to the Canadian National railway and lies in a thickly populated district which is void of forests.

The surface of the bog is level, but is overgrown with small birch and alder. Apparently fires have several times passed over the bog. It could be easily drained towards the south to Missisquoi bay.

MINERAL DEPOSITS IN NOVA SCOTIA AND NEW BRUNSWICK

By M. E. Wilson

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Illustrations

INTRODUCTION

The latter part of the field season of 1926 was spent by the writer in examining mines and mineral prospects in Nova Scotia and New Brunswick. The purpose of this investigation was to assist where possible in the development of each prospect or mine visited and to obtain the information necessary for a description of either the development work being performed or the entire property examined. The writer wishes to acknowledge his indebtedness to the owners and officials in charge of operations at the various properties, and to others for assistance given in making the examinations, and for plans of workings and other data placed at his disposal. Thanks are specially due to Mr. Norman Mackenzie, Deputy Minister of Mines and Works for Nova Scotia; Mr. J. P. Messervey, Deputy Inspector of Mines; Mr. R. E. G. Burroughs, Mr. J. W. Warner,

Manager, Consolidated Mines and Power Company, Goldenville; Mr. A. J. Oakes, Manager, and Mr. E. C. Henderson, Superintendent, Cochrane Hill Gold Mining Company; Mr. J. A. MacLellan, Manager, River Denys Sand and Clay Company; Mr. G. R. McLaren, Superintendent, Sterling Zinc Limited; Mr. A. L. Schneider, Manager, Bradford Mines, Limited, Tangier; Mr. E. S. Sweet, Superintendent, Oldham Mining Company, Oldham; Mr. A. W. Grant, Bridgeville, N.S.; Mr. W. E. McMullen, Department of Lands and Mines, Fredericton, N.B.; and Mr. J. D. Williamson, St. George, N.B.

NOVA SCOTIA

WAVERLEY SCHEELITE

This property is situated about 1 mile northwest of Waverley and 10 miles (14 miles by road) in a straight line north of Halifax. It has been under development since 1925 by E. S. Romilly Smith and associates. Alonzo Zwicker was in charge of operations at the time the writer examined the deposit. A mill was under construction. The rocks exposed in the property consist of interstratified beds of slate and arkose belonging to the Gold-bearing series. The beds vary in thickness from 1 to 18 inches, strike approximately east-west, and dip 75 degrees north.

The deposit consists of a vein of quartz and scheelite up to 8 inches wide, conforming to the strike and dip of the slate-arkose wall-rock. It is exposed in two shafts 140 feet apart and in an open-cut that has been opened practically the whole distance between the shafts. The east shaft, which was sunk many years ago in prospecting for gold, is said to be 35 feet deep. It was partly filled with water at the time the writer visited the property (August, 1926). The open-cut between the two shafts ranges in width from 3 to 5 feet and in depth from 4 to 8 feet. The vein lies along the north wall of the opening and is from 2 to 8 inches wide. The west or main shaft is inclined 80 degrees to the north. At the time of the writer's examination it was 42 feet deep. From the bottom of the shaft drifts had been driven about 35 feet to the east and west, and two crosscuts, one 10 feet north from the shaft and the other for 8 feet south from a point 10 feet east of the shaft. The vein is 3 to 4 inches wide in the east drift, but pinches out in the west. The crosscuts were being driven in the hope of intersecting parallel veins. The scheelite occurs scattered through the quartz in aggregates and zones up to 2 inches wide and several inches long. The other minerals observed to occur sparingly in the quartz are calcite and mispickel. It is difficult to estimate the proportion of scheelite in a deposit of this kind, but it is probable that the scheelite forms more than 1 per cent and less than 5 per cent of the vein material. A mill test would be necessary to determine the exact proportion of scheelite present. In estimating the value of this deposit the following data must be taken into consideration.

The vein has an average width of less than 6 inches, so that (if drifts 4 feet wide were driven on the vein) a width of 3½ feet or 7 tons of rock for every ton of vein material mined would have to be taken out.

Scheelite has a market value of about $3 a unit of tungsten trioxide, or $240 a ton at the mine.

It can be calculated, therefore, that the vein material has an average value of more than $3 and less than $15 a ton, or not more than $2 a ton of rock mined.

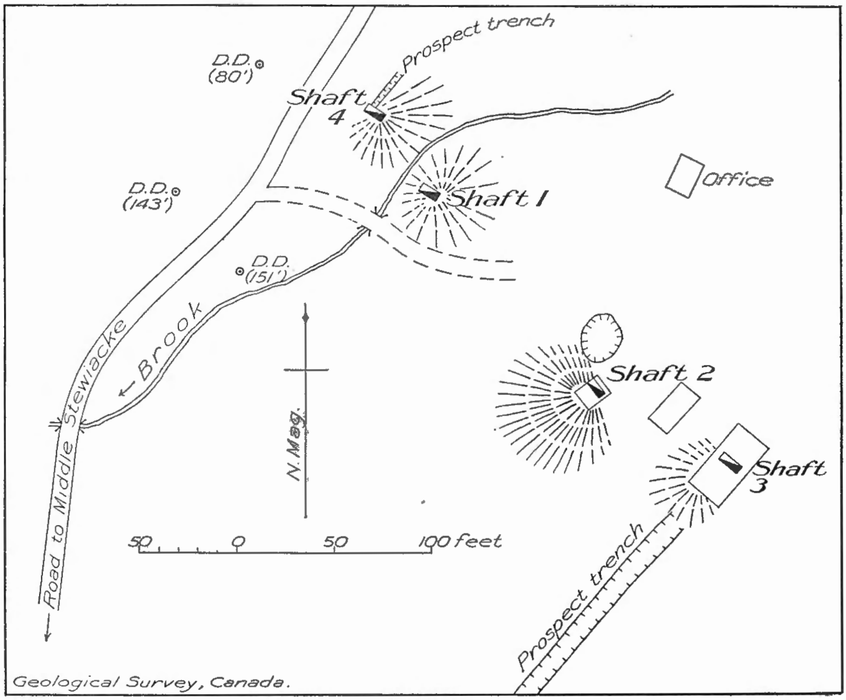

Figure 11. Surface plan of Leadvale galena-sphalerite property, Colchester county, Nova Scotia.

LEADVALE GALENA-SPHALERITE PROPERTY

(*See* Figures 11 and 12)

Location and History. This property is situated at Leadvale (formerly known as Smithfield) in Colchester county, about 12 miles southeast of Truro. It lies 9 miles in a straight line and 13 miles by road from Brookfield station on the Canadian National railway.

Development work on the deposit was begun in 1881 and continued at intervals to 1884. During this period shafts Nos. 1 and 2 were sunk and a small smelter constructed in which about 300 tons of ore were treated. During the winter of 1894-95 operations were resumed for about 6 months. At this time shafts Nos. 3 and 4, and three diamond-drill holes (Figure 11) were put down.[1] No further work was attempted until 1925, when Mr.

[1]Reports of Department of Mines, Nova Scotia, 1881, p. 14; 1882, p. 11; 1883, p. 24; and 1884, p. 34; and private report by Edwin Gilpin, jun.
Hardman, J. E.: "On the Occurrence of Galena at Smithfield, N.S."; Jour. Can. Min. Inst., vol. 1, pp. 215–219

R. E. G. Burroughs and associates obtained an option on the property and in 1926 dewatered the workings for the purpose of determining the extent and grade of the deposit. It was at this time that the property was examined by the writer.

Geology. No rock outcrops were observed anywhere near the openings, but development work has shown that the deposit occurs in grey limestone close to its contact with red, impure sandstone (Figure 12). The limestone, the ore deposit, and the sandstone for several feet from its contact with the limestone, have been very much broken, a condition indicating that faulting has occurred along the contact of the sandstone and limestone since the ore deposit was formed. The bedding of the sandstone, which appears to lie parallel to the contact of the limestone, trends north 55 degrees west magnetic and dips about 70 degrees south. According to Fletcher the limestone belongs to the Carboniferous and the sandstone to the Devonian. It has since been discovered by W. A. Bell that the sandstone contains fossils of the Horton series and, therefore, belongs to the lower or middle part of the Mississippian or Lower Carboniferous and that the limestone is Windsor and belongs to the Upper Mississippian.[1] The nearest outcrops to the deposit, seen by the writer, lie about 2,000 feet westward. The most southerly of these lie behind Mr. Lewis Fisher's house and consist of thin-bedded, blue-grey limestone striking east-west magnetic and dipping 40 degrees south. The limestone is considerably jointed and cut by seams of calcite, but is not cut by a fault. North of this point there is another outcrop of irregularly bedded limestone striking in the same direction and dipping 55 degrees south. Uniformly bedded sandstone hav-

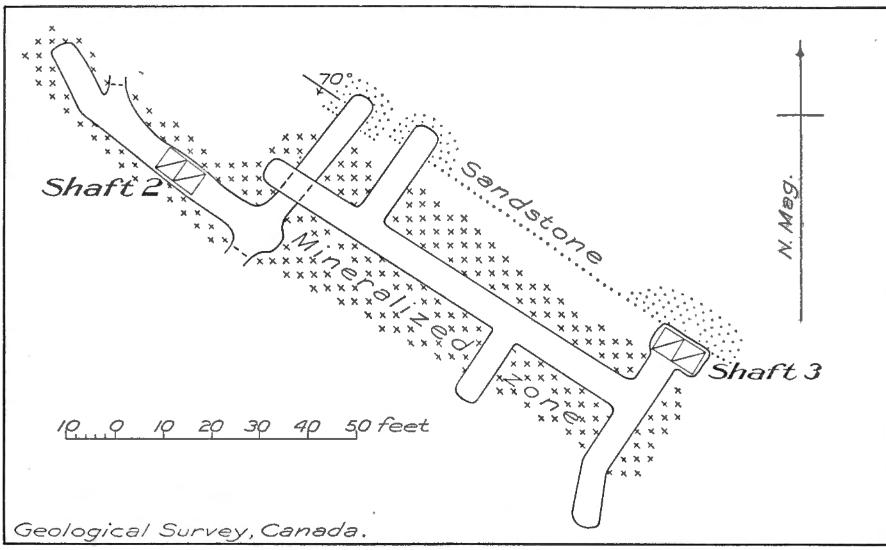

Figure 12. Plan of workings, Leadvale galena-sphalerite property, Colchester county, Nova Scotia.

[1]Personal communication.

ing the same strike and dip is exposed 35 feet north of this point. The contact hidden between these two exposures is presumably the same contact as that seen in the mine workings and is so indicated on Fletcher's map.[1]

Character of Deposit. The deposit as exposed in the shafts, drifts, and crosscuts is composed of angular blocks of ore and of grey limestone enclosed in a muddy matrix of finely broken ore and limestone. The ore masses consist chiefly of pyrite, and galena, with smaller proportions of sphalerite and calcite. The galena in the ore-blocks occurs in veins cutting the pyrite and as a matrix enclosing fragments of pyrite. The sphalerite and calcite occur as aggregates within the galena. The limestone forming the blocks within the breccia is a grey variety cut by numerous veinlets of calcite. The ore-breccia zone trends north 55 degrees west magnetic, is from 25 to 30 feet wide, and has a known length in the workings of 220 feet. It is stated, however, that ore was cut in a diamond-drill hole situated about 100 feet south of the No. 1 shaft, the most westerly shaft in which ore was found.

A number of samples, representing as nearly as could be obtained an average across widths of 4 to 5 feet, were taken from the faces of the drifts and the walls of the crosscuts for the purpose of determining, if possible, the approximate average grade of the deposit. Analyses and assays of these samples made by A. Sadler and R. J. Offord of the Mines Branch showed that they contained from a trace of silver and no lead and zinc, up to 0·28 ounce of silver a ton, 11·86 per cent of lead, and 4·23 per cent of zinc. The average was 0·08 ounce of silver a ton, 2·05 per cent of lead, and 0·88 per cent zinc. Gold was absent from all the samples. Twenty channel samples from the walls and faces of the drifts and from the walls of the crosscuts, taken by W. L. Goodwin, who examined the property previous to the writer, showed a similar variation in grade up to 26·69 per cent of lead, 0·34 ounce of silver a ton, and 10·62 per cent of zinc. The average was 0·14 ounce of silver a ton, 5·04 per cent of lead, and 3·51 per cent zinc. The difference in the average grade of the samples collected by the writer and those collected by Mr. Goodwin is probably due, for the most part, to the fact that the writer's samples were taken chiefly from the crosscuts, whereas Mr. Goodwin's samples were chiefly from the walls of the drifts. A sample taken by Mr. Goodwin across a width of 7 feet on the east wall of the westerly of the south crosscuts from No. 3 shaft (Figure 12) contained 8·48 per cent of lead, 0·42 per cent of zinc, and 0·17 ounce of silver a ton, whereas two samples taken by the writer across adjacent widths of 4 feet on the opposite side of the same crosscut contained, respectively, 0·54 and a trace of lead, 1·46 and no zinc, and 0·10 and a trace of silver. It is evident, therefore, that it is impossible to determine the average grade of ore in a deposit of this irregular character by the usual sampling methods. Nevertheless, the results of the assays indicate that the deposit is probably not of average workable grade throughout its whole extent, but that within the mineralized zone there may be a deposit at least 5 to 10 feet wide and containing 5 per cent of lead and 3 per cent of zinc.

[1]Geol. Surv., Canada, Map No. 636 (Truro Sheet).

Origin. Deposits of galena and sphalerite are thought to originate in two principal ways: either by downward concentration of lead and zinc, disseminated in rocks at the earth's surface, through the agency of meteoric waters or as emanations from intrusive igneous rocks. Deposits of the first class are believed to form by the weathering of limestone and other sediments containing disseminated lead and zinc-bearing minerals. The lead and zinc go into solution, are carried downward in the ground-water circulation, and are precipitated in the form of galena and sphalerite by the interaction of these descending waters with solutions containing hydrogen sulphide. Deposits of the second type are believed to be emanations from intrusive igneous rocks. They occur either within the intrusive itself or more commonly within the contact zone adjoining the intrusive.

In attempting to explain the origin of the Leadvale deposit it may be pointed out that no igneous rocks of post-Mississippian age are known to outcrop near the deposit, that galena and sphalerite also occur at the base of the Windsor limestone at Pembroke about 6 miles east, and at Gay River about 20 miles southwest of Leadvale, and that such a contact[1], especially where pyrite was present, would be a favourable locality for the meeting of descending acid solutions with solutions charged with hydrogen sulphide. On the other hand, the rocks in which the Leadvale deposit occurs are folded, a condition indicating that igneous rocks may be present nearby at depth. Moreover, basic lavas of Triassic age occur along the bay of Fundy less than 40 miles to the west; and in Cobequid mountains, about the same distance away, W. A. Bell has found the rocks of the Horton and Windsor series to be highly metamorphosed near outcrops of syenite, a relationship indicating that the syenite is intrusive into the Horton and Windsor series. It is possible, therefore, that the galena-sphalerite deposits of Leadvale were derived from deep-seated igneous intrusives. At present a definite conclusion regarding the mode of origin of this deposit is scarcely warranted.

Development Work. The development work performed on the property (Figures 11 and 12) includes four shafts having the following depths: No. 1, 30 feet; No. 2, 55 feet; No. 3, 40 feet; No. 4, 40 feet; and drifts and crosscuts from shafts Nos. 2 and 3 as shown in Figure 12. It is stated by Gilpin that there is also a crosscut extending for 40 feet south from shaft No. 1 in which there is ore for 30 feet. This was not examined by the writer. Three diamond-drill holes are said to have been drilled to depths of 80, 143, and 151 feet respectively, at the points indicated in Figure 11. It was in the hole between the road and creek that ore is said to have been cut at the bottom.

Possibilities. The data upon which an estimate of the possibilities of this property must be based have been previously stated. Briefly summarized they are as follows:

(1) A mass or zone of breccia containing blocks of high-grade galena-sphalerite ore is exposed in the mine workings for a width of 25 to 30 feet, and a length of 220 feet.

[1]Poole, Henry S.: "A Mineralized Zinc in Nova Scotia"; Jour. Can. Min. Inst., vol. I, pp. 221–231 (1896).

(2) The average grade of this zone is unknown, but the high-grade blocks are sufficiently numerous along the drifts to indicate that a deposit of ore of workable grade and width may be present within the larger zone.

(3) Ore is said to have been cut in a diamond-drill hole situated between the road and the creek at a depth of 151 feet, or at the point where the ore-body would occur if the deposit dipped about 60 degrees to the south.

It is probable that there was originally an unbroken deposit of high-grade ore present in this locality and that it has been shattered and mingled with blocks of limestone by deformation. Owing to the absence of rock outcrops no information could be obtained regarding the extent of the deposit beyond the workings or the fracturing to which it has been subjected, but if it maintains the grade of the material exposed in the drifts for a considerable distance, and especially if it passes out of the fracture zone or becomes less fractured and consequently becomes better defined and higher in grade it would almost certainly be workable. In any case the presence of the large masses of high-grade ore, up to 2 to 3 feet in diameter and ranging in composition from mingled pyrite, galena, and sphalerite, to pure galena, is sufficiently important to warrant the expenditure necessary to determine by diamond drilling or in other ways the extent of the deposit at depth and along the strike.

GAY RIVER GALENA-SPHALERITE DEPOSIT

About three-fourths of a mile south of Gay River, Halifax county, some pits in which galena and sphalerite occur have been opened in grey to buff Windsor (Mississippian, Carboniferous) limestone close to its contact with the Gold-bearing series. The limestone lies as a veneer of irregular thickness over the surface of the older series, with masses of the older rock protruding through in places. The galena and sphalerite occur in calcite aggregates or in irregular zones up to $\frac{1}{4}$ inch wide. They have no regularity, but occur more or less everywhere in small amounts. On the whole the proportion is small. Samples from one of the dumps collected by Mr. Burroughs contained $1\frac{1}{2}$ to 3 per cent lead, but this would represent a maximum rather than the average of the deposits. The known deposits exposed in the property, therefore, are not of workable grade under present market conditions. They are of interest, however, in that they occur at the base of the Windsor limestone, a relationship which is similar to that of a number of galena deposits in Nova Scotia and which possibly has some bearing on the origin of these deposits.

HIRSCHFIELD GALENA PROSPECT

(*See* Figure 13)

This deposit is situated on the south bank of the west branch of St. Mary river about 2 miles west of Glenelg post office, Guysborough county. It is said to have been discovered by David Smith in 1873 and was first worked in 1875 by Francis Zwicker who drove the main adit (Figure 13) to within 10 feet of its present termination. Since that time some additional development work has been performed by George Hirschfield. This includes the upper adit (about 15 feet higher than the lower) driven in 1904, and the extension of the main adit and the west drift, in 1925. The property is held at present under lease by Mr. Hirschfield.

