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HON. ARTHUR MEIGHEN, MINISTER; CHARLES CAMSELL, DEPUTY MINISTER.
GEOLOGICAL SURVEY
WILLIAM McINNES, DIRECTOR.

Summary Report, 1919, Part E

CONTENTS

OTTAWA
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PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
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No. 1820

SUMMARY REPORT, 1919, PART E.

SHORE OF LAKE SUPERIOR BETWEEN PORT ARTHUR AND NIPIGON.

By T. L. Tanton.

CONTENTS.

Illustration.

GENERAL STATEMENT AND ACKNOWLEDGMENTS.

In 1846, W. E. Logan examined the north shore of lake Superior from Pigeon river to Sault Ste. Marie and supervised the laying out of the original twenty-seven mining claims in the district. His report[1] marks the commencement of the history of mining on the Canadian shore of lake Superior. The search for mineral deposits at that time was instituted in the hope of finding deposits similar to those in the copper-bearing formations on the south shore. The largest area of the copper-bearing series (now termed Keweenawan) on the north shore was found to lie between Thunder bay and the eastern end of Nipigon bay, but since no workable deposit of copper was encountered no detailed geological mapping was undertaken. Many prospectors and geologists have examined this district but, as yet, no dependable geological map of the region is available.

In 1919, the only active industries relating to mineral production were: (1) the quarrying of Animikie indurated shale at Port Arthur for road metal; (2) the extraction of a grey and greenish shale from the upper measures of the Animikie in Hoorigan bay, for the manufacture of high grade brick; and (3) the dredging of a gravel composed of sized, irregularly shaped, small fragments of red quartz porphyry, off the east coast of Bowman island, for cement construction.

Metalliferous veins have been found at many places through the district and on certain of these a considerable amount of development work has been done. The recent advance in the price of metals, especially silver, suggests the desirability of re-examining the old prospects and compiling information which might assist in systematic prospecting for further deposits. Areal geological mapping will contribute toward the recognition of the great reserves of building stone in this region. The excellence of certain structural materials is known locally, but there is evidence that the extent of these deposits and their accessibility is not fully realized. For the purpose of assisting in the development of the mineral industry the Geological Survey plans to prepare a geological map-sheet extending from the Shebandowan sheet, Map 589, to the Nipigon basin,

[1] "Remarks on the mining region of lake Superior and report on mining locations addressed to the Commissioner of Crown Lands," 1846.

Canada
Department of Mines

HON. SIR JAMES A. LOUGHEED, MINISTER; CHARLES CAMSELL, ACTING DEPUTY MINISTER

GEOLOGICAL SURVEY

WILLIAM McINNES, DIRECTOR.

Issued 1920

LEAD AND ZINC BEARING VEINS, DORION TOWNSHIP AND VICINITY, THUNDER BAY DISTRICT, ONTARIO.

Scale of Miles

1 3/4 1/2 1/4 0 1 2 3

To accompany report by T.L.Tanton, Summary Report Part E, 1919.

C.O.Senécal, *Geographer and Chief Draughtsman,*
J.J.Carr, *Draughtsman.*

Publication N° 1811

Diagrammatic section along line A B

Horizontal scale of miles 1 3/4 1/2 1/4 0 1 2 3

Vertical scale of feet 500 0 500 1000

LEGEND

Mineral occurrences and trend of vein deposits

KEWEENAWAN
- Diabase (*dykes and sills*)
- Nipigon sediments

BASEMENT COMPLEX
- Granite and gneiss (*batholithic intrusives*)

Symbols
- Strike and dip of foliation
- Trails

Map 1090. The initial work which was performed by the writer in 1919 consisted in the examination of the principal mineralized localities of the district, the geological mapping of certain inland areas in the vicinity of Port Arthur and Dorion, and the examination of the shore and islands of lake Superior between Port Arthur and Nipigon. The shore geology was laid down on the excellent charts which have recently been completed by the Hydrographic Survey.

The writer was assisted in the field by A. G. Smart. Grateful acknowledgment is given for information supplied by members of the Port Arthur Board of Trade and Mr. John Cross of Silver Islet Landing.

TOPOGRAPHY.