The rocks in which the deposit occurs are interstratified, impure quartzite and slate belonging to the Gold-bearing series, and strike about east-west magnetic. They stand almost vertical at the entrance to the main adit, but elsewhere dip 75 degrees to the north. The galena occurs in two veins (Figure 13). The east vein trends about north-south mag-

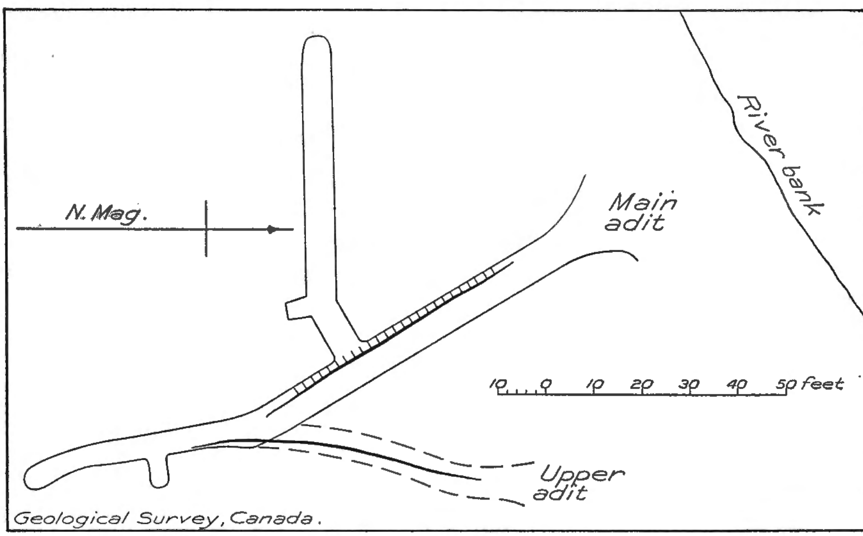

Figure 13. Plan of workings, Hirschfield prospect, Guysborough county, Nova Scotia. Veins are shown by heavy lines; and the fracture zone bordering the west vein by short parallel lines.

netic and has a maximum width of 6 inches. The west vein trends north 30 degrees west magnetic and has a maximum width of 8 inches, but is adjoined on its west side by a fracture zone up to $2\frac{1}{2}$ feet wide, in which there is considerable galena in places. According to assays made for Mr. Hirschfield the galena carries from 15 to 16 ounces of silver a ton of lead.

These deposits are obviously too small to be of much value, but they are important in so far as they may indicate the presence of more extensive deposits nearby. There are two factors that have a bearing on this possibility—the source of the galena and the presence of a large fracture or other opening in which galena could be deposited. The deposits as shown on the geological map[1] lie several hundred feet north of a dyke of granite which may be the source of the galena. On the other hand they are adjoined on the north by Carboniferous conglomerate resting unconformably on the Gold-bearing series, and numerous deposits of galena are

[1]No. 36. West River St. Mary, Geol. Surv., Canada.

known to occur in Nova Scotia along this contact. In the one case the possible continuation of the deposit might lie to the south and in the other to the north.

BOSTON-RICHARDSON GOLD MINE

This property at Goldboro in Guysborough county has been acquired by Mr. Max Gordon and associates. At the time of the writer's visit to the district in August, 1926, the tailings from the old workings were being retreated for the recovery of the gold-bearing mispickel that they contain, and some ore from a pile near a shaft at the south end of the property was

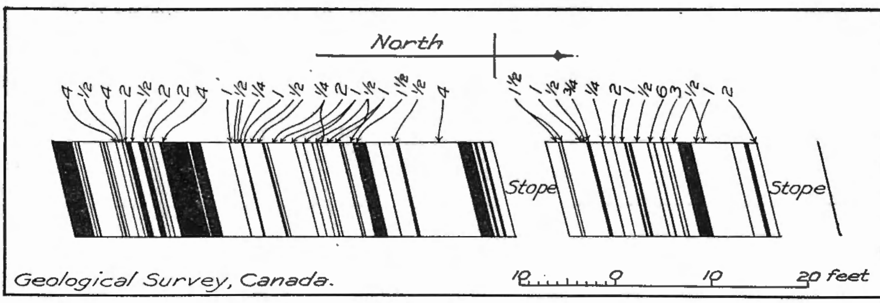

Figure 14. Cross-section of Mitchell belt, along crosscut reached from Main shaft, Cochrane Hill mine, Guysborough county, Nova Scotia. Slate shown in solid black; quartzite bands are blank. The position of each quartz vein is indicated by an arrowhead; the attached numbers are the thicknesses, in inches, of the veins.

being milled. The concentrates remaining on the property from previous operations had been hauled to the wharf at Goldboro for shipment. An average sample of these submitted to the Chemical Division of the Mines Branch was found to contain 0·5 ounce ($10) in gold and 22·01 per cent of arsenic.[1] Mr. E. S. Romilly Smith was manager, and Mr. R. F. Brison superintendent, of the property.

COCHRANE HILL

(*See* Figure 14)

The Cochrane Hill Gold Mining Company, Limited, of which A. J. Oakes is president and E. C. Henderson, superintendent, has renewed operations on the Mitchell belt near Cochrane Hill, Guysborough county. At the time the writer visited the property a 10-stamp mill was being constructed and the workings had been dewatered, but mining had not been undertaken. The Mitchell belt consists of a zone of numerous quartz veins and lenses up to 14 inches wide, intercalated in quartzite and slate as shown in Figure 14. Average samples across various widths up to 9 feet in this belt, according to Mr. Henderson, contained a few cents to $42.50 in gold, but in most cases $3 to $4 or less. Galena occurs in the veins in places, and at one point the quartz in the roof of the main drift was observed to contain

[1]Assay for gold by R. J. Offord.
Arsenic determination by A. Sadler.

coarse free gold. Free gold was also seen in mispickel in slate. A number of average samples were collected by the writer for assay, with the following results:

Locality	Description of sample	Gold, oz. per ton	Silver, oz. per ton	Arsenic, oz. per ton
East end of second drift south of shaft, total width 7 feet	Quartzite (whin) in face, total width 3 feet 3 inches	None	Trace	
	Slate in face, total width 3 feet 5 inches	0·04	0·04	0·36
	Quartz, 4 inches................	None	0·10	None
Northern part of east face of open-cut adjoining west shaft	Lens of quartz 14 inches wide...	None	Trace	None
	Average of slate: total width 2 feet 4 inches	Trace	0·08	0·47
Southern part of east face of open-cut adjoining west shaft	Average of slate and quartz: total width quartz, 6 inches; slate, 16 inches	Trace	0·3	1·21

Assays for gold and silver by R. J. Offord.
Determination of arsenic by A. Sadler.

The preceding data indicate that there is a certain amount of mineralization throughout the Mitchell belt and that in places high-grade ore is present, but that the distribution of the gold is too irregular for the average value of the ore-zone or zones to be determined by ordinary sampling methods. E. R. Faribault states in accordance with the theory that applies in most of the gold-bearing districts of Nova Scotia, that "in depth, the pay-shoots dip westerly, parallel with the pitch of the fold, and they probably also recur on the different adjacent veins, towards the north, in a plane parallel with the axis-plane of the fold which dips north at an angle of 68 degrees". It is possible, therefore, that the crosscut, and drifts adjacent to the crosscut, are in a pay-shoot, whereas the open-cut adjacent to the west shaft in which gold seems to be absent is in a barren part of the veins.

MCGRATH AND SUTHERLAND

This deposit, situated in the southwestern part of Forest Hill district, Guysborough county, was discovered by Robert Sutherland and John Mason about 1896. There are three shafts in the property, an old shaft about 40 feet deep sunk at the time the original discovery was made, and the O'Brien and McGrath shafts put down in 1907-08 and situated about 100 feet east of the old shaft. The southerly of these shafts, the O'Brien, was started by M. J. O'Brien under option, but the option was allowed to lapse and the work was taken up by Mr. McGrath who continued the O'Brien shaft to 25 feet, drove a crosscut from the O'Brien 25 feet north, and sunk the McGrath shaft 30 feet at the north end of the crosscut. At the time the writer visited the property, McGrath and Sutherland were engaged in sinking farther on the McGrath shaft.

The writer's examination was confined to the McGrath shaft and the upper part of the O'Brien. Both shafts are in a biotite-muscovite-garnet schist containing considerable disseminated mispickel. The schist strikes north 65 degrees east and dips steeply to the north. In the O'Brien shaft quartz veins from 2 to 16 inches wide are intercalated in the mica schist and form about one-third of the total width of 6½ feet. Average samples of the quartz and schist, assayed by R. J. Offord of the Mines Branch, were found to contain 0·07 ounce ($1.40) and no gold per ton respectively. In the McGrath shaft there is a quartz vein about 18 inches wide along the south wall, that in the bottom increases in width by overthrusting to over 4 feet. The north wall of the shaft coincides with the contact of the schist and a coarse muscovite granite that is foliated parallel the contact. A slickensided surface along which the mispickel has been smeared occurs in the schist close to the contact. An average sample assayed by Mr. Offord, of the quartz in the bottom of the shaft, contained no gold and only a trace of silver. The quartz on the dump from the McGrath shaft contains mispickel, pyrrhotite, and fine gold and galena in linear zones along cleavage planes the surfaces of which are covered with fine flakes of muscovite. The occurrence of this gold shows, as in the case of other properties, that the gold in the quartz is distributed too irregularly for the determination of its average content by the usual sampling methods.

GOLDENVILLE

The Consolidated Mines and Power Company, of which John W. Warner is manager, owns a large part of the "areas" at the west end of Goldenville district and is mining and milling ore from several belts at the 260-foot level on the Stewart shaft. The mill on the property was built with the intention of eventually putting 40 stamps in operation, but only 20 of these have been installed. The mill is also equipped with a Wilfley table for the concentration of the mispickel and other sulphides from the tailings. A sample of the concentrates from this table submitted to the Chemical Division of the Mines Branch[1] was found to contain 0·63 ounce of silver, 0·23 ounce ($4.60) a ton of gold, and 28·50 per cent of arsenic. If it be assumed that all of the gold is contained in the mispickel, this would be equivalent to $7.42 in gold for a concentrate of pure mispickel. During 1926, 6·797 tons of ore yielding 1·737 ounce and 10 pennyweights of gold[2], or an average of approximately $5 a ton of ore, were treated in the mill. Power for the operation of the mill is provided by an hydro-electric power plant on Liscomb river about 10 miles west of Goldenville, but without the construction of dams to provide storage the supply of water is insufficient to keep the plant in operation during the dry season of the year and consequently when the writer visited Goldenville in August and September, 1926, the mill was idle and the workings had been allowed to fill with water.

The plan of operation adopted by Mr. Warner in this property has been to mine belts of quartz and slate from 5 to 8 feet wide, thus pro-

[1]Analysis for arsenic by A. Sadler.
Assay for gold and silver by R. J. Offord.
[2]Rept. on Mines: Dept. of Pub. Works and Mines, Nova Scotia, 1926, p. 72.

ducing a large quantity of low-grade ore, but eliminating the cost of sorting. Since in the past the practice on these properties had been to mill only the quartz and to throw the slate and quartzite (whin) between the leads on the dumps, a number of samples of quartz, quartzite, and slate (which usually contains mispickel) were taken from the old dumps in order to determine, if possible, what amount of gold, if any, remained in these. It is probable that the gold is too irregularly distributed in the dumps for their average content of gold to be determined in this way, but the results, except in the case of a sample of quartz, were so consistently low that they suggest that the gold is largely confined to the quartz and this constitutes a very small proportion of the dumps. A mill test would be necessary to determine positively whether any of these contain sufficient gold to be profitably recovered in a mill. The determinations also showed that at least traces of silver are present even when gold is absent, and that the mispickel of the slate does not always carry gold.

TANGIER

(*See* Figure 15)

The Tangier Mines and Power Company is carrying on development work at Tangier and at the time the writer visited the district (September, 1926) had extended the north crosscut from the 340-foot level on the Kent shaft to a point 80 feet beyond the axis of the anticline. At the axis there is a breccia of slate and quartzite (whin) containing some lenticular masses of the quartz, probably the locus of a small fault. On opposite sides of this point the quartz veins are overthrust towards the axial plane of the anticline as shown in Figure 15. Mr. A. L. Schneider is manager of the company.

OLDHAM

The Oldham Mining Company is carrying on development work at a depth of 700 feet on the Sterling shaft at Oldham, under the direction of Mr. Charles Spearman. Mr. E. S. Sweet is superintendent. The pitching anticline with which the gold-bearing quartz veins at Oldham are associated, as shown on the detailed map of the district, is traversed close to its axial plane by an east-west trending fault. About 25 years ago a shaft, inclined 30 degrees to the east, was started on the Sterling lead near the south side of this fault and has been continued at intervals since that time to a depth of 1,900 feet. Mining from this shaft was carried along the lead up to its termination at the fault. In 1926 the present company dewatered the shaft as far as the 700-foot level and from the end of the north drift, which at that level is 30 feet north of the shaft, drove drifts east and west along the fault-plane. When the writer visited the property in September, these had been driven 382 feet to the west and 453 feet east, or a total distance of 835 feet.

A lead believed to be the Sterling was encountered on the north side of the drift at 412 feet east of the Sterling lead on the south side. This newly discovered lead had been followed for 25 feet across a minor fault to its termination against a second fault-plane. It consists of a crumpled quartz

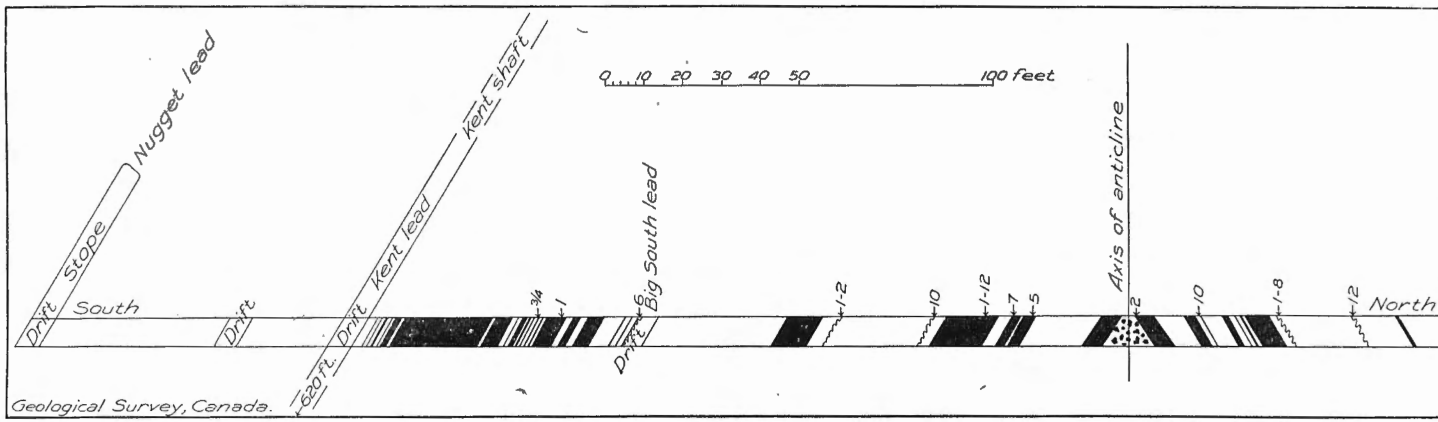

Figure 15. Cross-section of anticline, in crosscut at 340-foot level, Kent shaft, Tangier district, Halifax county, Nova Scotia. Slate is shown in solid black, quartzite (whin) is left blank, the brecciated slate and quartzite on the axis of the fold is represented by a pattern of dots. The positions and widths of quartz veins are indicated by arrowheads and attached figures giving widths in inches.

vein 6 inches wide lying between beds of massive whin containing some disseminated mispickel. There is a concentration of almost solid mispickel, 3 inches wide, on the upper side of the vein. The total width of the mineralized belt due to thickening of the quartz by crumpling and mispickel is about 1 foot. The quartz contains an abundance of free gold and probably contains at least as much gold as the average of 2·88 ounces a ton ($57.60) stated by E. R. Faribault to have been present in the Sterling ore-shoot on the south side of the axial fault.[1] At the point where the new lead meets the main fault it trends northeast and continues in this direction for 20 feet where it bends to the northwest. This indicates that the fault lies about 20 feet to the south of the axial plane of the anticline. The dip of the lead as in the case of all the other beds is to the east in conformity to the pitch of the anticline. Ten feet north of the main fault the lead is displaced 4 feet to the east along a minor fault and at 25 feet it terminates against a second fault along which the vein has been dragged downward, indicating that the continuation of the lead would be found to the west. Owing to the width of breccia along the main fault it is possible that all the leads meeting the fault have not been discovered. Those known to be present along the main drift are described in the following table.

Name of lead	Distance from entrance to drift from Sterling shaft	Direction from Sterling shaft	Side of drift	Character of deposit
	Feet			
Republican	184	West	South	Barrel quartz, width 3 inches, total width of quartz, 9 inches to 1 foot; quartz contains chalcopyrite
Logan (?)	209	West	North	Barrel quartz, width 4 inches; total width of quartz, 6 inches
(?)	38	East	North	Quartz aggregates and lenses; average width 1 inch
Vandergrift (?)	75	East	North	Leads of quartz up to 1 inch wide
North Wallace (?)	150	East	North	Veins up to 2 inches wide
(?)	190	East	North	Three quartz veins; total average thickness, 3 inches
Republican	230	East	North	Barrel quartz vein, containing sphalerite and galena; average width of vein, 3 inches; total width due to crumpling, 6 inches
Sterling	412	East	North	Barrel quartz vein, 6 inches wide. Total width of mineralized zone, 1 foot

[1]Guide Book No. 1, Geol. Surv., Canada, 1913, p. 194.

MOUNT UNIACKE

Some development work was performed during July and August, 1926, on the property of the Montreal Development Company in this district, under option by Dr. F. P. Temple and associates. At the time of the writer's visit, operations were being carried on at a depth of 150 feet on the Nuggetty lead from the shaft in area 814. According to the Annual Report on the Mines of Nova Scotia, for 1926, 8 tons of ore containing 1 ounce, 1 pennyweight of gold, or $2.71 a ton, were mined. Mr. J. A. Crease is superintendent for the Montreal Development Company.

SUMMARY

The following summarizes the writer's observations in the gold-bearing districts of Nova Scotia. Most, if not all, of them have been previously stated by Mr. Faribault and others, in numerous reports and papers, and in Memoir 32, compiled by Wyatt Malcolm. They are repeated here because of their importance or because some of them have been questioned in recent years.