The topographic features of the district are distinctly different according to the nature of the underlying rock. The areas of Pre-Huronian age show the mammillated surface such as characterizes the greater part of the Pre-Cambrian shield. The areas of Animikie and Keweenawan sediments appear as slightly inclined plains at various elevations. Diabase sills and dykes are found throughout the district and they form protecting mesa caps over the sediments or flat-topped ridges with precipitous cliffs at the sides. The Keweenawan lava area presents a variety of topographic forms, the most striking of which is the extremely rugged section of high relief in the southern part of St. Ignace island. The hill which rises 1,263 feet above lake Superior (which is 602 feet above the sea) 3 miles west of St. Ignace harbour, is the highest point in this vicinity. From the summit of this hill can be seen what appears to be the margins of successive lava outpourings that came from the south. The configuration of the surface with successive, irregularly scalloped terraces each out-curved toward the north is similar to that which may be observed near the margins of a viscous fluid which has been poured out intermittently on a plane surface. Field evidence indicates that the surface referred to has been exhumed comparatively recently.

All the main surface features have been modified in a measure by glacial erosion and the deposition of drift.

The differential erosion of comparatively soft or friable rocks and diabase intrusives has given rise to a number of indentations along the shore. Some of these were evidently formed at a time when the land was higher relatively to the water-level than at present, for they now form deep-water harbours. The most excellent of these, Nipigon harbour, with high protecting cliffs on either side of it, is the northern part of a submerged river channel which can be traced by soundings across Nipigon bay.

There are many small lakes in the hilly parts of the district. Numerous streams drain into lake Superior and accomplish their descent with such a number of falls and rapids as to be of no value as canoe-routes. The only river canoe-routes known west of Nipigon river are Black Sturgeon river and Wolf River system above Wolfe lake.

GENERAL GEOLOGY.

The solid rocks which occur on the north shore of lake Superior between Port Arthur and Nipigon are of Pre-Cambrian age and may be classed in two main divisions: the basement complex, and a younger division embracing the Animikie and Keweenawan.

Field observations indicate that rocks equivalent to the Couchiching, Keewatin, Pre-Huronian sediments and batholithic granitic intrusives of the districts to the east of lake Nipigon and to the west of Port Arthur are represented in the basement complex of this region. The rocks of this division do not occur abundantly along the shore, and of those present granite predominates.

The Animikie consists of a conformable series of sediments: conglomerate, siliceous argillite, a variety of peculiar ferruginous rocks usually referred to as

Iron formation, also black shale, greywacke, and dark greenish grey shale. Though this series is referred to as composed of sediments, since all appear to have been laid down in water in a state of fine division, it is known that some members are not normal sediments of erosion. The Animikie rocks outcrop around the shore of Thunder bay and along the end of Sibley peninsula for 6 miles east of Thunder cape.

The Keweenawan group consists of a series of interbedded and intermixed normal sediments and waterlain tuffs, a series of basic and acid lava flows, and dykes and sills of diabase which cut both sediments and lavas. The oldest of these rocks overlie the Animikie unconformably but with very slight discordance. The Keweenawan rocks are exposed along the greater part of the shore and on nearly all of the islands east of Thunder bay.

Keweenawan Epoch.

The most significant results of the season's work are here indicated by giving a concise statement of the geological history, embracing periods of mineralization, during Keweenawan time, as interpreted from field studies.

At the beginning of Keweenawan time, as recorded in the rocks of the district, sediments were being deposited in comparatively shallow waters. This fragmental material was derived from two different sources and resulted from two different processes, one process being normal erosion which formed gravel and sand and the other being vulcanism of the explosive type which produced volcanic ash. The normal clastic sediments came from neighbouring land areas on which were exposed Animikie sediments and rocks of the basement complex. Presumably the locus of volcanic activity in the early Keweenawan was far to the south in what is now the basin of lake Superior, for the channels of extrusion (except for the later flows) cannot be found, and a considerable thickness (over 300 feet) of sediments and waterlain tuff had accumulated before the lava fields spread over them. The gradual extension of the limits of the successive lava flows from the south, and their successive retirement at a later date, can be traced in the wedge-like vertical sections which are thickest toward the south; and in the flow-front structures observed in the recently exhumed flows of St. Ignace island. The deposition of waterlain tuff, sandstone, and limestone continued without interruption in certain parts of the district beyond the margins of the lava flows and there appears to be no basis for an age division between the lavas and sediments of the Keweenawan in this district. The subsidence of the Lake Superior basin began probably before the cessation of volcanic activity, for the channels of extrusion for the later flows are so near the margin as to be visible on the Canadian shore. Native copper occurs as amygdule filling in several flows; it is widely disseminated and no concentration has been observed.

Subsequent to the extrusion of the youngest visible flows a widespread movement of the earth's crust (expressed in the upper zones by faults) seems to have taken place, a local manifestation of which was the settling of the Lake Superior basin. Through the numerous faults and fissures an enormous volume of igneous material welled up and solidified in the form of diabasic dykes and sills. Some of this material may have extruded as lava, but no recognizable lava was observed connected with this irruptive. At a later time, possibly when the diabase intrusives solidified and contracted, a great number of small faults and fissures were developed whose positions and trends bear a relation to those of the diabase intrusives, there being a considerable number parallel and a smaller number at right angles to the trend of the diabase dykes. These fissures were cemented with vein material.

ECONOMIC GEOLOGY.

The veins which formed subsequent to the diabase irruptives are the features of greatest economic interest. The limits of their distribution have not been determined, but they occur near the great diabase dykes in the vicinity of the lake shore from Pigeon point to Nipigon bay. They were formed, probably, during the same geological period and through the same agencies. They characteristically consist of calcite, barite, white and amethystine quartz, and, when mineralized, carry galena, sphalerite, chalcopyrite, and pyrite in varying proportions and, in certain localities, silver ores and small amounts of gold.

The majority of the veins of this system trend parallel to the course of neighbouring diabase dykes or the strike of inclined sill sheets, others trend nearly at right angles to this direction. The openings which they have filled appear to have been simple fissures and brecciated fault zones developed by tensional forces. Some of the fissures may have been formed at the same time as the openings through which the diabase intruded, but in certain places where the veins cut the diabase the cooling and contraction of these irruptives appear to have developed the tension cracks.

Information is not at hand for preparing an accurate geological map of any considerable area within which these veins occur. But a geological sketch map (Map 1811) of the Dorion district has been compiled on which is shown the location of several of the mineral deposits. Though the geological colouring has not been greatly extended beyond observed outcrops, the extent to which the mineralized fault zones and fissures in this district are related to diabase intrusives in orientation and proximity is indicated on the map. The renewal of interest in these deposits was in a large measure due to a recent discovery by Mr. E. Lebel of a vein mineralized with zinc and lead near Dorion, and the opportunities for further prospecting and development seem favourable in this district.

The mineralized fissure fillings are of the following types: simple veins, vein stockworks, and vein material occurring as cement around brecciated fragments of country rock along shatter zones. No replacement deposits have been observed and no brecciation of vein material has been noted. Variations between simple veins and breccia cement may occur in a single deposit within short distances, these changes being due largely to the physical properties of the enclosing rock, and to some extent, to the amount of deformation that took place when the fissuring occurred.

The following notes refer to mineral occurrences, shown on the map.

Dorion Township and Vicinity.

Claims T. B. 3358 and T. B. 3461 lying in unsurveyed territory a short distance north of concession XII, were discovered and staked by the owner Mr. E. Lebel of Dorion, in 1917. The claims are underlain by fine-grained, interbanded mica schist and gneiss, trending north 65 degrees east, and cut by numerous large and small dykes of granite and pegmatite and pegmatitic quartz veins. The mineralized deposit trends north 35 degrees east across this complex, it has the character of a simple vein about 2 inches wide where it crosses granite dykes and a vein stockwork localized within 12 inches where the country rock is mica schist and gneiss. The surface is gently rolling and mantled with boulder clay; on the low ridge where the vein is exposed, the boulder clay has an average thickness of about 4 feet. Blocks of mineralized material can be seen in the drift along the trend of the vein for a distance of 18 chains. The vein has been stripped for 5 chains and two 20-foot pits have been sunk one chain apart, one in the granite and one in the schist. In the granite, the vein is sharp-walled and free of inclusions of country rock; it dips almost vertically and widens from 2 inches at the surface to 13 inches at a depth of 20 feet. The

vein is banded and shows the following succession from the walls to the middle: calcite; mixture of calcite, galena, and black zinc blende; quartz and yellow zinc blende; barite. The proportions of these minerals vary along the trend, but in general the vein is well mineralized. The vein stockwork, exposed in the pit sunk in the mica schist, consists of numerous veinlets localized within 12 inches; they carry a small amount of chalcopyrite as well as the minerals found in the other pit. On the southwest face of this pit the mineralized vein cements a shattered fault zone, the fault plane dips 80 degrees toward the southeast, and the rock to the southeast has moved relatively downward about one foot. The Quebec government assay office reported the following values in material taken across the simple vein where its width was 10 inches: silver 1·05 ounce per ton; lead 34·22 per cent; zinc 21·23 per cent. An average sample of the mineralized material would show less lead and more zinc.

Location 6 L lies immediately north of concession VIII, lot 14. In 1876, the owner, Mr. C. J. Johnson of Wallaceburg, Ont., reported that two parallel veins occur on this property about 20 rods apart, trending northeastward. One of the veins is 12 feet wide. Galena and a small amount of chalcopyrite occur in a gangue of calcite, quartz, and barite.