(1) The gold-bearing veins are interstratified in the slate and quartzite (locally known as whin) of the Gold-bearing series, and occur chiefly in aggregates along the crests or domes of pitching anticlines. They are thus conformable with, and are related in their form and distribution to, the folding of the sediments. These relationships were seen especially well in Oldham district where the Sterling and other veins were being followed around the end of the pitching anticline, and at Tangier where a cross-cut has been driven across the anticline showing the veins in cross-section overthrust towards the crest of the anticline on opposite sides of the axial plane.

(2) The gold occurs in the quartz in shoots and is distributed so irregularly that its average value in most places cannot be accurately determined by channel sampling across the veins or belts.

(3) The gold is commonly associated with galena and in thin sections was seen with the galena filling fractures in the quartz.

(4) The minerals observed in the veins included: quartz, mispickel, pyrite, galena, pyrrhotite, chalcopyrite, rusty-weathering carbonate, calcite, scheelite, and feldspar.

(5) Assays of the mispickel associated with the gold-bearing leads show that this may or may not carry gold. When present the gold content may range from a few cents to $40 or more a ton.

(6) The deposits may be classified into two types: (a) single, narrow but very rich veins in barren wall-rock; (b) numerous thin leads interstratified with slate-forming belts which, taken as a whole, form a low-grade ore. The Sterling lead at Oldham is an example of the first type. Some of the belts in Goldenville district illustrate the second type.

NEW BRUNSWICK

DISCOVERY OF COPPER-BEARING MINERALS AT GOSHEN, ALBERT COUNTY

(*See* Figure 16)

In the autumn of 1925 a visitor to the farm of John B. Graves at Goshen pointed out to Mr. Graves that a boulder of conglomerate in a fence near his house contained the green carbonate of copper, malachite. Knowing that he had obtained this boulder on the hill-slope about 2,000 feet east of his house, Mr. Graves searched along a creek in this locality and succeeded in finding the malachite in place. He then obtained a mining lease of the territory adjoining his discovery and early in 1926 gave an

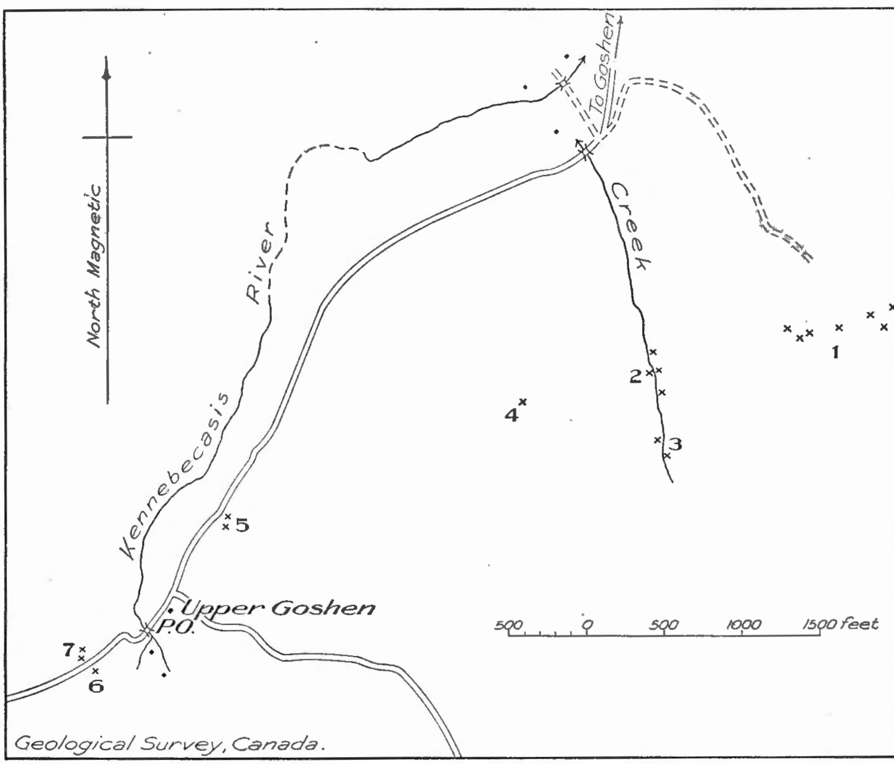

Figure 16. Plan showing prospect pits for copper near Goshen, Albert county, New Brunswick. Prospect pits and trenches are represented by crosses numbered as in text.

option on the property to Major Downer of Anagance who, in turn, transferred the option to N. A. Timmins of Montreal. In the spring of 1926 Mr. Timmins opened several prospect pits in the zone of conglomerate in which the copper occurs and then allowed the option to lapse.

Geology. The rocks occurring in this region, as described by W. J. Wright in the Moncton map-area, which lies a few miles to the east of Goshen,[1] belong to two groups: (1) a Pre-Carboniferous complex consisting of bedded volcanics, basic dykes of different ages, and batholiths of granite; and (2) a great thickness of sediments occurring in several series separated in some cases by unconformities, but all belonging to the Carboniferous (Mississippian and Pennsylvanian) system. The rocks of the second group are largely clastic and consist chiefly of sandstone and thick beds of conglomerate.

The rock in which the copper occurs at Goshen, except for irregular local zones of sandstone, consists of coarse, poorly sorted conglomerate containing pebbles of volcanics (chiefly andesite), felsite, and slate. There are few rock outcrops in the area and the extent of the conglomerate was not determined, but it occurs in a northeasterly trending belt and was observed for a width of at least 800 feet. Along the road south of Goshen to the east of the conglomerate belt, outcrops of volcanics belonging to the pre-Carboniferous complex were seen. It is uncertain to which of the several beds of Carboniferous conglomerate this conglomerate belongs, but it resembles most closely the basal conglomerate of the lowermost division, the Albert series.

Character of the Deposit. The deposits consist either of malachite or of malachite and chalcocite. The malachite occurs in thin films lying along the margins of the pebbles or filling fractures or other openings in the conglomerate. The chalcocite occurs in aggregates up to 1 inch in diameter distributed at intervals throughout zones up to 2 feet wide. The mineralized rock, except where the narrow zones of chalcocite occur, averages less than 1 per cent of copper and even in these restricted zones would carry little more than 1 per cent copper. A selected sample from pit 7 of the conglomerate, containing chalcocite, when assayed gave 2·95 copper and 0·16 ounce silver a ton. The chalcocite when pure, therefore, contains 4·32 ounces of silver a ton. The descriptions of the six openings or groups of openings examined (shown in Figure 16) are included in the following table:

[1] "Geology of Moncton Map-area"; Mem. 129, Geol. Surv., Canada (1922).

No.	Dimensions of pits	Character of deposit	Wall-rock	Remarks
1	Numerous pits up to 20 feet long, 8 feet wide, and 12 feet deep, and trenches to bedrock	Malachite here and there in western openings of group, average content of copper less than 1 per cent	Conglomerate including zones of sandstone	Conglomerate cut by fault in some pits
2	Excavation in face of slope 25 feet long and 20 feet wide. Prospect pits in drift nearby	Malachite and chalcocite here and there. Selected sample, about double average copper content of deposit, contained 1·88 per cent of copper	Conglomerate including irregular red sandstone zones	Sandstone appears to dip 25 degrees to west
3	Excavation to bedrock 30 feet long up to 20 feet wide	Malachite and a very little chalcocite in places	Conglomerate with sandy zones	Opening in bed of creek
4	Pit 30 feet long up to 10 feet wide and 10 feet deep	A small amount of malachite in spots	Conglomerate	A mass of grey and red clay in bottom apparently filling a cavern
5	Shallow prospect pits in glacial drift		Not exposed	
6	Pit 5 feet long and 5 feet wide, with a face 4 feet high in slope on roadside	Malachite chiefly occurs in a zone 2 feet wide. Average copper content 0·35 per cent	Conglomerate with irregular red and grey sandstone zones	Strike of sandstone north 40 degrees east magnetic, dip 60 degrees northwest
7	Opening 40 feet long in hill-slope, face 10 to 15 feet high	Malachite and chalcocite in conglomerate. Chalcocite chiefly in a zone 2 feet wide	Conglomerate and sandstone, a stratified zone of grey sandstone 8 inches thick	Strike north 45 degrees east, dip 70 degrees northwest

Origin. Deposits of malachite and chalcocite similar to those of Goshen are very common in the Carboniferous and Permian conglomerates and sandstones of Nova Scotia and New Brunswick. The known occurrences and the references to their descriptions are included in the following table:

Locality	Reference
Nova Scotia	
Cape Breton county: Irish Cove, and East Bay.	Fletcher, Hugh: Geol. Surv., Canada, Rept. of Prog. 1876–7, pp. 450–451.
Victoria county: Wasahaback, North River, and Middle River	Fletcher, Hugh: Geol. Surv., Canada, Rept. of Prog. 1876–7, pp. 450–451.
Antigonish county: Pomquet forks, Brierly Brook, Addington Forks, and St. Joseph	Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. I, pt. A, p. 23 (1886).
Antigonish county: Clydesdale................	Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, p. 74 (1887).
Pictou county: Knoydart brook................	Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept., vol. II, pt. P, p. 85 (1887).
Pictou county: Cariboo........................	Gesner, Abraham: "The Industrial Resources of Nova Scotia", Halifax, 1849.
Pictou county: Durham, Millbrook, Hopewell, river John, Plainfield brook, Scotsburn, and Toney river	Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept., vol. V, pt. P, pp. 185–6 (1893).
Colchester county: Tatamagouche.............	Gesner, Abraham: "The Industrial Resources of Nova Scotia", Halifax, 1849.
French River, Waugh River....................	Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. I, pt. E, pp. 14 and 41 (1886).
Colchester county: Wentworth Centre..........	Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept., vol. XV, pt. AA, p. 167 (1907).
Cumberland county: Malagash point...........	Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. I, pt. A, p. 21 (1886).
Cumberland county: between Maccan and Nappan	Fletcher, Hugh: Geol Surv., Canada, vol. X, pt. A, p. 101 (1899).
Cumberland county: Pugwash River...........	Fletcher, Hugh: Geol. Surv., Canada, Ann. Rept., vol. XV, pt. AA, p. 166 (1907).
New Brunswick	
Albert county: Cape Enragé, and New Horton..	Ells, R. W.: Geol. Surv., Canada, Ann. Rept., vol. I, pt. E, p. 21 (1886).
Westmorland county: Dorchester, and Maringouin peninsula	Ells, R. W.: Geol. Surv., Canada, Rept. of Prog. 1877–78, pt. D, p. 12.
Gloucester county: Bathurst....................	Ells, R. W.: Geol. Surv., Canada, Rept. of Prog. 1879–80, pt. D, p. 8.

In most of the descriptions of these deposits the association of the copper with coal or lignite is noted, and in some cases it is stated that the chalcocite is found to replace the roots or trunk of a tree.[1]

There are two obvious ways in which the chalcocite of these deposits could be formed: (1) by the solution of disseminated copper-bearing minerals in meteoric waters percolating through the conglomerate or adjacent rocks and the reprecipitation of the copper as chalcocite; or (2) by the precipitation of chalcocite from emanations ascending from deep-seated igneous intrusives.

The first of these hypotheses was proposed by J. W. Dawson[2] to explain the origin of deposits in Pictou county, and by Wadsworth[3] for a deposit on Waugh river, Colchester county, Nova Scotia. The Carboniferous and Permian conglomerates of Nova Scotia and New Brunswick contain an abundance of volcanic fragments derived from the pre-Carboniferous complex and these rocks contain considerable chalcopyrite, so that either the

[1]Gesner, Abraham; "The Industrial Resources of Nova Scotia", Halifax, 1849, p. 289; Geol. of Nova Scotia, Halifax, 1836, pp. 139–40.
[2]"Acadian Geology", London, 1868, p. 327.
Proceedings of the Boston Society of Natural History, vol. XXIII, pp. 204–5 (1885–8).

underlying basement or the conglomerate may be the source of the copper found in the deposits. The conglomerates are cavernous and would permit the easy circulation of the ground-water. According to the second hypothesis the chalcocite emanated from basic or acidic igneous rocks that intrude the Carboniferous and older formations. The copper carbonate (malachite) is, of course, in either case a secondary product resulting from the oxidation of the chalcocite.

The mode of origin of the copper deposits at Goshen and of similar deposits occurring in New Brunswick and Nova Scotia has a bearing on their value, for if they are concentrations by meteoric waters they are probably for the most part less extensive than if derived from igneous intrusions. The information gathered by the writer in making a two days' examination of a single group of deposits is not sufficient to warrant a positive conclusion, but numerous similar deposits are known in other parts of the world, most of which are thought to have originated through the agency of circulating meteoric waters.[1] The small extent and numbers of the deposits in Nova Scotia and New Brunswick suggest that they also have been formed in this way.

DICK COPPER DEPOSIT

(*See* Figures 17 and 18)

This property is situated in Kings county, about 1½ miles south of Annidale station on the railway (New Brunswick Coal and Railway Company) from Norton to Chipman, operated by the Canadian Pacific Railway Company. It lies about three-quarters of a mile east of the railway and one mile from the nearest siding at Scotch Settlement.

Chalcopyrite was discovered in this locality about thirty years ago by Thad Dick, a miner and prospector. About 1902 Dick, in partnership with his brother Edward Dick and G. W. Ganong of St. John, purchased a lease of the territory adjoining the discovery and from that time until their deaths in 1922 the Dick brothers returned to the property at intervals and sank numerous short shafts. In 1916 two carloads of ore were shipped to the United States Metal Refining Company and about two more carloads of sorted ore remain on the dumps. The present owners of the property are Mrs. Dick and John and Ernest Williamson of St. George, and Mrs. G. W. Ganong of St. John, New Brunswick.

There are few rock outcrops near the deposits and most of the pits and shafts had caved in or were filled with water when the writer visited the property. From an examination of the rock outcrops and accessible openings, however, it was found that the property is underlain by altered volcanics cut here and there by irregular fracture zones, along which the volcanics have been impregnated with quartz, carbonate, pyrite, and chalcopyrite. Most of these mineralized zones are small, but one of them, that on which shafts Nos. 3 and 4 (Figure 17) have been sunk, is at least 100 feet long. Shafts Nos. 2, 3, and 4 could not be examined, but two carloads of

[1]Lindgren, W.; "Mineral Deposits", 1919, pp. 400–415.
Beyschlag-Krusch-Vogt, Die Lagerstatten DercNutzbaren Mineralmen and Gesteine, 1913, vol. III, pp. 601–619.
Rastall, R. H.: The" Geology of Metalliferous Deposits", 1923, pp. 254–259.

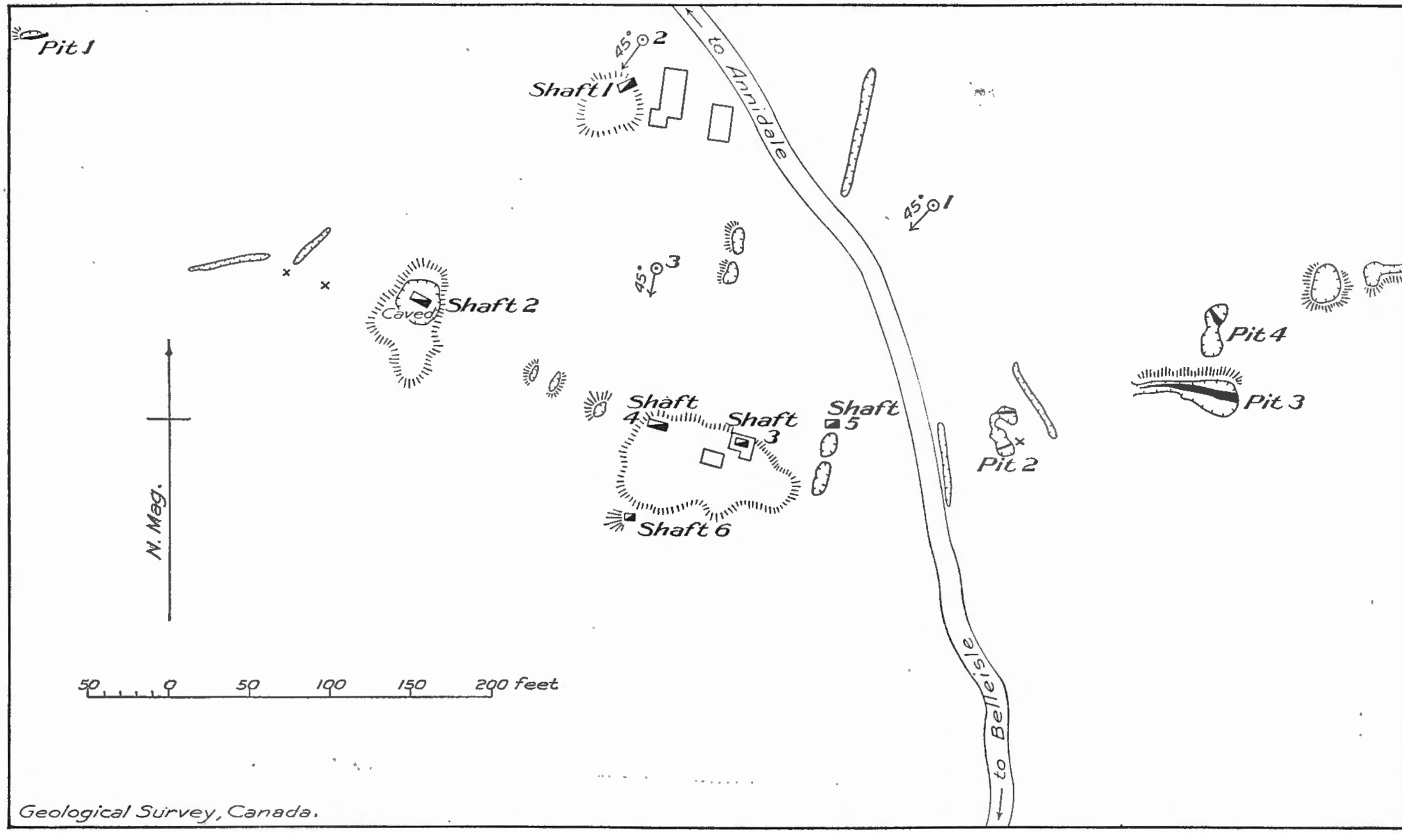

Figure 17. Dick copper property, Annidale, Kings county, New Brunswick. Ore deposits shown in solid black; the larger pits are outlined, smaller pits and prospect pits are represented by crosses; drill-holes are represented by circles with arrows and numbers indicating direction and inclination of the holes; shafts, pits, and drill-holes are numbered as in text.

ore from these, one of which contained an average of 10·09 per cent copper and 1·19 ounces of silver a ton and the other 7·99 per cent of copper and 1·07 ounces of silver a ton, were shipped in 1916, and about 100 tons of ore averaging over 5 per cent copper remain on the dumps. According to an assay plan (Figure 18) by C. E. Wuensch and a report by R. T. Cornell, there is a deposit averaging nearly 2 per cent copper exposed for widths ranging from 3½ to 26 feet in the workings on shafts Nos. 3 and 4; but the

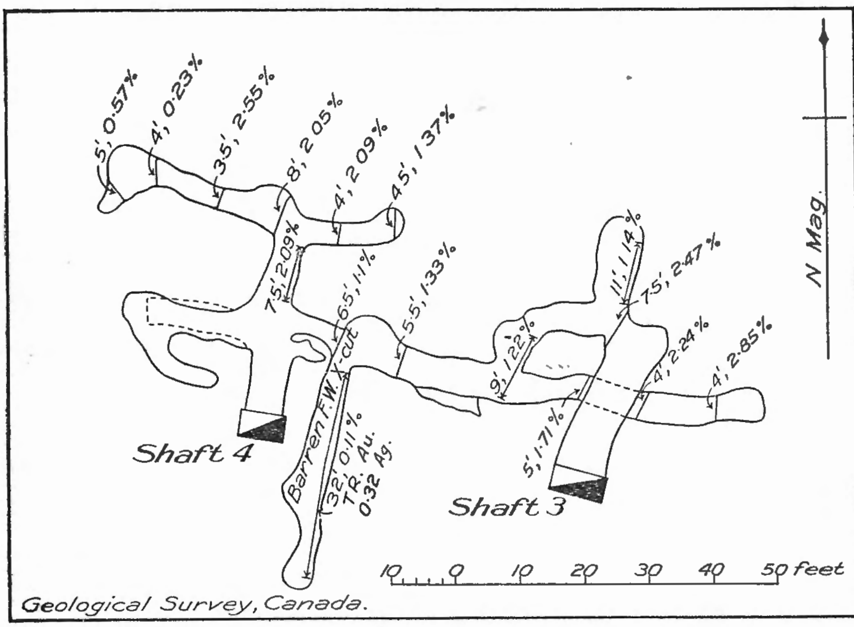

Figure 18. Assay plan of workings, Dick copper property, Annidale, Kings county, New Brunswick; by C. E. Wuensch. Shafts are numbered as in text and on Figure 17.

face of a crosscut 32 feet long to the south near shaft No. 4 contains an average of only 0·11 per cent copper. The specimens of sorted ore on the dumps consist largely of much-altered, fractured, and more or less schistose volcanics impregnated with either chalcopyrite and pyrite, or quartz containing chalcopyrite and pyrite. Under the microscope the ore is seen to consist of angular fragments of pyrite and chalcopyrite and small particles of magnetite enclosed in quartz and carbonate, or quartz, carbonate, and chlorite. The relationships of the minerals to one another have been obscured by deformation. The volcanic wall-rock has been largely transformed to chlorite and carbonate. The principal details regarding the different openings are included in the following table:

No. of shaft or pit	Dimensions of opening	Character of deposit
Shaft No. 1....	55 feet deep.............	Not observed. Material in dump contains much quartz
Shaft No. 2....	50 feet deep.............	Not observed. About 35 tons of sorted ore averaging over 2 per cent copper on dump. Some ore in dumps from pits between shafts No. 2 and No. 4, indicating that mineralization occurs here
Shaft No. 3....	48 feet deep.............	Timbered shaft inclined about 70 degrees to north
Shaft No. 4....	48 feet deep.............	Shafts Nos. 3 and 4 are adjoined by flat dumps in which fragments of chalcopyrite are common. Approximate average sample contained 1·67 per cent copper. Approximate average samples of 3 piles of sorted ore on dump and in ore-house contained over 5 per cent copper
Pit No. 1......	12 feet long, 5 feet wide, 4 to 8 feet deep	A poorly developed fracture zone trending north 10 degrees west magnetic in fine-grained greenstone. Zone up to 4½ feet wide, consisting of irregular aggregates and veins of sparingly disseminated chalcopyrite and pyrite. Average grade probably less than 2 per cent
Pit No. 2......	35 feet long, 10 to 20 feet wide, 8 to 12 feet deep	Two east-west trending mineralized zones about 20 feet apart. Width of zones 1 foot or less
Pit No. 3......	60 feet long, 10 to 25 feet wide, 12 feet deep	A lenticular mineralized zone up to 4½ feet wide. Approximate average sample across face contained 7·54 per cent copper and 1·12 ounces silver a ton
Pit No. 4......	Two circular, connected openings. Total length 40 feet, width 15 feet, depth 12 feet	A wedge-shaped mass of high-grade ore in north end. Maximum width 3 feet. It pinches at northwest end and disappears in southeast wall

There is, therefore, in this property an east-west trending belt several hundred feet wide, in which the volcanic complex has been impregnated here and there with chalcopyrite; but with the possible exception of a zone extending from shaft No. 2 to shaft No. 3 the known deposits are too small or too far apart, if taken together, to be workable. The two carloads of ore averaging approximately 10 and 8 per cent copper, respectively, taken from shafts Nos. 2, 3, and 4, were evidently sorted material and do not represent an average of the deposit. According to the assay plan of the workings on shafts 3 and 4, prepared by C. E. Wuensch, the deposit carries an average of less than 2 per cent copper, and unless it maintains this average considerably beyond these workings it is not of workable grade. The other deposits so far discovered in the property appear to be associated with small, local fractures. It would seem advisable, therefore, to determine positively whether a continuous mineralized fracture zone is present in the fracture belt. Three diamond-drill holes, as shown in Figure 17, said to have been 285, 230, and 90 feet deep, respectively, were put down in 1915 and presumably obtained such data for the part of the property drilled, but the writer has no information regarding the results of these operations. All that can be stated regarding the future possibilities of the property, therefore, is that the abundance of the mineralization here and there, and especially near shafts 2, 3, and 4, indicates that a workable copper deposit may be present in the mineralized belt.

PROSPECTS FOR PETROLEUM IN LAKE AINSLIE DISTRICT, CAPE BRETON ISLAND, WITH NOTES ON THE OCCURRENCE OF BARITE AND GRANITE

By W. A. Bell

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Illustrations

INTRODUCTION

Lake Ainslie, in Inverness county, Cape Breton island, has an area of about 20 square miles. Trending northwesterly for 12 miles it has a maximum width of only 4 miles. The present outlet to the north by way of Southwest Margaree river is a youthful one (Plate I A) and probably the lake owes its origin to glacial damming of a pre-Glacial valley that wound its way seaward by way of loch Ban and the valley of Mabou river; for a kame or esker of sand at the western head of loch Ban is the most conspicuous feature in the glacial drift deposits that border the lake.

The lake is pleasantly situated in a land of rolling, forested uplands of 700 to 900 feet elevation, that are cut by short, youthful, rocky stream channels, and that are separated from one another by mature, lowland, pastoral valleys developed on softer rock formations. It is readily accessible from the south by way of Whycocomagh, 6 miles distant on the Bras d'Or chain of lakes, or from the north by way of Inverness, 4 miles distant from loch Ban. The latter locality is touched by the Inverness railway at a point about 50 miles from Hawkesbury on the strait of Canso.

Lake Ainslie district has attracted geological attention on account of the presence there of barite veins and of surface indications of petroleum. In addition there is a hill of granite, at the southwestern margin of the lake, which is a potential source of rock for building and monumental use.

The present report presents the results of investigations made in 1926 and which were concerned primarily with a study of the geology for the purpose of evaluating anew the prospects for the existence of petroleum in payable quantities, and the study of other minerals or economic rocks was only incidental to this survey. The conclusion has been reached, however, that the latter form the only potentially valuable mineral resource of the district.

REGIONAL GEOLOGY

The central belt of Cape Breton island, of which Lake Ainslie district forms a part, consists broadly of a number of linear uplands, trending generally northeasterly, developed on pre-Carboniferous crystalline rocks, separated and indented by low-lying tracts underlain by Carboniferous sediments. The crystalline areas are either the cores of anticlinal folds, or are wholly or partly the cores of horsts bounded by fault-line scarps or slopes. North mountain, which forms the north shore of West bay, is a good example of the first type, whereas St. Anne mountain, which rises steeply from Great Bras d'Or channel, is separated from the Boularderie Island Carboniferous lowland by a marked fault-line scarp.

Whatever may have been the succession of topographic forms in Tertiary time, the northeasterly trending and structurally depressed, elongated tracts between the crystalline uplands controlled the final stage of pre-Glacial drainage and determined the present lowland pattern. In post-Glacial time submergence of the land by several hundreds of feet partly flooded the lowland valleys and gave birth to the present scenic estuaries and to Bras d'Or lakes. In the last glacial epoch local damming of valleys by terminal moraines or by kames and delta outwash gave rise to lakes such as Mira lake and lake Ainslie.

LOCAL GEOLOGY

The local geology of the district does not require detailed treatment, as the stratigraphic relations are already on record in the reports of Hugh Fletcher,[1] and particularly on Map-sheets 13, 14, and 15 of the Nova Scotia serial geological map-sheets.

Table of Formations

Period	Lithology	Correlation	Remarks
Recent..........	Stream gravels, lake beach and bottom deposits, etc.		
Pleistocene......	Glacial boulder clay, stratified fluvioglacial deposits	....	Kame of Beech Hill, loch Ban
Pennsylvanian...	Laminated, sandy shales, argillaceous shales, rippled sandstones, colour chiefly grey, some red	Hawkesbury (Riversdale) series	Restricted to small area on Doherty cove
Mississippian....	Limestones, red shales, and sandstones, gypsum, anhydrite	Windsor series........	Laminated limestone at base of Windsor, maximum thickness 50 feet, widespread
	(Basic dykes, and intrusive masses)	....	Trap north of loch Ban
	Massive sandstones, rippled sandstones, argillaceous and arenaceous shales, "kankar" shale. Thick red and grey arkoses and conglomerates at base	Upper Horton series...	Upper sandstone member locally stained with petroleum
	Siliceous shales, argillaceous shales, quartzites, sandstones	Lower Horton series	
Pre-Carboniferous	Grey granite, pink acid volcanics, etc., mica schist, quartzite	....	Locally contain barite veins

[1] Fletcher, Hugh: Geol. Surv., Canada, Rept. of Prog. 1882-84, pt. H (1883).

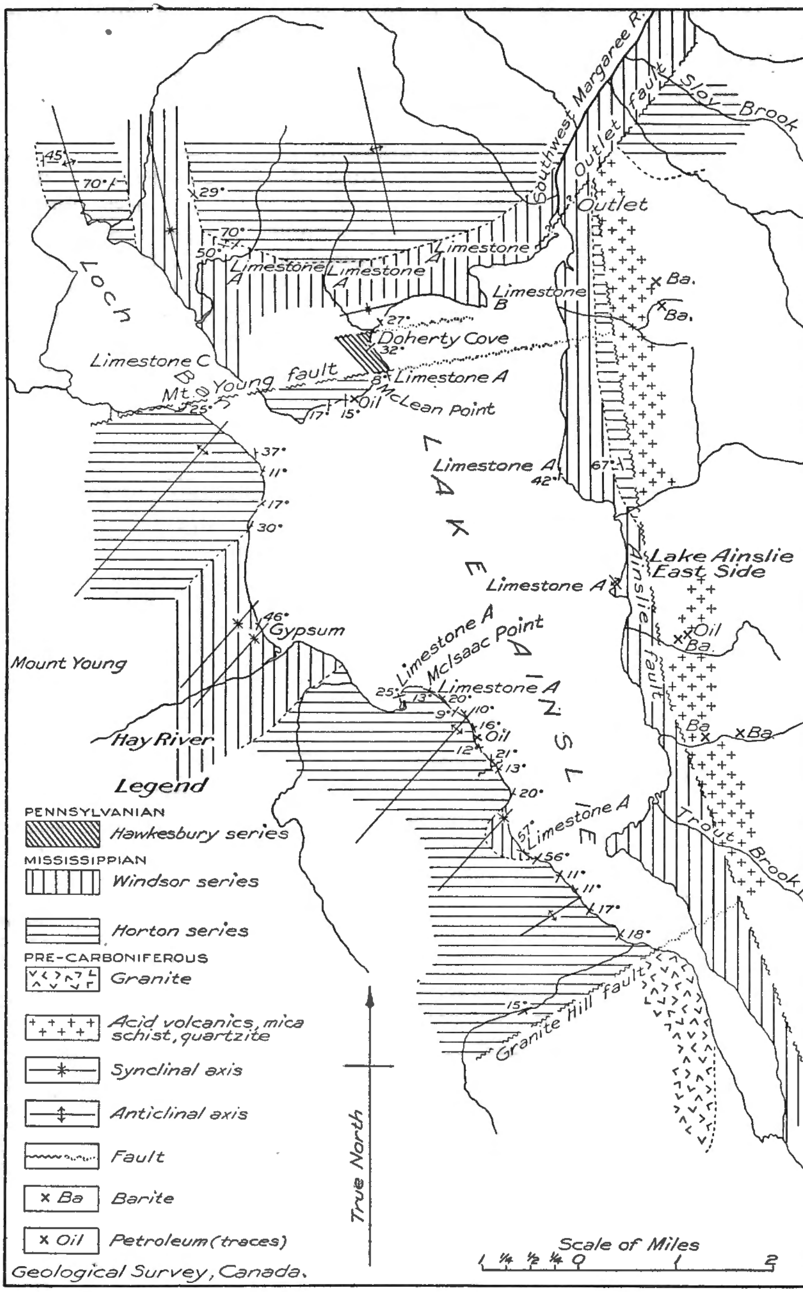

Figure 19. Lake Ainslie, Inverness county, Nova Scotia.

PRE-CARBONIFEROUS ROCKS

These underlie the greater part of the upland immediately east of lake Ainslie. At the northern end of the upland ridge mica schist and quartzite are cut by dykes of pink acidic, and greenish basic, volcanics, whereas pink acidic, commonly brecciated, weathered, volcanic rock occupies the ridge farther south. Both groups of rock carry veins of barite. To the east, these igneous rocks are seemingly capped by conglomerate of Upper Horton age. The western contact is a faulted one against either Windsor or Horton, Mississippian strata.

At the southwestern end of lake Ainslie there is a prominent hill of biotite granite. The rock is massive, coarsely granitic, abundantly charged with biotite, mostly of a pleasing grey colour, although reddish in places. On the north the granite is faulted against strata of Upper Horton age, but the nature of the other contacts is not known. As there is no metamorphism of the Upper Horton sediments and as pebbles of similar granite have been noted in conglomerates of Upper Horton age at mount Young, there is no doubt that the granite is pre-Upper Horton at least.

MISSISSIPPIAN

Horton Strata

Sloy brook, about 2 miles northeast of Outlet at the foot of lake Ainslie, was the only locality visited where strata of Lower Horton age outcrop. These are tilted almost to the vertical and consist mainly of dark grey, argillo-arenaceous shales interbedded with quartzites and arkosic sandstones. Palæoniscid fish scales and teeth, and *Lepidodendron corrugatum,* were observed rarely.

The base of the Upper Horton series in the country around lake Ainslie is a very thick, coarse conglomerate member. A little conglomerate of this age outcrops on the shore of lake Ainslie, where it forms part of the northern limb of the Mount Young anticline. But to observe the conglomerate to better advantage one must visit outlying localities, e.g. Salt mountain at Whycocomagh, the escarpment south of Mullach brook, Skye mountain, etc. A convenient section too is afforded by Southwest Mabou river above the upper bridge.

There are three localities on the Lake Ainslie shore that furnish incomplete sections of the youngest strata of Upper Horton age. These are McIsaac point on the west shore, and mount Young and McLean point on the north shore. At McIsaac Point section the total thickness of strata exposed possibly does not exceed 250 feet, as a part of the section is repeated as a result of faulting. Grey sandstone, in part soft, massive, crossbedded, broken by joints into irregular narrow blocks, in part shaly or flaggy and rippled makes up the bulk of the exposed deposit. Alternating with the sandstone, or embedded within it as lenticular masses, are thin members of areno-argillaceous shale, greenish grey or dark grey, with the exception of two or three thin, chocolate bands. Accompanying the shale are several bands with nodules of lime or bands of intraformational conglomerate with pebbles of concretionary lime. Certain bands of sandstone are brownish and when struck with a hammer yield a noticeable odour of petroleum.

Several such lie near the anticlinal axis, but a prominent band outcrops at the summit of the section in the northern limb of the anticline at an horizon not more than 25 feet below the basal Windsor laminated limestone. The actual contact of the latter is not exposed here, although outcrops of the limestone are seen. The limestone is concealed in the southern limb, but it must lie close to the first Horton outcrops.

In the shore section of mount Young there are exposed 400 feet or more of strata of Upper Horton age. Grey, massive sandstones, and, more abundantly, rippled, flaggy sandstones, alternate with greenish grey, argillaceous, and argillo-arenaceous shales. Chocolate-red argillaceous shale is confined to several thin bands. Palæoniscid fish scales and teeth, plant stems like the stipes of a pteridosperm, and a few of the plant spores, *Sporangites glabra,* were the only fossils noted. The abundant ripple-marks are mostly oscillatory in type, although current ripples running south 175 degrees west, with stoss slopes to the east, were observed at one horizon. Exposures are poorer in the northern limb of the anticline, but the dips are much steeper and strata are exposed that are older than those exposed in the southern limb or in the McIsaac Point section. They comprise pebbly arkosic grits and grey conglomerates, coarsely micaceous, with pebbles up to 4 inches diameter of quartz, pink and grey granitic rocks, orthoclase feldspar, etc. Associated with the conglomerate is a band of soft, chocolate red, argillaceous sandstone with masses of "kankar" or concretionary lime similar to beds in the Horton section of Southwest Mabou river near the upper bridge.

The Horton beds exposed at McLean point on the north shore of lake Ainslie are much like those of McIsaac point, as massive, soft, grey sandstone predominates. There is one bed, at least 10 feet thick, of pebbly, arkosic, grey grit with quartz pebbles. Patches in several of the sandstone beds near the summit of the section are strongly petroliferous and the colour is a dark brown. Laminated limestone of basal Windsor age is seen in direct contact with the Upper Horton sandstone. The disconformable character of the contact is well revealed by the truncation by the limestone of imprints of plant roots that grew in situ in the sand.

Isolated exposures of Horton strata may be seen at other localities around the borders of lake Ainslie. At the head of loch Ban there is a sharp anticline in Upper Horton strata and exposures of shaly, fine-grained, grey and reddish sandstones are seen. East of the lake a narrow belt of Horton rocks is present in the north underlying part of the slope to the upland. Outcrops of grey sandstone may be seen there dipping steeply towards the lake.