In the same year the St. Clair location as described by Mr. C. J. Johnson, embraced parts of lots 10 and 11 in concession 6, and 9 and 10 in concession VII. A vein 12 feet to 20 feet wide trending a little north of east is reported carrying promising quantities of galena. It could be traced for 30 chains on the surface. It occurred on the high land a short distance south of the diabase cliff which lies about 4 miles west of Dorion.

Mr. C. J. Johnson also reported that on lot 10, concession VI, zinc blende occurred in a vein 3 or 4 feet wide trending northwest and southeast.

Lots 6-8 L embrace two mineralized fault zones which trend north 49 degrees east, and dip at a steep angle toward the southeast. One of these marks the contact between granite and Nipigon sediments. The rocks have been brecciated along a zone about 16 feet wide, and this breccia is cemented with quartz and calcite carrying small quantities of galena and zinc blende; several small simple veins cut this material and some of these are heavily mineralized with galena and sphalerite. The shaft which was sunk on this deposit some years ago, is locally known as the Dorion mine. The narrower mineralized fault zones which are shown on the map to the northeast and east of Dorion mine have Nipigon sediments on both sides of the faults at the surface. A great deal of work has been done on these deposits, but so far as known, no ore has been shipped, and operations have been suspended for over twelve years. Barite occurs in small quantities in the deposits of this system, and a local concentration was observed at a point near Bishops trail, 60 chains northeast of Dorion mine. Here, a vein of almost pure barite, 18 inches wide, can be traced for 4 chains through the brecciated Nipigon sediments; it trends north 49 degrees east and becomes narrower at both ends where it passes under drift.

On concession VI, lot 4, Stirling township, four well-defined brecciated zones, from 2 feet to 8 feet wide, and spaced at intervals of about 20 feet, trend parallel to each other north 55 degrees east. The Nipigon sandstone, which here forms a thin layer over the granite, has been step-faulted down on the southeastward, the total dislocation being about 5 feet. The brecciated zones are cemented with gash veins and vein stockworks composed of quartz and amethyst carrying small specks of chalcopyrite. Nothing of economic interest is exposed in this locality though stripping and test pitting have been done in the past.

The following note on the abandoned Ogema mine which lies 10 miles by road from Dorion station on mining locations 80E and 157E has been supplied by Mr. W. A. Cross of Port Arthur. A mineralized quartz vein averaging 3 feet in width and trending east of north cuts a high granite hill on this property. A few hundred feet east of the vein a dyke cuts the granite trending parallel

to the vein. The deposit which was discovered by an Indian named Ogema (or Ogama) was first worked by Mr. James Dickenson of Port Arthur, in 1890. A tunnel driven 125 feet into the base of the hill reached the vein and at the end of the tunnel a shaft was sunk to a depth of 25 feet on the vein. At the bottom of the shaft the vein was 5 feet wide and carried abundant galena with low silver values, and finely crystalline pyrite. The walls of the vein were of granite. Water difficulties caused cessation of development in 1890. The property was sold in 1892 to the Ogema Mining and Smelting Company who put down a 40-foot shaft on the vein near the top of the hill, about 300 feet above, and 800 feet to the northeast of the older workings. This part of the vein carried pyrite and very small quantities of galena and sphalerite. This material was regarded as gold ore and a small button of gold was recovered from rock treated on the property. The gold content, however, was too small to be of economic value. The mine closed in September 1892 and since that time the tunnel has caved in and the shafts have become filled with water.

The abandoned workings of the Enterprise mine are situated in McTavish township on mining lot C near the Canadian National railway about 2½ miles in a southerly direction from Ancliff. The vein trends north 60 degrees east and is said to occupy one of a series of step faults which are downthrown on the southeastern side. Nipigon sediments form the country rock on either side of the vein at the surface, granite occurs about 300 yards to the northward. Very rich lead ore carrying copper pyrites, gold, and silver occurred in the upper 4 feet of the vein, but in the lower workings the deposit was irregularly mineralized and for the most part lean[1]. The ore at this locality appears to have been the richest found in the district.

The location of the Arctic mine, McTavish township, is copied from the map in E. D. Ingall's report on "Mines and mining on lake Superior."[2] No information regarding this mine is at hand other than Mr. Ingall's note that work was in progress in 1884.