The correlation of all these strata with the Horton series is based on their stratigraphic position below the Windsor series and on the presence within them of the Horton species *Lepidodendron corrugatum* and *Sporangites glabra.* Lithologically the strata of Horton age in Lake Ainslie district testify to a freshwater, terrestrial origin, for the most part fluvial, and this testimony is in agreement with the absence elsewhere, so far as known, of any marine beds in the Horton series.

Windsor Strata

Limestone of basal Windsor age (limestone A in the sketch map) outcrops at many localities on the shores of lake Ainslie. It is perhaps seen to best advantage at McLean point on the north shore, where its disconformable contact with sandstone of Upper Horton age has already been noted, and on the east shore near Lake Ainslie East Side settlement. At the latter locality the limestone, about 50 feet thick, is folded in a small anticline. The limestone rests here upon 8 feet of grey conglomerate, below which are exposed, in the axis of the fold, several feet of grey, crushed sandstone bearing coalized plant debris. The conglomerate carries pebbles of a volcanic porphyry as well as of quartzite, and probably should be included with the Windsor strata, whereas the sandstone is considered to be Horton. The limestone is typically very sparingly fossiliferous, bituminous, and thinly bedded. Most of the beds are finely laminated (Plate I B).

Little attention was given to younger Windsor strata on account of their meagre exposure in the immediate vicinity of lake Ainslie. Near the mouth of Hay river an earthy, light brown oölite and limestone, at least 8 feet thick (limestone B on map), underlies a gypsum member. Small gasteropods and brachiopods are fairly abundant in the calcareous beds and amongst them *Diaphragmus tenuicostiformis* was recognized. The oölite is seemingly underlain by gypsum, unless the latter is the overlying member repeated by faulting. On the eastern shore of loch Ban, northwest of McLean point, there is an outcrop exposing 16 feet of oölitic limestone of Upper Windsor age. The basal 6 feet is dense oölite with *Schizodus* fairly abundant, the upper 10 feet is lighter coloured and cavernous. The limestone is underlain by red shale and thin, argillaceous sandstone. This Upper Windsor limestone (limestone C on map) is better exposed at other localities in the surrounding region. It may be seen near Glendyre station, but is best studied at Vertical point on the north shore of Port Hood island (Smith island), where it caps an excellently exposed section of Upper Windsor strata that totals 1,700 feet in thickness. The thickness of the limestone exposed at Vertical point is 40 feet.

The correlation of the basal laminated limestone is readily made on the basis of lithology; the limestone is identical with a limestone member occurring at the base of the Lower Windsor at many localities in Nova Scotia and even in New Brunswick. Limestone of the same character and age outcrops on the shore of the strait of Canso at Hastings. The laminated limestone is likewise well exposed on Southwest Mabou river and is succeeded by a much faulted section of higher Windsor strata extending to a junction with Pennsylvanian strata.

PENNSYLVANIAN STRATA

The single locality at which beds of Pennsylvanian age outcrop on the shores of lake Ainslie is on the western shore of Doherty cove. The strata here are laminated, grey, argillaceous, and argillo-arenaceous shales that alternate with chocolate-red shales and sandstones. The red beds are more prevalent in the northern and higher part of the section. These strata are limited to the north by a concealed interval beyond which are chocolate-red, argillo-arenaceous shales and more massive grey and red sandstones that may belong to the same series or that possibly may be of Horton age.

The correlation of these strata is based on the presence of small *Anthracomya* of a species common to the Hawkesbury series of Lower Pennsylvanian age. Beds of similar lithological character and containing *Leaia* and *Estheria,* as well as *Anthracomya,* are well exposed in the lower part of Southwest Mabou river.

STRUCTURAL GEOLOGY

Folds and normal faults are the two dominant structural features of the district, and of these faulting is of major importance. The strata west of lake Ainslie are folded along northeasterly trending axes, as shown in the accompanying sketch map (Figure 19), whereas the axes of folding north of the Mount Young fault trend about north by west. To what extent the latter axes owe their present direction to rotation consequent upon the faulting is a problem that was not solved.

The main faults of the district are: (*a*) the Ainslie fault, trending north 10 degrees west to north 20 degrees west, that borders the eastern margin of the lake and determines the fault-line slope of the upland; (*b*) the Outlet fault, a branch of the Ainslie fault, which trends about south 40 degrees west; (*c*) the Mount Young fault, trending north 80 degrees east and which probably continues eastward to the Ainslie fault; (*d*) the Granite Hill fault that trends about north 60 degrees east. In addition, a fault probably limits on the north the Pennsylvanian strata of Doherty cove. The resultant vertical throws along most of these faults, unless undue allowances are made for non-sequence of sedimentation, must be hundreds, if not thousands, of feet.

ECONOMIC GEOLOGY

PETROLEUM

The existence of surface indications of petroleum in Lake Ainslie district is readily verifiable. The indications observed by the writer were: (*a*) petroleum impregnations of sandstone; (*b*) presence of an inspissated product of petroleum in a barite vein near Lake Ainslie East Side.

Petroliferous sandstone is confined to the uppermost beds of Upper Horton age, and may be observed near McIsaac point on the west shore of the lake, at certain horizons in the Mount Young shore section; and near McLean point on the north shore. The strongest impregnation noted was at the latter locality. Certain sand horizons appear to be slightly petroliferous within the areas of single outcrops, but in other instances the petroleum was mainly restricted to patches adjacent to strong joint-planes or small faults. Slightly petroliferous sand horizons were noted in both limbs of the McIsaac Point anticline, as well as near the anticlinal axis. At McLean point the dips are all eastwardly and the dominant structural feature is a fault situated a short distance north of the observed petroliferous rocks. At times of high-water level of the lake, films of petroleum have been reported as occurring on the water, and there would seem to be little doubt of the validity of these observations, as the petroliferous sandstone in places might be a source of oil seepage.

The locality of the petroliferous barite vein is about one mile south of Lake Ainslie East Side settlement. The vein was worked in the past for barite and surface openings still permit of observations. The petroleum product is in the nature of a black mineral tar, readily fusible and inflammable, that occupies spaces between the barite crystals. The vein itself is enclosed in an acid volcanic country rock resembling pink rhyolite, and the locality is several hundred yards distant from the Ainslie fault that separates this rock from strata of Windsor age (Upper Mississippian). Laminated, slightly bituminous limestone of basal Windsor age outcrops on the lake shore only one mile northwesterly from the vein outcrop.

From these observations it must be granted that traces of petroleum are present at the surface at various localities in Lake Ainslie district. What, therefore, are the prospects for greater quantities of petroleum underground? The presence of petroleum in underground reservoirs is dependent on the following geological conditions: (*a*) an adequate source rock, or rocks, from which migration of large amounts of petroleum is possible; (*b*) structural conditions permitting of such migration and of final concentration into reservoirs capped by impervious rock—factors of sedimentation, porosity, jointing, tilting, folding, and faulting are all concerned in these conditions; (*c*) structural conditions permitting retention of oil after concentration.

Applying these conditions to the facts of local stratigraphy as outlined above the writer is forced to the conclusion that there is no known source rock in Lake Ainslie district or surrounding country that was originally sufficiently rich in petroleum to have yielded economic supplies of it. It is true that this conclusion is based partly on the premise that economic supplies of petroleum are rarely or never genetically related to terrestrial deposits of the type of the Horton series. Geological data from oil-fields have grown so enormously in amount during the past decade, and are scattered so widely in the literature, or hidden in the files of producing companies the world over, that their analysis with particular regard to the genesis of the oils and to the limits of migration has long been delayed. It would appear to be a safe inference, however, that the preponderant majority of productive oil pools bear a close genetic relation to adjacent marine- or brackish-water source rocks, and that the few exceptions that suggest a freshwater source indicate particular types of lacustrine sediments.

There are only two probable sources for the petroleum or petroleum residues in Lake Ainslie district, viz., the Horton series and the Windsor series. The Horton series within the district has already been briefly described and its freshwater origin has been inferred. Only the upper part of the series outcrops around the shores of lake Ainslie. The lowest exposed beds of this upper formation are conglomeratic and in nearby districts the thickness of the conglomerate is measured by thousands of feet. A still older part of the Horton series is partly exposed by eastern tributaries of Southwest Margaree river, as already noted in Sloy brook. Of prime importance is the fact that no thick lacustrine members, comparable for instance to the Albert formation of New Brunswick (likewise of Horton age), have been detected in any part of this very thick Horton series. At the top of the series, however, and only a few hundred feet below the Lake Ainslie petroliferous sandstone horizons, there are several hundred feet of dark grey argillaceous and arenaceous shales exposed in Southwest Mabou river, and from these shales palæoniscid fish scales and plant spores have been sparingly collected. These beds seem to be the most probable source rocks for petroleum, if the latter has been derived at all from the Horton series. But the limited thickness of such beds does not hold out any promise that the supply was ever adequate to provide economic pools of oil or gas.

Turning to the Windsor series as a possible source for oil, the most likely member is the basal laminated limestone that has an average thickness of about 40 feet. This limestone is still slightly bituminous and gives off a fetid odour where struck with the hammer. It outcrops at many localities on the shores of the lake and in the surrounding country. It is downfaulted against the fractured pre-Carboniferous rocks that contain the petroliferous barite veins and is likewise downfaulted north of McLean point well below the petroliferous sandstone of the latter locality. The limestone is actually seen to rest disconformably upon the sandstone immediately south of the fault-line at McLean point, but the downthrow immediately to the north has brought down rocks as young at Lower Pennsylvanian. Both on the north and east sides of the lake, therefore, the laminated limestone by reason of the faulting has been placed in a position favourably disposed to give rise to the present traces of petroleum. The migration of oil into the porous barite veins might readily have been effected along the main Ainslie fault from a source in either the Windsor or Horton series. In McIsaac Point area there is no evidence that the limestone has been downfaulted immediately adjacent to and below the horizon of the petroliferous sandstones. The limestone, however, is downfolded in synclines to the north and south.

In summation, the evidence must be considered insufficient to lay greater stress on either one or the other of the two series as the more probable source of the oil observed. At any rate the limited thickness of the lower calcareous members in the Windsor series does not warrant considering them a potential source of petroleum of much greater significance economically than that of certain members of the Horton series. Neither series is regarded as an adequate source for economic concentrations of oil.

Nor are the structural features in the district more favourable to oil accumulation and preservation than the genetic ones. The prevalence of faulting has already been emphasized and although faults are not uncommonly favourable factors in oil accumulation their abundant occurrence is more likely to favour the permanent loss of migrating oil by dissipation than to favour its storage.

BARITE

Barite veins are numerous in the upland ridge east of lake Ainslie, and have been developed to some extent in the past. It seems probable that many veins still await discovery, as there is more or less definite alignment of fracture planes in the crystalline rocks in a direction about south 60 degrees west. On the basis of field observations alone the veins are believed to be, in the main, fissure deposits. The thickness of the veins varies from place to place, and this, in conjunction with the presence in many veins of abundant inclusions of country rock, is detrimental to their value, but this is offset to a great extent by the parallelism and close spacing of the deposits, which will permit of their development from a few main adits. The extension of old veins, the location of rich shoots and of new veins might be rapidly facilitated by modern methods of mechanical prospecting such as the use of the torsional balance.

The accompanying map (Figure 19) shows the location only of those barite localities that were visited by the writer. At the most southerly locality, a mile north of Trout brook, seven veins were seen, with thicknesses as follows: (*a*) 2·5 feet; (*b*) 5·5 feet; (*c*) 5 feet; (*d*) 0·8 feet; (*e*) 3·9 feet; (*f*) 3·9 feet; (*g*) 6·3 feet. Corresponding trends of the veins were: (*a*) south 71 degrees west, dip 65 degrees north; (*c*) south 91 degrees west, dip 47 degrees north; (*d*) south 54 degrees west; (*e*) south 54 degrees west, dip 75 degrees north; (*f*) south 54 degrees west, dip 72 degrees north. A second locality lies a mile farther north, and here the main vein, which is petroliferous, strikes south 60 degrees west. At both localities the country rock is a pink volcanic rock resembling rhyolite. It is finely fractured, in places jointed in sheets, and breaks readily into small, angular fragments.

Several veins were visited at a third locality which lies about 1·5 miles southeast of Outlet. The country rock at this place is mainly mica schist, but volcanic rock forms the hanging-wall of two of the veins examined. One vein strikes about south 66 degrees west and pitches 25 degrees southeastwardly. The foot-wall of this vein was not exposed, but is probably mica schist, as an old dump has abundant samples of barite carrying schist inclusions. Another vein, 1,400 feet south of the first, has a thickness of 6 feet in places and trends about south 15 degrees west, pitch 48 degrees east. The foot-wall is mica schist, whereas the hanging-wall, which is not sharply defined owing to large inclusions of it in the vein, is a red volcanic rock.

GRANITE

Granite forms a prominent hill at the southwestern end of lake Ainslie. There are a few small outcrops and the drift cover is slight. Vertical or highly inclined jointing, confined chiefly to directions approximately south 160 degrees west, south 60 degrees west, and south 90 degrees west, should permit of the quarrying of large blocks, and operations would be facilitated by cutting into the steep slope above the roadway. The rock is massive, grey in colour, spotted black with abundant biotite, and should be suitable for building and monumental purposes.

QUARTZ SAND AND CLAY DEPOSITS, MELFORD, CAPE BRETON

By T. D. Guernsey

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Illustrations

INTRODUCTION

The writer made, during the summer of 1926, an investigation of a deposit of quartz sand and clay which occurs near River Denys station, Cape Breton. This investigation was carried out in conjunction with the geologic mapping of an independent area to the south.

The writer desires to acknowledge the kindness and courtesy shown by the officials and employees of the River Denys Sand and Clay Company, owners of the deposit; to Mr. J. A. MacLellan and Mr. D. J. Beaton, manager and foreman respectively, he is especially indebted. M. E. Wilson of the Geological Survey visited the writer in the field and his suggestions and criticisms were very much appreciated. Special thanks are due to the School of Mines, Columbia University, for the use of apparatus in making screen tests. To Professor C. P. Berkey, Professor Ida M. Ogilvie, and Mr. H. P. Woodward, of the Department of Geology, Columbia University, the writer is indebted for criticisms and suggestions during the preparation of the report. Mr. R. M. Williams of Halifax proved to be a very willing and capable assistant.

The deposit is located on Diogenes brook, Inverness county, Cape Breton. The workings are about 4 miles from the village of Melford, and about 10 miles from River Denys station of the Intercolonial Division, Canadian National railway. The deposit is owned and operated by the River Denys Sand and Clay Company, Limited, whose headquarters are at Melford; Mr. J. A. MacLellan is president and managing director. The chief product is moulding sand, which is shipped to Sydney, Cape Breton, and to New Glasgow, Nova Scotia. A little clay has been shipped to St. John, New Brunswick, for use in the manufacture of pottery.

Although the deposit was known for nearly forty years, and some work had been done prior to 1911, it was not exploited to any extent until 1917, when it was acquired by the present owners. The property from which the sand is mined consists of 95 acres and, in addition, the owners hold leases and rights of search over a greater area in the vicinity.

Owing to the location of the property it was necessary to rebuild and construct nearly 4 miles of road in order that material might be brought to, and sand taken from, the deposit. This road, completed in 1924, connects with Victoria highway near Melford, from whence a branch road leads to the railway near River Denys station. Active mining commenced in 1924.

So far as the writer knows, the only published information on sand in this district is to be found in the report of H. Ries and J. Keele on "The Clay and Shale Deposits of Nova Scotia and Portions of New Brunswick".[1] Mr. Keele, who visited the locality, reported as follows:

A deposit of white clay is found near the headwaters of Diogenes brook, one of the tributaries of Denys river. This brook cuts through the eastern flanks of the Craignish hills, which form the western border of a wide valley across which Denys river flows.

The clay is at present only exposed at one point on the brook at a short distance below a small fork that comes in from the west. A few years ago a small quantity of the clay was shipped, but the openings made then are now concealed by gravel slides.

The portion of the brook where the clay occurs is situated in a narrow gorge of steep grade, sunk to a depth of about 250 feet below the level of the upland. A road was built down the brook leading to the open valley below, in order to haul the clay to River Denys station, a distance of 9 miles. The bottom of the gorge is so narrow that there is scarcely room for both the road and the brook.

Borings made in the clay were said to have revealed a sufficient thickness to form a workable deposit, but that the clay was interstratified by sandy layers. The deposit, however, appears to be of limited width, as rim rock outcrops at several points along the gorge. Any attempt to mine the clay on a large scale is liable to serious interruption by land slides from the glacial drift, which clings in large masses to the steep slopes.

Both the valley bottom and the slopes of the gorge are now heavily timbered, which serves to hold the loose material in place.

At the forks of the stream, at the upper end of the clay deposit, is a considerable thickness of white, clayey sand, from which the white clay appears to have been derived by the washing of the brook. The white sand appears to be preglacial and is probably derived from the igneous rocks which form the upland. The principal rocks are felsite, syenite, and sericite schist, judging by the wash in the brook.

A short distance below the white sand a mottled red and dark blue clay is found widespread in the valley through which Denys river meanders, and is worked for brickmaking at Eden siding on the Intercolonial railway. This clay overlies the glacial drift in the valley, and may be a lake or estuarine clay. If so it would indicate a greater submergence for the land than has been indicated for this region.[2]

GENERAL GEOLOGY

Diogenes brook flows down the southern slope of an upland area known as the Craignish hills, which trend east-of-north from the strait of Canso. They are about 4 miles wide and their extreme summits are about 980 feet above sea-level. The general appearance is that of a rather flat-topped ridge, rising abruptly from broad, lowland areas and incised by numerous swift-flowing streams, all of which rise in the highland.

[1]Geol. Surv., Canada, Mem. 16, pp. 155 (1911).
[2]Op. cit., pp. 65–66.

The sand occurs where Diogenes brook flows in a deep valley cut into Craignish hills. The immediate relief is in the neighbourhood of 300 feet, and although the valley sides are well wooded, they are very steep and, in many places, even precipitous.

The rocks making up Craignish hills have been mapped by Fletcher[1] as Precambrian, and are by him divided into two groups: (1) a series consisting of "syenitic, gneissoid, and other feldspathic rocks"; and (2) a series called the George River Limestone. Both series have been metamorphosed and are highly crystalline. Occupying the broad, open valleys and penetrating into the crystalline area as occasional re-entrants are Carboniferous sedimentary strata. These are unconformable to the older crystalline complex, and although at the present time their chief development is in the valleys, there is little doubt that at one time they extended farther up the slopes, if not over the summits, of the present hills. In the main, the higher overlapping members have been stripped off by erosion, and their remnants are of rare occurrence. Unconsolidated deposits of fluviatile, lacustrine, and glacial origin rest on both the crystalline rocks and the later sediments, although for the most part their development is limited to the valleys.