The Caribou lode, McTavish township, is one of a number of galena-bearing veins discovered in this vicinity in 1863 and 1865[3]. The vein occurs at the contact of a vertical dyke of diabase 12 feet wide which trends south 78 degrees east cutting flat-lying Nipigon sediments. The structural relations of the dyke and vein are exposed on the face of a cliff 20 feet high. The dyke occupies a fault fissure and a subsequent minor dislocation opened a channel which was cemented with vein material. In the dump, galena, sphalerite, and small amounts of pyrite and chalcopyrite occur in a gangue of white quartz, amethyst, calcite, and barite; the vein material occurs as a stockwork of veinlets and as a cement of wall rock breccia. The vein appears to have been small and irregular, but locally rich in galena and sphalerite.

A veinlet trending northeast and southwest, half an inch wide and over a foot long and composed of galena and quartz, was discovered 50 chains west of the extremity of Granite point in Nipigon sediments close to the granite contact

Silver Islet.

The vein which crosses Silver Islet is of a similar character to the lead- and zinc-bearing veins of the Dorion district in respect to its general mineral composition and its geological relationships. The bonanzas and pockets of rich silver ores which were found in the Silver Islet vein during the period of mining activity, between 1868 and 1884, were confined to a very small part of the explored vein, the largest ore-bodies being near the surface. It has been concluded from a study of structural relations in the district that the gravel-covered

[1] Personal communication; J. Cross, Port Arthur.
[2] Geol. Surv., Can., Ann. Rept., 1877, pt. H.
[3] Ibid, p. 13.

depression that extends across Sibley peninsula from Sawyer bay to Perry bay is an eroded multiple-fault zone. The landward extension of the fault occupied by the Silver Islet vein is recognized as one of the faults which traverses it. Other faults have not been located within this fault zone, but it is quite probable that the submerged vein, which occurs off the east headland of Perry bay and trends toward the depression, occupies a second fault. Silver-bearing veins might be expected to occur in the depression, on the mainland[1].

Iron and Copper.

The mineral deposits, other than those found in post-Keweenawan veins, which are of interest in the district are of iron and copper.

Iron formations of Keewatin and Animikie age present a variety of phases, one of which, in each case, is interbanded iron oxide and silica. The more ferruginous parts of this material constitute the iron ore of the district. The areas underlain by iron formation have been rather carefully prospected, and magnetic iron ore has been found in the Keewatin near Kaministikwia and hematite ore has been found in the Animikie near Loon lake[2]. As yet, no extensive body of ore which would run over 50 per cent iron is known in either the Keewatin or Animikie iron formation, but improved methods of beneficiation may in the future permit of the profitable development of the known ore-bodies.

Native copper occurs in the amygdules of certain Keweenawan lava flows in association with chlorite, calcite, agate, and zeolites; also in agate and calcite veinlets cutting the lava. The mode of occurrence is similar to that found in the Keweenawan lavas of Isle Royale and Keweenaw point, but no deposit of commercial importance has been discovered in the district between Port Arthur and Nipigon.

THE OIL FIELDS OF ELGIN, ESSEX, AND THE SOUTHERN PART OF KENT COUNTIES, ONTARIO.

By M. Y. Williams.

CONTENTS.

INTRODUCTION.

The field work undertaken in southwestern Ontario in 1919 was begun on June 2 and finished on July 22. The purpose was to survey the oil fields and prospects not covered in previous work. The work included a study and survey of the oil prospects south of the old oil field near Shetland, Lambton county;

[1] "Silver Islet and vicinity". Bull., Can. Min. Inst., May, 1920.

[2] Ont. Bur. of Mines, 1906, vol. 15, pt. 1, "The Animikie iron range," by L. P. Silver.
Mines Branch, Pub. No. 217, vol. 2, 1917, "Iron ore occurrences in Canada," by E. Lindeman and L. L. Bolton.

the drilling in Aldborough township, Elgin county; the late work in the Mosa oil field, Middlesex county; the Dutton oil field, Dunwich township, Elgin county; the Fletcher oil field, Tilbury East township, Kent county; the Romney and Wheatley oil fields, Romney township, Kent county; the Leamington oil field, Mersea township, Essex county; and the old Pelee Island oil fields.

H. F. Bush and W. O. White acted as field assistants, and performed their duties in a very satisfactory manner.

Important assistance was received from the following gentlemen: J. Quillinan, of Glencoe; John Slater, of Leamington; Wm. Flum, of Dutton; David Barr and C. C. Roberts, of St. Thomas; C. H. Bookmiller, of Tilbury; Chas. Palmer and Hugh Scratch, of Kingsville; John McLeod, of Bothwell; Wm. J. Hussey and A. Randall, of Petrolia; H. Smith, of Ruthven; E. S. Estlin, Gas Commissioner of Chatham; and H. R. Davis, general superintendent of the Dominion Natural Gas Company, of Buffalo, N.Y. To Mr. Davis the writer is indebted for the privilege of using the structural maps of the gas fields of Kent county, prepared for his company by their geological staff under the supervision of D. W. Williams. The structure and extent of the Kent County gas field is taken with slight variations from the maps.

ALDBOROUGH OIL PROSPECT.

Two wells were drilled by the Rockwood Oil Company, in 1918, south of Thames river, in Aldborough township, on what appeared to be favourable structure. No. 1 well which is located near a small creek, on the north end of lot 6, concession I, struck a heavy flow of salt water with considerable oil. No. 2 well which is about two-fifths of a mile north of No. 1, on the north end of lot 7, a short distance south of Thames river, encountered a very strong flow of salt water without any sign of oil. In 1919, another well was drilled near the northeast corner of the southwest quarter of lot 4, concession I, about $1\frac{1}{8}$ miles a little west of south of No. 1. This well struck some oil in the middle lime, but no oil in the Onondaga limestone.

Table of Wells.

Well.	No. 1.	No. 2.	No. 3.
Surface elevation	650 ft. A.M.T.	655 ft. A.M.T.	702 ft. A.M.T.
Surficial deposits	96 ft.	87 ft.	275 feet.
Middle lime at	258-14 ft. thick	214-19 ft.	275-7 ft.
"Corniferous" limestone at	317	344	314
Salt water at	370 with some oil.	495	
Finished at	386	495	

The geological section here consists in descending order of the following: surficial deposits of sand, gravel, and glacial tillite (that encountered in well No. 3 being especially hard to penetrate with the drill); soft clay shale known by the drillers as the "upper soap," but more properly called Petrolia shale; impure shaly limestone, the "middle lime" or Widder beds; soft shale, the "lower soap" or Olentangy shale; Corniferous limestone, popularly known as the lower or big lime. This limestone includes an upper portion of shaly limestone called the Delaware limestone, and a lower portion of fairly pure limestone, the Onondaga limestone. The production of oil is generally greatest from the lower beds of the Onondaga limestone.

From the table it may be seen that the elevation of the top of the Corniferous is, for No. 1 well, 333 feet, for No. 2, 311 feet, and for No. 3, 388 feet above

mean sea-level. Although the structure seemed favourable, as indicated by the rise in the formation toward No. 3, the results obtained from this well were such as to discourage further drilling in the vicinity. It is now clear that the high elevations reported for the Corniferous on lots 2 and 5, concession II, are due to the drillers mistaking the "middle" lime for the "lower" lime.

GAS FROM THE SALINA FORMATION IN EUPHEMIA TOWNSHIP, LAMBTON COUNTY.

During the autumn of 1918 and the summer of 1919, the Castle Oil Company prospected the area south of the shallow oil field at Smiths Falls, Lambton county. Drilling was carried on there a few years ago, and a good gas well was struck on the east end of lot 26, concession IV. The production was estimated at about 250,000 cubic feet of gas per day of 24 hours, and the well has been supplying the village of Shetland and the neighbouring farms with gas for more than three years. The first well drilled by the Castle Company is situated on the Palmer farm, on the east end of lot 25, concession IV, and was completed and closed in on March 1, 1919. Gas was struck at 1,585 to 1,590 feet from the surface and a little oil was struck at 1,690 feet. This well is said to promise a fair production of gas. In No. 2 well on the Moorhouse farm near the middle of the west half of lot 25, concession V, oil and gas were struck at 1,605 to 1,611 feet, and, after shooting, the well was reported to have an open flow of about 1,000,000 cubic feet of gas, the closed pressure being about 750 pounds per square inch. In well No. 3, situated on the Tanner farm in the northwest corner of the east half of lot 24, concession V, the drill penetrated 15 feet of black shale; and on the assumption that the shale indicated unfavourable structure the well was abandoned.

It may be pointed out that only by a purely fortuitous circumstance has the presence of the black Huron shale over the Hamilton formation indicated low and consequently unfavourable structure for oil and gas. The great formations of the region lie for the most part in parallel arrangement, and as the erosion accomplished by the glaciers reduced the rock surface to the semblance of a plain, it followed that the highest formation (in this case the Huron shale) would be preserved in the structural depressions. It has so happened that in the shallow oil fields (those in which the oil occurs in the Corniferous formation) the edge of the black shale areas is the approximate limit of the oil fields. That this is not true in every case is shown in the eastern part of the Petrolia field, where oil occurs beneath the black shale. In testing the Salina and lower formations, the presence of black shale should not be relied upon entirely for the structure of the oil or gas horizons, for the deeper formations may depart to a considerable degree from parallelism with the upper strata.