A hasty reconnaissance over the area failed to show many exposures of the granitic series, but those noted resembled very closely rocks which have been studied by the writer in a similar area about 10 miles to the south. In the southern area they are granitic rocks, of coarse grain, with large, pink or flesh-coloured feldspars, large quartz grains, and hornblende or mica, or both. The ferromagnesian minerals vary in their relative proportions over local areas, and the mica may show considerable chemical variations, being in some cases very biotitic and in others tending toward the light-coloured varieties. The granitic rocks in many outcrops hold partly digested xenoliths, whose original character is completely destroyed. Where larger portions of the intruded material are present, the rock becomes gneissoid in structure, the colour deepens, and the texture becomes finer. On exposure to the weather the granite disintegrates very rapidly by decay or solution of the feldspars, leaving the quartz grains as nobby protuberances on the surface. As weathering continues, the quartz is liberated and accumulates at the bottom of the outcrop as coarse, siliceous sand, very similar in appearance to rock salt.

According to Fletcher's map (No. 19) the valley of Diogenes brook is cut in the George River series. In its typical development this group is described as " crystalline limestone and dolomite . . . interstratified with . . . quartzite . . . and hornblende schist"[2] and intruded by igneous rocks. The strata are highly metamorphosed and are inclined at high angles. All the rocks common to the George River series in the type area were noted in the valley of Diogenes brook, although the true sediments have by far the largest development. The structural trend of the series is northeast (magnetic), with steep dips, and much crumpling and shearing.

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[1]Fletcher, H.: "Report on Part of the Counties of Richmond, Inverness, Guysborough, and Antigonish, Nova Scotia"; Geol. Surv., Canada, Rept. of Prog. 1879–80, pt. F, pp. 10–14, 24–32.

[2]Fletcher, H.: "Report of Explorations and Surveys in Cape Breton, Nova Scotia"; Geol. Surv., Canada, Rept. of Prog. 1875–76, p. 382.

It is probable that all the carbonate rocks of the George River series are more or less magnesian. Variations occur in the colours, textures, and structures, and these were used to make a rough division between what are probably true dolomites and the magnesian limestone. The dolomite is best seen along the road, about halfway between the sand deposit and the mouth of the valley, where it is exposed in small cliffs. In colour it is buff, grey, or reddish, with the buff-coloured varieties predominating. Mixtures of these three colours are common. The texture as a rule is fine, although the coarse sugary texture, common to dolomites, is very marked in some places. Bedding or banding is lacking, and no clue was obtained which might throw light on the original structures. The fine-textured varieties are commonly brecciated, presenting, on both the weathered and freshly broken surfaces, a network of anastomosing veinlets of clear or reddish carbonate. In places the rock appears to have been replaced, but if this is so the evidence is very obscure. Banded limestones are exposed on the valley side north of the sand deposit. They appear to carry less magnesium than the buff-coloured rocks, and in colour are white or grey, with medium texture. Well-defined banding is especially prominent on the weathered surface, which assumes a blue-grey colour.

The George River quartzites seen along the valley sides, both above and below the sand deposit, as a rule are massive rocks with few structures. They are white or light grey on the weathered surface, but when freshly broken are pinkish, due to ferric oxide between the grains, which dissolves out on weathering to form small pits. The strike of the largest exposure is 78 degrees (magnetic). Magnetite occurs on the south side of the valley not far from the mouth. The magnetite is in bands up to an inch or more in thickness and is associated with quartzite and sulphides, in a zone about 5 feet wide. The rocks in the vicinity are somewhat darker than the other exposures of quartzite observed, and display considerable shearing. A drift about 40 feet long, carried in along this zone during the summer of 1926, showed many small faults. At the time of the writer's visit the magnetite zone was faulted from the drift face.

The George River schists in the vicinity of the sand deposit are dark, fine-grained rocks, usually stained with ferric oxide. Cleavage is well developed and there appears to be no limit to which the rock will not cleave. This feature makes unweathered surfaces of rather rare occurrence. The schists are associated with some thin, blue, limestone bands, and are cut by small melanocratic dykes.

The small exposures of Carboniferous sediments occur at the eastern edge of the area mapped. These exposures are over a mile from the mouth of the valley, where the normal Carboniferous succession begins. They include a very small exposure of coal in the bottom of the brook, and a slightly larger mass of gypsum which was uncovered by a cut made during the building of the road. No definite structures were noted in the gypsum, but the coal seam, whose width was not uncovered, apparently strikes 156 degrees (magnetic) and dips about 30 degrees west. The coal is very tender and has not entirely lost its woody character. Small plates of gypsum occur in the carbonaceous layers. This occurrence is believed to represent a small block, down-faulted into the crystalline complex. The reason for postulating a fault is the westerly dip of the coal seam which, under normal conditions, should dip to the east at a small angle.

The glacial and other unconsolidated deposits are of variable thickness and are generally red or chocolate-coloured. They consist of gravels and sands, developed as delta deposits on the lowlands, and derived in large part from the crystalline rocks of the highlands. Many of the deposits are of flood-plain origin, and consist of fine, red gravels interstratified with red and grey clays. Glacial till is common over the whole district and consists of fragments of crystalline rocks mixed with finer siliceous and argillaceous material having the prevailing red colour.

DESCRIPTION OF THE QUARTZ SAND AND CLAY DEPOSIT

With the exception of the above-mentioned coal and gypsum at the lower end of the deposit, no exposures of bedrock were noted within the area where the quartz sand occurs. The sand is found directly beneath the unstratified and heterogeneous glacial drift, which is thinnest at the bottom of the valley and increases in thickness up the slopes. The boundaries of the deposit have not been exactly delimited, although the sand probably does not extend laterally beyond the nearest bedrock exposures.

Since the glacial drift is thinnest at the bottom of the valley, it is there that the sand is exposed with the least work and to the best advantage. The sand is exposed by six excavations, three tunnels, and a number of test pits. The locations of these and other points where the sand was observed are indicated on the accompanying map (Figure 20).

The sections exposed in the larger excavations show that the deposit is bedded. The beds range in thickness from a few inches to 3, or even 5, feet. In some, but not all, cases, alternate beds differ in texture. Clay is present in greater or less quantity in all the beds of sand and forms beds of itself.

The sand is silvery or yellow-brown and consists of quartz grains, silvery mica, and creamy white or grey clay. The quartz grains vary in size from very fine particles, almost too small to be seen with the unaided eye, to pebbles a quarter of an inch or more in diameter. The larger grains have the edges and corners well rounded. When freshly exposed the sand is rather dark and is fairly compact, but as drying proceeds the colour lightens and the mass becomes more friable. Where beds of clay occur, the colour is generally grey, and, rarely, white. The clay is gritty, indicating the presence of siliceous material.

The contact of the sand with the overlying glacial drift is sharp, and does not follow the slopes of the valley. Thus, the tunnel at test-hole No. 14 follows the contact into the hill-side where a layer of nearly white clay overlies the sand. The top of the sand at the end of the longest tunnel, west of test-hole No. 13, is said to be about 6 feet above the back, which would indicate that the depth of the glacial drift over the end of the tunnel was 35 feet. At test-hole No. 3 the contact of the sand with the drift plunges sharply westward, and as no sand is known to occur west of this

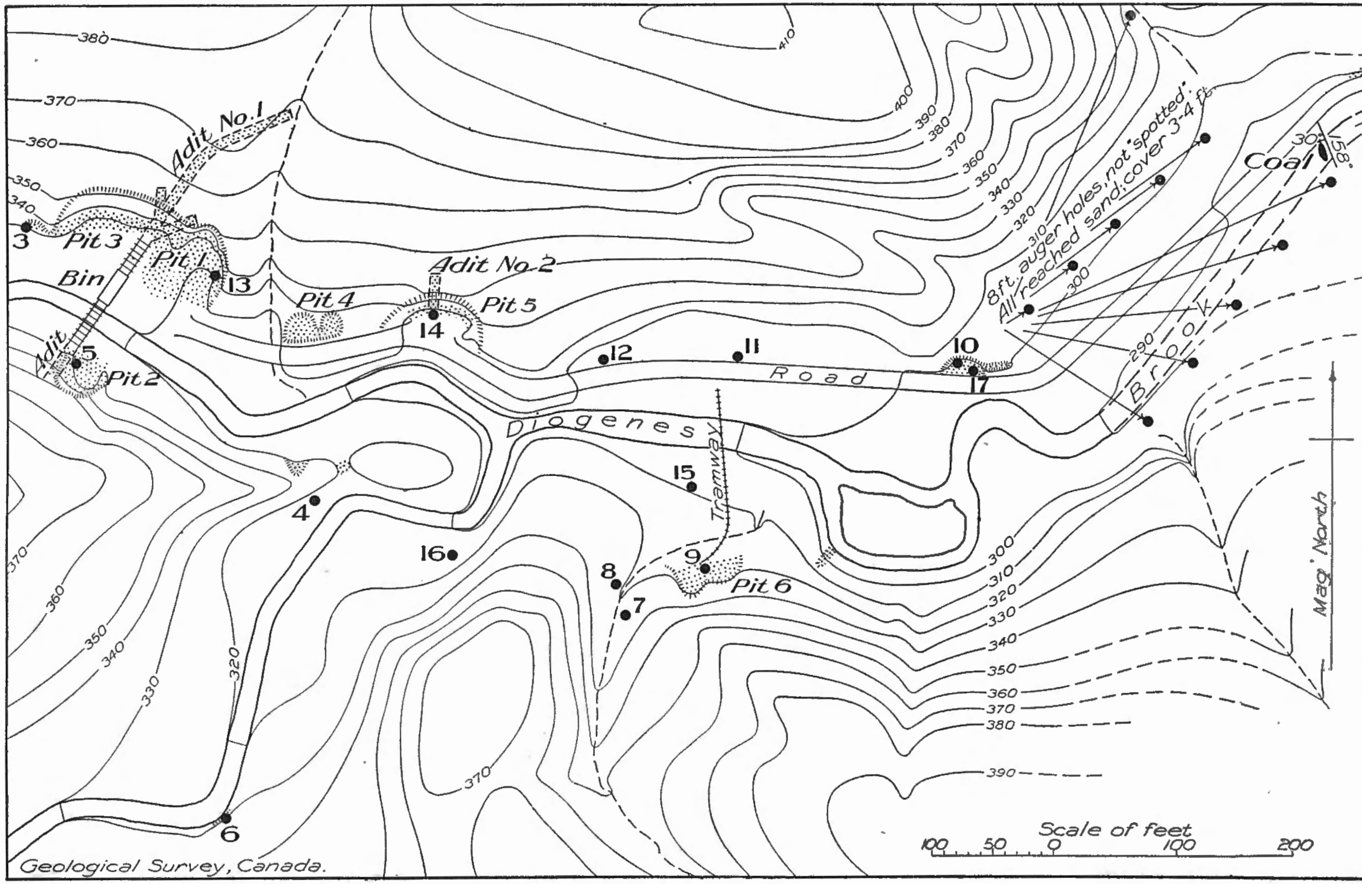

Figure 20. Quartz sand deposits, Diogenes brook, Inverness county, Nova Scotia. Exposures (mainly artificial) of sand shown by dotted pattern; test-holes in sand by solid circles numbered as in text.

point it may be taken to indicate the western limits of the deposit. At test-hole No. 7 the contact plunges into the hill-side with a steep southerly dip.

In the larger artificial exposures, where cuts were made into the deposit, the beds dip at angles of about 40 degrees east, i.e. down stream. This angle exceeds the angle of repose of dry sand in air by 6 degrees and although there does not appear to be any good reason why it may not at times be exceeded, it is not believed to represent the original dip of the sand layers. Some beds, especially those in which the clay content was high, were more lenticular than others, but since the exposures were not of sufficient extent to permit a single bed to be traced any distance, the lensing did not appear prominently.

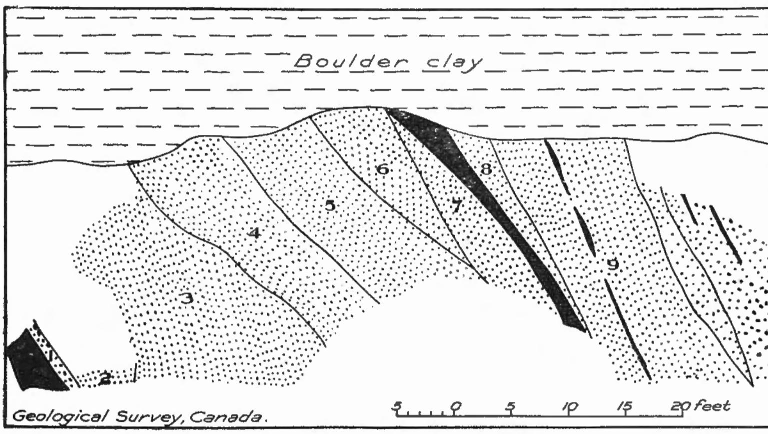

Figure 21. Sand and clay in face of large excavation near test-hole No. 13; by M. E. Wilson. Clay shown in solid black; and sand by pattern of dots. Layer No. 1 is composed of pebbly sand, No. 2 of coarse sand, No. 3 of medium-grained, crossbedded sand, No. 4 of coarse sand, No. 5 of moderately fine sand, No. 6 of fine, crossbedded sand, Nos. 7 and 8 of fine, crossbedded sand containing clay, and No. 9 of fine sand containing clay beds.

The large excavation near test-hole No. 13 exposes a subsidiary series of what at first sight appear to be bedding planes (*See* Figure 21). These latter are steeper than the normal dips, being about 70 degrees, and intersect, but apparently do not cross, the normal structures. The dip-planes separate thin laminæ of rather lenticular outline, which do not exhibit gradations in texture from one to the other. The exact significance of these structures is not clear. They may be the effects of slight slumping during or after the deposition, or on the other hand they may be the result of some outside force which has modified the deposit. Glacial ice is a common cause of deformation in unconsolidated deposits. Not only do the movement and weight of the ice play an important role, but the partial cementation of the material through freezing causes it to act in a manner which appears wholly anomalous when the ice melts.[1] Deformation structures

[1]Berkey, C. P., and Hyde, J. E.: "Original Ice Structures Preserved in Unconsolidated Sands"; Jour. Geol., vol. XIX, pp. 223-231 (1911).
Hollick, A.: Dislocations in Certain Portions of the Atlantic Coastal Plain Strata and Their Probable Causes"; N.Y. Acad. Sc. Trans., vol. XIV, pp. 8-20 (1894).

caused by glaciation might well be expected in a deposit overlain by glacial drift and they are substantiated by structures noted at the east end of the deposit where the sand is mixed to some extent with glacial till. This locality is close to the outcrops of the Carboniferous coal and gypsum, and the sand besides being contorted carries flakes of coal and small aggregates of grains cemented by pyrite.

Another indication of movement occurs near test-hole No. 5. Here a seam of red clay dips 52 degrees west and cuts across the normal dips. At its intersection with a carbonaceous layer the latter is dragged and displaced 5 or 6 inches. Only a single instance of this character was noted.

Small lenses or blebs of fairly pure clay are common in some of the sand layers, but are too small to be of importance, except in so far as they affect the clay content of the sand. Occasional carbonaceous streaks, lenses, and seams follow the structures of the beds, but are not continuous for any distance. This material is very friable and seldom exhibits original structures, although an occasional woody piece may be seen. These seams form channels for circulating waters, and are characterized by the rusty colour of ferric iron. Ferric iron is also deposited where sand overlies or grades downward into clay.

In the vicinity of the large excavation (test-hole No. 13), masses of sand grains, cemented by ferric iron, are fairly numerous. These are characteristic only of the sand, although not confined to any particular bed. The shape is roughly globular, and the average diameter is about 1¼ inches. Compound globules give larger sizes and more irregular shapes. The sand near these bodies is stained yellow, but the masses themselves are red or brown. They are hard enough to resist sharp blows with a hammer. Sections made show an outer crust of sand cemented by hematite, from one-eighth to one-half inch thick, and an interior filled with sand cemented by limonitic material. The interior is soft and may be scraped out with any sharp instrument. There appears to be little doubt that these bodies are concretionary, and, according to their occurrence, composition, and structure, they would be classed as "excretions",[1] although no central nucleus was noted. In comparison with the sand, their size and colour permit easy separation and removal during the process of mining.

SAMPLING AND TESTING

Owing to the nature of the excavations, sampling of the deposit was by no means thorough. In only three excavations was the sand exposed in such a way that samples could be obtained from individual beds. Each sample, about 5 pounds in weight, was as representative of a bed as was possible. Five-pound samples were also taken from the ends of the tunnels on the north side of the brook.

Test borings with an 8-foot auger were made by the author at a number of points, but in many cases it was not possible, owing to the compactness of the sand, to drive the auger to its full extent. The oper-

[1]Grabau, A. W.: "Principles of Stratigraphy", New York, 1913, pp. 718–721.

ators collaborated in this testing, using pipe and a small hand-operated churn drill. In this way greater depth was obtained. The data with respect to these test-holes are given below.

Hole No.	Type of hole	Depth in feet	Material	Cover in feet	Depth of cover in vicinity in feet
1	Auger	5–6	Red clay..	Not shown	on map
2	"	7	Red gravel		
3	"	6	Sand	....	....
4	"	8	"	....	1
5	"	8	"	....	2–5
6	"	6	"	....	4
7	"	5	"	....	4
8	"	7	"	....	3
9	"	7	"	....	3
10	"	5	"	....	3–4
11	Pipe	21	"	1	1
12	"	20	"	1	1
13	Churn drill	31	"	....	3–4
14	Pipe	19·5	"	....	4–6
15	Auger	8	"	2	2
16	"	7	"	4	4
17	Pipe	20	"	....	3–4

A further series of ten auger holes was made at the eastern end of the deposit, but the exact location of each was not determined. Their approximate location is shown on the map. Sand was reported from all these.

The larger samples were tested for clay content and were also subjected to a screen analysis. The procedure was as follows:

The sample was cut down to about 75 grammes in weight. This was dried for one hour at a temperature between 105° and 110° C. A 50-gramme portion of the dried sample was placed in a glass jar with 475 cubic centimetres of water and 25 cubic centimetres of a solution of sodium hydroxide (10 grammes in 1,000 centimetres). The jar was then sealed and agitated in a mechanical device for one hour, allowed to stand ten minutes, and the suspended material siphoned off. The jar was again filled with water, and at the end of ten minutes again siphoned. Water was added again, and at the end of five minutes siphoned off. The process of five minutes standing and siphoning was repeated until the water was clear at the end of the period. The residue was then filtered, dried, and weighed, and the loss, calculated to per cent, is called clay-substance.

The dried residue was next placed in the first of a series of screens (Tyler's Nos. 10, 20, 28, 35, 48, 65, 100, 150, and 200) and the sieve-nest placed in a Ro-Tap testing machine, which was run for twenty minutes. The amounts remaining on each screen were weighed and expressed in per cent. That passing through the 200-mesh screen is known as -200. The results of these tests are given below.

Sample No.	244	279	291	299	300	284
	%	%	%	%	%	%
Clay-substance	6·7	4·0	6·5	16·8	10·9	11·8
-200	2·1	2·8	2·2	7·9	3·4	3·2
on 200	0·9	1·3	0·6	4·4	1·5	1·1
on 150	3·0	3·6	1·6	10·9	4·0	4·0
on 100	11·9	11·6	5·6	22·8	12·2	14·5
on 65	24·0	12·4	9·9	19·3	29·0	20·5
on 48	25·5	27·0	18·9	11·0	25·9	19·7
on 35	16·1	25·6	26·3	4·9	10·1	14·2
on 28	4·1	7·8	15·7	1·0	2·2	5·6
on 20	3·7	3·2	9·7	0·4	0·4	3·8
on 10	0·7	0·1	1·8	0·0	0·0	0·3
Loss	1·7	0·5	1·1	0·5	0·2	1·3

No. 244, end of long tunnel; 279, near test-hole No. 13; 291, near test-hole No. 5; 299, near test-hole No. 9; 300, near test-hole No. 9; 284, test-hole No. 8.

The screen analyses show that the bulk of the sand lies between 35 and 65 mesh and that the finer sands, as might be expected, carry the higher proportion of clay-substance. As the samples are believed to be fairly representative, the deposit as a whole should average about this grade. The loss during screening is attributable to two causes, viz., handling and adherence to the screens.

The washed and dried sand after screening was examined under a microscope, both in air and in index liquids. By means of bromoform the heavier minerals were separated from sample No. 290. Although some quartz and mica settled with the heavy residue, the total proportion of heavy minerals by weight did not exceed 0·5 per cent.

MINERALOGY

Under the microscope the individual sand grains exhibit angular to sub-angular outlines, increasing in angularity in the finer sizes. Mica was present in fairly constant proportions in all the specimens examined. Owing to the difficulty of handling the extremely fine flakes, no attempt was made to calculate the proportions of this mineral. Soluble constituents are scarce and probably do not exceed 0·5 per cent. Specimen No. 290 was treated for twenty minutes with hot, dilute HCl (1:10). The loss was 0·4 per cent.

QUARTZ

Quartz is the most abundant mineral in the sand. It exceeds in quantity all the other minerals, and although in places the clay-substance may exceed it in amount, such occurrences are not numerous.

Two varieties of quartz were noted, both of which occur throughout all sizes of the sand. The most abundant variety is white and of more even dimensions than the second, which is glassy, clear, and is characterized by conchoidal fractures with acute edges. Both varieties are angular below 100 mesh, but above that figure rounding and polishing become evident.

The white grains, although of irregular surface, show good rounding at 65 mesh, whereas the clear grains do not exhibit much rounding and polishing below 35 mesh.

On mounting the grains in either Canada balsam or clove oil, the reason for the difference in appearance becomes evident. The white grains are very dusty, with minute crystalline, gaseous, and liquid inclusions, whereas dustiness in the clear grains is not nearly so pronounced. The latter also exhibit etched and modified crystal faces. Composite quartz grains may occasionally be noted, especially among the finer sand grains. For the most part these are inclined to be elongate and in appearance resemble the quartz grains of some schists and gneisses which have been granulated and broken.

CLAY-SUBSTANCE

The word "clay-substance" is used to indicate the material which was washed out of the sand by successive decantations and, although not strictly a mineral, it may be considered under this head. Much of the decanted material settled within half an hour from the time of siphoning, but a considerable proportion remained in suspension for twelve hours, and it was found necessary to effect its coagulation and settling with sodium chloride.

The composition of the clay-substance was not determined, but it undoubtedly carries silica in a finely divided, if not colloidal, state, as well as microscopic flakes of mica and true kaolin.

Tests,[1] made on clay from this locality and published in the previously quoted report by Ries and Keele, are given below.

Laboratory No.	Field No.	Locality	Water required	Air shrinkage
			%	%
1580	57a	Red clay, Diogenes brook, C.B.	19	6·6
1581	57b	White clay, Diogenes brook, C.B.	22	6·3
1583	57d	Blue clay, Diogenes brook, C.B.	20	7·0

Laboratory No.	Cone 010			Cone 03		
	Fire shrinkage	Colour	Absorption %	Fire shrinkage	Colour	Absorption %
1580	-0·9	red	13·66	0·0	pink	12·03
1581	0·1		13·72	1·0		12·41
1583	-0·2		11·97	4·0		6·73

MICA

Mica is found in all the sands examined and is also present in the clay beds. The most common type resembles muscovite and occurs in clear flakes of all sizes down to and below 200 mesh. This mineral was a source

[1]Geol. Surv., Canada, Appendix I: "The Clay and Shale Deposits of Nova Scotia and Portions of New Brunswick", Mem. 16 (1911).

of trouble in testing, as the finer flakes were disturbed by the slightest current of air, and all were most difficult to transfer from one container to another. For the most part the mica is clear and colourless, exhibiting no inclusions or discolorations. Some of the larger flakes, however, carried grains of magnetite and were discoloured by iron oxide.

Biotite was present in some of the samples examined. The flakes were not smaller than 100 mesh and were generally much coarser than that figure. The biotite was dark brown and exhibited pleochroic haloes and inclusions.

FELDSPAR

Very little feldspar was noted in any of the specimens examined. Small grains, showing alteration, occur in the finer sizes and may represent partly decomposed feldspar. A few small crystals of orthoclase were noted in some of the specimens, but their occurrence was rare.

HEAVY MINERALS

The minerals which separated from the sand by the use of bromoform include the following: tourmaline, rutile, magnetite, augite, andalusite, epidote, staurolite, hornblende, zircon, and corundum. For the most part these are associated with the finer sand grains. Although crystal forms, except on the tourmaline and rutile, were not abundant, few of the grains were rounded.

ORIGIN AND AGE OF THE SAND

The exact conditions of deposition have not been determined. The bedded character of the material and the results of sorting action exhibited by the beds of various textures, together with the angularity of the finer particles and the abundant mica, are ample indications that the deposit is sedimentary. The absence so far as is known of similar deposits in the surrounding region lends support to the view that the cause was local and not regional. That no marine fossils were noted does not show conclusively that the deposit is non-marine, but several other factors favour the hypothesis of fluviatile origin. These are: the carbonaceous streaks between and within the beds; the clay lenses or blebs in the sand layers which are considered to be clay balls; and the presence of the fairly high clay content of the sand layers, evidence of only moderate sorting and of rapid deposition.

The attitude of the beds, however, is not consistent with normal fluviatile deposition and must be due to one or more of several modifying factors, viz., deposition as a delta, torrential crossbedding, or deformation. In the case of the first two the original dip of such deposits rarely exceeds 34 degrees and one other factor must still be considered. Regional tilting is not thought to have been of sufficient extent to affect a deposit such as this one, but as mentioned previously glacial ice may at times exert a profound influence on unconsolidated and englacial deposits. It appears more than likely that some of the structures noted in these sand beds are due to deformation by ice, but it is not believed that the deposition of the sand is in any way directly connected with glaciation. The colour of the sand differs quite sharply from the chocolate colour of the overlying drift and the presence of the hematite concretions suggests a certain amount of subaerial exposure to leaching action before the drift was deposited.

The data noted are not such as would easily aid in the determination of any one of these phenomena and at the present time the writer does not feel justified in assigning either a deltaic, torrential, or glacial origin to the deposit.

The original source of the material and its history previous to the time that it was laid down are not easily deciphered. Since the sand is known to overlie the eroded Carboniferous sediments in the bottom of the brook, it is clear that the sand was deposited after the granitic and older rocks had been uncovered and after the Craignish hills had assumed somewhat their present form. Therefore, the stream that deposited the sand was probably not much longer than the present Diogenes brook, whose sources are not more than 1½ miles above the sand deposit. It is believed, therefore, that the materials of the deposit must have come from within this radius.

The constituents of the sand are largely such as would be afforded by the weathering of the granite and presumably were so produced, but the clear quartz grains are not characteristic of either the granites or the quartzites, and these constituents at least were probably derived from some other rock type. The white mica is probably derived from the granite either by direct weathering or from the breaking down of the feldspars. The heavy minerals are not reliable criteria for either igneous or sedimentary rocks, but from the angularity of the grains the latter possibility appears to be the least feasible. The data point to the granitic rocks as the most likely source of the sand, but in an area of complex structure it would be strange if one rock type should contribute all constituents. It is concluded that the sand is mainly the result of the decomposition and decay of the granitic rocks of the immediate neighbourhood and that it was deposited in the valley by stream action.

AGE OF THE DEPOSIT

Data relating to the age of the deposit are extremely meagre. Ries and Keele in their previously cited report classify this occurrence with several others under the heading "Pleistocene Clays", but give no evidence in support of this classification. It is evident that the sand is older than the drift which overlies it; but if there have been two advances of the ice, as the evidence at times seems to indicate,[1] the sand may represent a delta deposit, built during a glacial interval and preserved by reason of its position. In this case there might be another drift sheet below the sand.

Pre-Glacial sands and clays, referred to the Mesozoic, have been reported from the Musquodoboit valley, Nova Scotia, and are believed to be estuarine in origin.[2] Other unconsolidated marine deposits of sand and clay underlie the glacial drift of the Atlantic coastal plain. They carry glauconite, and from the structural and faunal evidence are referred to the Tertiary and Upper Cretaceous.[3]

[1]Goldthwait, J. W.: "Physiography of Nova Scotia"; Geol. Surv., Canada, Mem. 140, pp. 60–103 (1924).
[2]Ries and Keele: op. cit., pp. 73–87.
[3]Bowman, I.: "Atlantic Pre-Glacial Deposits"; Am. Jour. Sc., ser. 4, vol. 22, pp. 313–325 (1906).
Fuller, M. L.: "The Geology of Long Island, New York"; U.S. Geol. Surv., Prof. Paper 82 (1914).

Little information bearing upon the age of the deposit is available from the contained carbonaceous material. A few fragments of wood were collected from the beds at the eastern end of the deposit where the sand, either through slumping or deformation, is to some extent involved with the glacial drift. The best of these was submitted to Professor C. C. Curtis of the Department of Botany, Columbia University, who kindly identified it as a species of hemlock. Although this genus is not a reliable criterion for an age determination, some of the features are significant. The fragment, showing the heart of the tree, is about an inch in diameter and on this surface the writer counted no less than fifty annual rings. The density of these rings, indicative of slow growth, leads to the supposition that the tree did not grow in a warm or temperate climate. If the specimen is actually from the sand and not from the glacial drift the evidence would appear to favour an age not far removed from the Pleistocene, but the presence of such a specimen is given little weight in assigning an age to the deposit.

The lithologic evidence may serve to place the age as either Cretaceous or Tertiary. The stratigraphic evidence, however, signifies nothing more definite than a pre-Glacial age.

PRODUCTION AND DEVELOPMENT

The production of sand by the River Denys Sand and Clay Company has not been large; but taking into consideration the long haul and the difficulties attendant upon the building up of a business, each year's production has shown a satisfactory increase over the previous one.

The production by years is as follows:

	Tons
1923	
1924	400
1925	1,500
1926	1,000, to Sept. 10

Active mining is carried on only from May to October. During the season of 1926, twenty-five men were employed and seven 1-ton Ford trucks were in constant use between the workings and the railway. The average load per truck was a little over one ton.

Mining at present is carried on by hand, the sand being loaded into coal trucks in the tunnels, or shovelled directly into the Ford trucks from the open excavations.

Before sand can be extracted by open mining, it is necessary to clear the standing timber from the locality selected and then remove the glacial drift, which so far has not exceeded 20 feet as a maximum, and generally has been about 3 or 4 feet. No great difficulty has been encountered from slides.

Where mining is carried on by means of tunnels, the sand of the quality desired is allowed to flow into the opening and is removed as required. It is necessary to lag the tunnels throughout, and advance is made by fore-poling, square sets being used, as the lateral pressure is found to be heavy.

If properly constructed the tunnels appear to stand well. The longest tunnel was not used or repaired during the summer of 1926 and was open on September 20 of that year.

POSSIBILITIES

The future of the deposit depends on several factors, chief among which are the extent of the deposit, the behaviour of the sand under actual working conditions in a foundry, and economic factors such as cost of mining, freight rates, etc.

The size of the deposit cannot as yet be determined. An attempt was made by the author to estimate the volume outlined at present, from data obtained during the examination. This was done by calculating the areas of a mean, and an average, cross-section of the deposit and multiplying these figures, respectively, by a length of 800 feet. Another calculation was made on a plan view by joining the various test-holes together to form a series of triangles and computing the volume of sand in each. The results of these calculations reduced to tons are 127,000, 122,000, and 139,000 respectively. The calculations thus indicate that within the tested part of the deposit there are 120,000 to 140,000 tons of sand. These figures at best are only a very rough approximation and it is probable that the tonnage of the whole deposit is far greater.

The behaviour of the sand under actual working conditions appears to be quite satisfactory. Replies from letters addressed to several of the firms now using the sand and clay indicate that the sand is equal to the previously used imported sands, and that the clay appears to be perfectly satisfactory for stoneware, Rockingham, and yellowware. It should be pointed out, however, that mica, in more than a very small proportion, is a very undesirable constituent of moulding sands, as it greatly reduces the refractoriness. This fact should be carried in mind as the mica content of this sand may prohibit its use for certain moulds.

The difficulties attendant upon mining may prove important factors in the cost of production. It may be that, as the deposit is worked, the thickness of the glacial drift will so increase that tunnelling will have to take the place of the open workings now used. The difficulties which will arise when mining has progressed below the level of Diogenes brook must also be considered. It was noted during the testing that water entered the low test-holes as soon as they were 2 or 3 feet below the surface, indicating a shallow and mobile water-table. The width of the valley will not permit the brook to be diverted except near the headwaters, and if difficulties are met from this source it will be necessary to devise some other method to take care of the water.

DEEP BORINGS IN ONTARIO AND MARITIME PROVINCES[1]

By E. D. Ingall

The Borings Division of the Geological Survey exists for the purpose of securing, when possible, records of borings made in Canada, whether in search for water, petroleum, or natural gas, etc. It is now universally recognized that the collection of reliable data illustrative of the nature and structure of the strata passed through in boring is of the utmost importance for the intelligent direction of efforts to locate gas, oil, water, etc.

This work is carried on directly in co-operation with operators in some provinces, and in others with the assistance of provincial and federal government organizations, and results in the building up of extensive reference files of well records obtained from drillers, geologists, and others. In order to study the characteristics of the strata penetrated by boring operations, samples, in the form of pulverized rock or cuttings, of the material produced during the process by the ordinarily used percussion tools, are taken by the driller at about 10-foot intervals and sent to the Borings Division. They are there submitted to intensive study by chemical, mechanical, and microscopic methods, and the succession and characters of the strata established and utilized for the guidance of further drilling operations.

Since the establishment of the succession in depth of the various strata is greatly facilitated by a study of the fossil contents these evidences are carefully looked for, and where the samples are solid rock, as produced by the various types of core-drill, the geological ages of the various strata can in many cases be definitely established and the distance to be bored to reach conditions favourable to the occurrence of gas, oil, etc., approximated in advance. The samples received from the borings made with percussion or rotary drills are in pulverized form, so that the larger fossil forms are destroyed and useless for the determination of the ages of the strata, but the smaller forms of life known as ostracods, diatoms, foraminifera, etc., are available for this purpose.

The following tabulation gives the particulars of the records, etc., received during 1926, from eastern Canada.

[1]Information regarding boring records for the Prairie Provinces will be found in part B of Summary Report, 1926.