In well No. 4, on the Leng farm, in the southwest corner of the east half of lot 27, concession V, about one foot of black shale was penetrated by the drill; but the well was completed and is reported by the company to have an open flow of approximately 350,000 cubic feet of gas per day, the rock pressure being 780 pounds per square inch. Two additional wells are reported to be in progress, one on the Smith farm in the northeast quarter of lot 26, concession IV, and one on the Tully farm in the southwest corner of the northwest quarter of lot 27, concession V. The anticline on which the shallow oil field is situated, pitchee to the north, and deep drilling at a previous date found no oil or gas in the Salina to the north of Sydenham river. The Moorhouse well, above described, is the best well in the field, the available information thus indicating the probable location of the extension of the oil pool to the south rather than to the north. Reducing the reported occurrences of oil and gas to sea-level, the gas horizon in the original well supplying Shetland is 1,034 feet below sea-level; the horizon in No. 1 well of the Castle Oil Company is 932 feet below sea-level, the lower oil horizon being 1,033 feet below; in No. 2 well the gas horizon is 945 feet below

sea-level. This would suggest that there may be a still higher structure in the gas horizon on lot 24, concession IV.

DUTTON OIL FIELD.

The so-called Dutton oil field is situated on lots 13, 14, and 15, con. 10, Dunwich tp., Elgin co. This field was opened in 1898, produced its maximum amount, 19,376 barrels, in 1906 and has now dropped to a small but relatively constant production, that for 1919 being 1,272 barrels.

The oil is obtained from the Onondaga limestone, the average depth in it being about 168 feet. The following log is of a well drilled by the Elgin Field Oil and Gas Company[1], near the centre of the field on lot 13, con. X, Dunwich tp., Elgin co.

	Thickness. Feet.	Depth. Feet.
Surface	200	200
Shale	7	207
Blue clay shale	25	232
Corniferous (Onondaga and Delaware)	170	402

Oil at 392 feet.

With the data at hand, it is possible to draw the boundaries of the field as shown by the drilling and it is of interest to note that the oil accumulation, although it includes the apex of the dome, occupies a position for the most part on the west side of the fold. Drilling on the east side did not prove successful.

An abandoned deep well on lot 15, concession XI, contains considerable oil, and during the summer of 1919, the Beaver Oil and Gas Company drilled a well on the adjoining lot to the west. This well is reported by the superintendent to have struck oil at 440 feet from the surface, or 168 feet in the Corniferous. The initial production was two barrels per day, but it has now (March 1919) fallen to about one-half barrel. The well has not been shot and no additional drilling has been done. The structure at this locality appears to be very similar to that of the field to the north, and there is a sufficient amount of unexplored land to permit of the opening of a small field.

The Dutton field is not troubled with much water, and the operating costs are consequently light.

ROMNEY SHALLOW FIELD.

The Romney oil field was situated in the north-central part of Romney township, on lots 21 and 24, concessions IV and V. The main activity appears to have been along the road separating the concessions. This field was opened in 1906, produced 11,165 barrels in 1908, 1,082 barrels in 1909, and was abandoned in 1910. Today a few abandoned wells mark the location.

The oil which was heavy and "dead" was obtained from the Corniferous limestone at an horizon about 30 feet below its top, which is there about 170 feet below the surface. The field was clearly a "top show" field, that is a field which contains its oil in rock crevices rather than in porous rock. Such a field yields its oil readily, but rarely lasts long. It is reported that the field was carelessly drilled and that the consequent water troubles shortened its life and curtailed the production of oil. There is not sufficient information regarding this field to make it possible to construct an accurate structural map.

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[1] Ont. Bur. of Mines, vol. XIV, pt. I, p. 108.

TILBURY OIL FIELDS.

Fletcher Field. The Fletcher oil field was situated to the south, west, and north of Fletcher and covered about 5,000 acres in Tilbury East township and 600 acres in Raleigh township, Kent county This field was discovered in 1905, attained its maximum production of 344,358 barrels in 1907, and is now abandoned, with the exception of nine wells on lot 1, con. VIII, Raleigh tp. The oil was obtained from light buff-coloured dolomite at the top of the Guelph formation, or at the base of the Salina. Gas was obtained from the oil horizon and from the overlying shales and dolomites of the Salina formation.