Records Received from Eastern Canada, 1926

Location						Description					Remarks
Lot	Con-cession	Township	County	Province	At or near	Year drilled	Depth in feet covered by records	Yield	Depth in feet to first rock	Number of samples received	Drilling company, well name, etc.
7	I	Gosfield South...	Essex.......	Ontario..	....	1925–26	1,092	Gas	112	....	H. C. Riach
18	II	Colchester........	"	" ..	....	....	1,440	....	....	....	Eagle Oil Co. (graphic log)
......	....	Romney..........	Kent.......	" ..	186 Talbot rd.....	1925	1,320	Gas	155	....	Union Natural Gas Co., No. 253
......	II	"	"	" ..	Gore A...........	1926	1,378	Gas	134	....	Southern Ontario Gas Co., No. 2
5	XIII	Camden..........	"	" ..	Gore.............	1924	597	Oil	40	....	Ajax Oil and Gas Co., No. 1
3	III	Dover West.......	"	" ..	....	1925	3,774	....	86	....	Union Natural Gas Co., No. 19
19	XIV	Walsingham North	Norfolk....	" ..	....	1926	1,334	Gas	207	....	The Dominion Natural Gas Co.
8	A	Walsingham South	"	" ..	....	1925	1,468	Gas	315	....	" "
14	A	" "	"	" ..	....	1925	1,355	Gas	274	....	" "
......	....	" "	"	" ..	Port Rowan......	....	1,371	....	300	....	" "
14	II	Middleton........	"	" ..	....	1925	1,307	Gas	....	....	" "
17	II	"	"	" ..	....	1925	1,308	Gas	243	....	" "
18	II	"	"	" ..	....	1925	1,291	....	229	....	" "
16	III	"	"	" ..	....	1925	1,284	Gas	230	....	" "
16	II	"	"	" ..	South Talbot rd..	1925	1,322	Gas	245	....	Medina Natural Gas, No. 1
16	II	"	"	" ..	" "	1925	1,326	Gas	246	....	Medina Natural Gas, No. 2
16	II	"	"	" ..	" "	1925	1,367	....	246	....	Dominion Natural Gas, No. 2
16	III	"	"	" ..	" "	1925	1,298	Gas	235	....	Medina Natural Gas, No. 3
17	III	"	"	" ..	" "	1925	1,302	Gas	231	....	Dominion Natural Gas
4	I	Cayuga north.....	Haldimand.	" ..	....	1925	700	Gas	60	....	Canboro Gas and Oil Co., Ltd.
4	II	"	"	" ..	....	1925	705	Gas	60	....	" "

6	III	"	"	"		1925	706	Gas	57		Dominion Natural Gas Co.
10	IV	"	"	"		1925	748	Gas	100		" "
9	I	"	"	"	North Talbot rd.	1925	650		55		Azoff Gas Co.
6	I	"	"	"	South Talbot rd.	1925	640		52		" "
25		"	"	"	" "	1926	584	Gas	37		Dominion Natural Gas Co.
S. ½ 8	I	"	"	"	" "	1925	687	Gas	37		The Canfield Gas Co.
6 and 7		Moulton	"	"	Gore Bay	1925	728		107		United Gas Companies, Ltd.
N.E.	IV	Rainham	"	"		1926	898	Gas	1		O.G. Richheld and Associates
2	V	"	"	"		1926	917	Gas	19		The Dominion Natural Gas, Ltd.
2	V	"	"	"		1925–26	952	Gas	9		" "
3	V	"	"	"		1925	915	Gas	5		Erie Gas and Oil Syndicate No. 8
7	VI	"	"	"		1925	880		15		Erie Gas and Oil Syndicate No. 7
7	VI	"	"	"		1925	905	Gas	27		Erie Gas and Oil Syndicate No. 5
6	VI	"	"	"		1925	880	Gas	15		Erie Gas and Oil Syndicate
6	V	"	"	"		1925	915	Gas	17		Erie Gas and Oil Syndicate No. 4
7	V	"	"	"		1925	925	Gas	28		Erie Gas and Oil Syndicate No. 6
2	IX	"	"	"		1925	859		7		W. C. Patterson
24	V	Walpole	"	"		1926	913	Gas	16		The Dominion Natural Gas Co.
12	VI	"	"	"		1925	940		24		" "
23	VI	"	"	"		1925	920	Gas	17		" "
15	VII	"	"	"		1925	930	Gas	24		" "
14	VII	"	"	"		1925	937		35		" "
16	VII	"	"	"		1925	939	Gas	13		" "
13	VIII	"	"	"		1926	912	Gas	5		" "
16–15	VIII	"	"	"		1925	926	Gas	20		" "
17	VIII	"	"	"		1925–26	921	Gas	18		" "
1	I	Wainfleet	Welland	"		1925	867	Gas		20	The Sterling Gas Co., No. 2
1	I	"	"	"		1925	867	Gas	20		The Sterling Gas Co., No. 72
1	I	"	"	"		1925	912	Gas	9		The Sterling Gas Co., No. 71
32	I	Humberstone	"	"		1925	918	Gas	11		The Sterling Gas Co., No. 74

Records Received from Eastern Canada, 1926

Location						Description					Remarks
Lot	Concession	Township	County	Province	At or near	Year drilled	Depth in feet covered by records	Yield	Depth in feet to first rock	Number of samples received	Drilling company, well name, etc.
32	I	"	"	"	......	1925	871	......	8	......	The Sterling Gas Co.
33	I	"	"	"	......	1925	912	Gas	10	......	The Sterling Gas Co., No. 73
......	......	"	"	"	Cassidy point.....	1925	913	Gas	......	27	Provincial Natural Gas Co.
1	II	Caistor...........	Lincoln.....	"	......	1925	515	Gas	78	......	Lincoln Gas Co.
1	I	Gainsborough.....	"	"	......	1925	515	Gas	68	......	" "
8	I	"	"	"	......	1925	515	Gas	49	......	" "
33	V	"	"	"	......	1925	450	Gas	87	......	" "
11	I	Flamborough West	Wentworth.	"	Woodly farm......	......	2,123	......	220	......	Valley Oil and Gas Co.
13	III	Tuscarora.........	Brant.......	"	......	1925–26	1,002	Gas and oil	82	......	Senator Michener
8	III	Onondaga.........	"	"	......	1925	650	Oil	......	....	Canadian Dutch Oils
12, 13, 14	III	"	"	"	......	1925	575	Gas	98	......	Dominion Natural Gas Co., well No. 1
......	......	......	"	"	Brantford highway	1926	560	......	......	87	R. Devereau well No. 1
......	......	Blanchard.........	Perth......	"	St. Marys.........	......	1,528	......	......	......	
20	II	Logan............	"	"	......	1926	3,187	......	......	451	Mitchell Oil Syndicate, well No. 1
......	......	Artemesia.........	Grey.......	"	Front street, Flesherton	......	668	......	......	......	T. Peat, driller
26	VII	Collingwood......	"	......	......	......	747	Gas	30	......	Blue Mountain Oil and Gas Co.
......	......	Granby...........	Shefford....	Quebec...	Granby..........	1926	931	......	......	44	W. Bell Co.
......	......	......	Inverness...	Nova Scotia	2 miles north of Southwest Mabou	......	215	......	......	116	Eastern Gulf Oil Co.
		Prince Edward Island			Governor island..	......	1,507	......	......	53	Doherty Co., well No. 1
		" "			" "	......	4,127	......	......	413	Doherty Co., well No. 2

In Ontario the work of the division was carried on, as in past years, in co-operation with Col. R. B. Harkness, Commissioner of Gas for the Provincial Government. Logs of some sixty-six wells, representing an aggregate length of boring of 77,537 feet, were received and copies made for the records, the originals being returned to Toronto. Sets of samples were received from a number of these wells.

The policy followed during the existence of the Borings Division, of acquiring and filing sets of samples in an orderly way, has justified itself on many occasions. Often where districts have been abandoned for years a renewal of boring operations has led to a demand for the logs of old wells and to a need for further examination of the samples. With the advance of geological science, new methods of study of the material are developed and new data are sought in the laboratory examination of the well cuttings, which were necessarily not foreseen in the past. Several instances of this need have occurred during the year and one of special interest occurred in connexion with the investigation of the helium-bearing natural gas obtained in the vicinity of Inglewood, Caledon township, Peel county, Ontario. In connexion with the boring operations undertaken in search for further supplies of helium inquiries were naturally made as to what information was available in the files of the Borings Division and as to what sets of samples from nearby borings would be available should more detailed study of the material be advisable. It was found that samples were available from a boring in the vicinity, put down in the year 1922 to a depth of 935 feet and passing into the Trenton formation at 880 feet.

In aid of the studies by Colonel Harkness of the Palæozoic strata in the peninsula of Ontario, laboratory examinations by the officers of the Borings Division were made of a number of wells from which samples had been received in past years. Preliminary examinations had been previously made during the progress of the borings, giving results for the guidance of the drillers, but the detailed examination had to be deferred. Graphic and other logs were prepared and copies sent to the Gas Commissioner for his use. In this connexion, also, a map was prepared showing the location of all wells from which samples had been received and were on file.

Thanks to the courtesy of the Wallace Bell Drilling Company of Montreal, samples were received from a well put down by the firm for the Miner Rubber Company of Granby, Quebec.

Few deep-boring operations were reported from Quebec and the Maritime Provinces, although there were doubtless the usual number of shallow wells bored for water supplies for country homes, villages, and small towns. These are undertaken by local drillers operating light portable rigs, are seldom reported to the Department, and would be mostly shallow wells in the surface deposits which would give little information regarding the underlying bedrock strata. These surface deposits of clay, sand, gravel, etc., have to be depended on over large regions in eastern Canada for most of the supplies of potable water, as that obtained in the underlying bedrock strata is in so many cases high in dissolved mineral salts. The quantity obtained by deep boring in these lower formations is in many localities largely dependent upon the accidental encountering of extended systems of channels representing fissuring or enlargement of joint-planes in limestones, etc., where solution of the walls by circulating surface waters can occur.

In Prince Edward island very complete sets of samples were obtained from two deep borings put down by the H. L. Doherty Company of New York on Governor island in the harbour of Charlottetown. The No. 1 well of this company was abandoned at 1,507 feet owing to difficulties encountered in drilling. The No. 2 well was, however, very successfully and speedily put down to a depth of 4,127 feet, when work was suspended. Laboratory work was done on all the 466 samples received and the results sent to the company in the form of graphic logs. To the depth attained there was no change in the general character of the strata, so that the hoped-for knowledge of the formations lying beneath the red and grey, incoherent, loose, sandy shales, sandstone, and shales of Permian (?) age was not forthcoming. Similar graphic logs of the two nearby borings put down by the Geological Survey in 1909 were also sent for comparison. These borings attained to the depths of 1,685 feet and 1,910 feet, so that the present borings add to our knowledge of the character of these flat-lying strata in depth by 2,217 feet. The deepest of the borings formerly put down in various parts of the island by the Geological Survey only attained a depth of 2,080 feet.

In New Brunswick no deep borings were reported outside of the activities of the New Brunswick Gas and Oilfields, Limited, which are practically confined to the deepening of various wells. As any samples obtained would be duplicating nearby borings from which the Borings Division has already received sets of samples, nothing was received during the year from this already thoroughly prospected field.

In Nova Scotia, interest in the oil and gas possibilities of the province has been revived due to the activities of the Gulf Oil Company, the H. L. Doherty Company, and the International Petroleums, Limited, whose officials have been studying the formations of the province in contemplation of a campaign of boring tests to be put down at likely places. Some few samples of cores from a boring by the Gulf Oil Company at Mabou represent, however, all that has been received from the province, and the inauguration of any extensive boring campaign is still in the future.

Particulars of the work done in the Laboratory of the Borings Division are given below by Mr. D. C. Maddox who is in charge of this branch of the work.

LABORATORY REPORT

MARITIME PROVINCES AND ONTARIO

With the exception of a few samples taken from a diamond-drill hole put down to a depth of 215 feet near Mabou, Nova Scotia, the only wells in the Maritime Provinces from which samples were received and examined were two put down in Prince Edward island by the H. L. Doherty Company of New York. Of these wells, No. 1 was drilled to a depth of 1,507 feet, and then abandoned. No. 2, situated 80 feet south and 20 feet east of No. 1, was drilled to a depth of 4,127 feet during 1926. Both wells are in the northwest corner of Governor island near Charlottetown, Prince Edward island. In all, 435 samples from the two wells were examined. The usual tests were made, determinations of material insoluble in hot dilute hydrochloric being made at intervals of 50 feet. Graphic logs of both wells were made and copies sent to the owners of the well. A sample of water taken from well No. 2 at a depth of 1,509 to 1,519 feet, was received by the Borings Division and submitted to the Mines Branch for analysis. The results of this analysis showed a salinity of approximately two and one-half times that of sea-water, with the chlorides of calcium and magnesium unusually high.

Eight samples from a diamond-drill core, sent in by an officer of the Eastern Gulf Oil Company, were also examined.

In the province of Ontario, with the exception of a single well in Carleton county, all the wells from which samples were received and examined were located in the peninsula region. This work was done at the request of Colonel Harkness, Gas Commissioner for Ontario, and the results of the sample examination were transmitted to him. Quantitative tests for the amount of material insoluble in hot dilute hydrochloric acid were made on all of the 784 samples, in addition to the usual lithological and colour descriptions. The results of the examination were expressed in graphic log form. The list of wells from which samples were examined follows:

Borings Division number	Location	Depth of samples
		Feet
443—64	Lot 18, con. II, Colchester tp., Essex co	40—1,440
431—53	Flesherton, Grey county	165— 668
431—57	Lot 26, con. VII, Collingwood tp., Grey co	0— 747
436—20	St. Mary, Blanchard tp., Perth	475—1,528
429—58	Lot 11, con. I, Flamborough West tp	1—2,123
432—57	Port Rowan, Ontario	115—1,371
426—59	Cassidy point, Humberstone tp., Welland co	500— 915
426—60	Lot 1, con. I, Wainfleet tp., Welland co	1— 867

In view of a renewed interest in the oil and gas possibilities of the area south of Ottawa river and east of the city of Ottawa, and included in the counties of Carleton, Russell, and Prescott, samples received some time back from a boring put down at Carlsbad Springs were examined in considerable detail, "insolubility" tests in acid being made on most of the 181 samples, covering a depth of 1,920 feet. A graphic log of the well was also made.

The only samples examined from the province of Quebec were 75 sent by the Department of Railways and Canals and obtained by them in the course of sinking test-holes in the district of Lachine and adjacent areas. The nature of the rocks of this area necessitated considerable detailed work to distinguish the chief types. This work was a continuation of that done in 1925. The results of the examination were sent to the Department which sent in the samples.

On practically all of the samples received from the Maritime Provinces, Ontario, and Quebec, effervescence tests with cold and hot dilute hydrochloric acid were made. This was of great assistance in distinguishing between limestones, magnesian limestone, and dolomites. A brief optical examination of the insoluble residue was also made and the original sample was submitted to an optical examination, the samples in some cases being rewashed, and dried, previous to this examination.

In addition to the work of sample examination the Borings Division undertook the mechanical analysis of fifteen samples of moulding sands obtained from a deposit on Diogenes brook near Whycocomagh, Inverness county, Cape Breton island. The samples were collected by Mr. M. E. Wilson.

OTHER FIELD WORK

Geological

T. L. Tanton. Mr. Tanton continued the detailed geological and geographical survey of Steeprock area, Rainy River district, Ontario, bounded by latitudes 48° 45′ to 49° and longitudes 91° 36′ to 92°. Further field work is necessary before publishing a report upon the area.

H. M. Bannerman. Mr. Bannerman commenced detailed examination and mapping of pyritiferous iron formations in the vicinity of Nickel and Furlonge lakes, Rainy River district, Ontario. This work will be continued in 1927.

E. Thomson. Mr. Thomson completed the geological and geographical mapping of the Woman River and Ridout areas, Ontario, lying between latitudes 47° 30′ to 47° 45′ and longitudes 82° to 83°. A report and maps are being prepared.

W. H. Collins. Mr. Collins continued geographical and geological mapping of Espanola area, an area of about 400 square miles immediately west of Sudbury nickel basin, Ontario, between latitudes 46° 15′ to 46° 30′ and longitudes 82° to 82° 30′. C. Tolman, in the same area, mapped and studied the Birch Lake granite. Further work will be done in 1927.

T. T. Quirke. Mr. Quirke continued the detailed survey and investigation of the mineral resources of an area along the north coast of Georgian bay, in the vicinity of the mouth of French river and westward, Ontario. A report upon part of this work and two maps are now nearly complete.

R. H. Pegrum. Mr. Pegrum made a detailed study of the nepheline syenites and related intrusives in the vicinity of French river, Ontario.

E. M. Kindle. Mr. Kindle examined newly exposed parts of the Welland Canal section and certain lake marl deposits in Ottawa valley.

A. E. Wilson. Miss Wilson continued the detailed geological study of Cornwall area, Ontario, between latitudes 45° to 45° 15′ and longitudes 74° 30′ to 75°.

B. S. W. Buffam. Mr. Buffam completed a geological survey of Abitibi East and Taschereau areas which extend eastward from Abitibi lake, Quebec, and form part of the "Rouyn" mineral district.

J. W. Goldthwait. Mr. Goldthwait completed a study, begun in 1925, of the physical features and geological history of the lowlands bordering St. Lawrence river. An account of this work is being prepared.

W. V. Howard. Mr. Howard completed the geological mapping of Carleton area bordering Chaleur bay in the vicinity of Carleton, Quebec, and bounded by latitudes 48° to 48° 15′ and longitudes 66° to 66° 30′. A report and map are being prepared.

A. O. Hayes. Mr. Hayes continued geological mapping of an area of about 400 square miles extending east and northeast of St. John, New Brunswick.

V. Auer. Mr. Auer investigated various peat bogs in New Brunswick and Nova Scotia for the purpose of ascertaining the conditions under which peat bogs have originated and of determining their economic value. A report upon this work, which will require considerable time to complete, is in progress.

T. D. Guernsey. Mr. Guernsey geologically surveyed an area including North mountain, Inverness county, Nova Scotia.

L. J. Weeks and M. H. Haycock. Mr. Weeks and Mr. Haycock accompanied the C.G.S. *Arctic* on her annual cruise to the Arctic islands. They are to land and winter on Baffin island, in order to conduct a general exploration of the southern part of the island.

Topographical

A. G. Haultain. Mr. Haultain completed the geographical control surveys for the Collins Inlet and Panache areas between latitudes 45° 45′ to 46° 15′ and longitudes 81° to 81° 30′. Geographical control surveys were continued in the Key Harbour and French River quadrangles, between latitudes 45° 45′ to 46° 15′ and longitudes 80° 30′ to 81°, and triangulation and transit control surveys were carried on in the Espanola quadrangles. All this work is for the control of map-sheets being prepared in connexion with geological investigations in Georgian Bay district, Ontario. These maps, and all others mentioned below, will be published in standard size sheets, 30 minutes of longitude by 15 minutes of latitude, on a scale of 1 inch to 1 mile.

R. C. McDonald. Mr. McDonald carried out geographical control surveys for Steeprock area, Rainy River district, Ontario. He also made a primary control traverse along the Canadian Pacific railway eastward from Kinogama station for the purpose of controlling geographic surveys in the Woman River and Ridout quadrangles, Ontario.

S. C. McLean. Mr. McLean accompanied by S. M. Steeves, carried out a primary control traverse along the Canadian National railway from the Ontario-Quebec boundary eastward to Megiscane station. This work forms primary mapping control for several map-sheets embracing Rouyn district, western Quebec. Mr. McLean also carried out the primary control traverse for the Lockport sheets, Nova Scotia.

R. Bartlett. Mr. Bartlett carried out geographical control surveys for the Dubuisson, Duparquet, and Opasatika quadrangles in Rouyn district, western Quebec.

H. N. Spence. Mr. Spence geographically mapped Carleton area, Bonaventure county, Quebec.

K. G. Chipman. Mr. Chipman carried out control surveys for an area in the vicinity of the Nictaux-Torbrook iron mines, Nova Scotia. He also revised and completed the topographical survey of an area in the vicinity of Springhill, Nova Scotia.

W. H. Miller. Mr. Miller completed the topographical survey of Springhill area between latitudes 45° 30′ to 45° 45′ and longitude 64° to 64° 30′, and of more than one-half of the adjoining Oxford area, Nova Scotia.

J. V. Butterworth. Mr. Butterworth continued geographical mapping along bay of Fundy, Digby county, Nova Scotia. The mapping of Digby area, latitudes 44° 30′ to 44° 45′, longitudes 65° 30′ to 66°, was completed, and of Belliveau area, latitudes 44° 15′ to 44° 30′, longitudes 66° to 66° 30′, was commenced.

A. Southwest Margaree river, looking north from outlet of lake Ainslie. (Page 100.)

B. Laminated limestone at base of Windsor series at McLean point on north shore of lake Ainslie. (Page 105.)

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The annual Summary Report of the Geological Survey is issued in parts, referring to particular subjects or districts. This year there are three parts, A, B, and C. A review of the work of the Geological Survey for the year forms part of the Annual Report of the Department of Mines.