Enormous quantities of gas occurred with the oil and as there was little demand for the gas at the time that the oil was being exploited, much of it was wasted. From the standpoint of oil production, the occurrence of a heavy flow of salt water a short distance below the oil, was the most serious problem to solve. According to the best available opinion it was largely mismanagement of the salt water that caused the field to be closed down prematurely. When wells on the Halliday farm (north half lot 1, con. VI, Raleigh tp.) were "pulled" in 1919, the workmen stated that the salt water flowed from the mouths of the wells. Another factor contributing to the early abandoning of the wells, was the high price offered for old casing, during the period of the Great War. In several cases, it is stated, properties producing as much as 200 barrels of oil per month were abandoned in order that the casing in the wells might be sold.

The structure of the oil-bearing formations cannot readily be determined owing to lack of data. The top of the Guelph formation is not easily distinguished in drill cuttings, and it is not well established that the oil and gas are confined to a well-defined stratum, as there is no definite, impervious covering formation. From the general study of the region, however, it seems probable that the lower formations have a structure nearly parallel to the Corniferous limestone. In that case the gas occurring so plentifully to the west of the oil field occupied the top of the dome (as would be expected) and the oil occupied its east side and the adjoining terraces. The following log of the Fletcher well has been prepared by the writer from drill cuttings furnished by the driller, and may be taken as representing the geology of the field, although the well was a little to the east of the producing oil field.

5866—2½

Location. South half of lot 1, con. VI, Raleigh tp., Kent co., north of the town of Fletcher.

			Thickness.	Depth.	
			Feet.	Feet.	
Devonian.	Surface.	blue clay	85	85	
		gravel	5	90	Fresh water.
	Huron	black shale	20	110	
	Hamilton.	shale, limestone, shale	170	280	
	Delaware	limestone	50	330	
	Onondaga	limestone	110	440	
		chert at 395.			
	Oriskany?	sandstone	5	445	Contains brine and sulphur water.
		dolomite	30	475	
		sandstone	5	480	
		dark buff dolomite	150	630	
		chert beds	20	650	
	Detroit River series.	buff dolomite	50	700	
		chert beds	60	760	
		buff dolomite	10	770	
	Sylvania?	fine sand in dolomite	20	790	
Silurian.	Bass Island	brown and buff dolomite	110	900	
	Salina.	grey shale	120	1,020	
		brown dolomite	70	1,090	
		dark grey shale	20	1,110	
		shale and dolomite	70	1,180	
		black shale	40	1,220	
		buff dolomite	40	1,260	
		dark shale	30	1,290	
		buff dolomite	70	1,360	
		grey shale	20	1,380	
		light buff dolomite	70	1,450	Oil and gas.
	Guelph and Lockport.	light buff and grey dolomite	10	1,460	Brine.
		cream dolomite	60	1,520	
		brown and grey dolomite	160	1,680	
	Rochester. Clinton. Medina-Cataract	(no record.)	70	1,750	
	Manitoulin	dolomite	50	1,800	
Ordovician.	Queenston.	grey shale	15	1,815	
		red shale	85	1,900	
		grey shale	10	1,910	
		red shale with grey streaks	90	2,000	
	Richmond. Lorraine. Utica.	grey shale and dolomite, principally shale to		2,780	
	Trenton and lower formations		387	3,167	Bottom of well.

The following log[1] illustrates the occurrence of oil and gas in the Tilbury field.

Location. Lot 6, con. IX, Tilbury East tp. Elevation 600 feet above sea-level.

—	Thickness.	Depth.	Formation.
Boulder clay	95	95	Surface.
Grey sand	5	100	"
Clay and gravel	28	128	"
Blue clay shale (upper soap)	37	165	Hamilton.
Middle lime	10	175	"
Blue clay shale (lower soap)	67	242	"
Yellow limestone	158	400	Corniferous.
Grey, drab, brown, and blue dolomites with gypsum and flint	.....	.....	.....
Shaly series with darker shaly dolomites and more gypsum from 835 to 1,185	1,020	1,420	Salina.
Blue white dolomitic limestone	9	1,429	Guelph.

Gas at 1,250, 1,362, 1,370, 1,376, 1,382 feet.
Oil at 1,392 to 1,400 and at 1,416 and 1,426 feet.
A little surface gas.

Future Prospects in the Tilbury Field.

It appears clear that the oil of the Tilbury field has not been as nearly exhausted as it might have been, and the question arises as to the probability of reopening parts of the field. The difficulty arising from water, both salt and fresh, is the serious drawback to further development. Although it is reported that the wells were plugged at the time the casings were pulled, the trouble was serious before the wells were abandoned, and it is probable that the oil-bearing rock is largely flooded. Possibly, with the lapse of time, a reconcentration of the oil may take place and there may be a further production. It is of interest to note that the north half of lot 3, con. VIII, Tilbury East tp., although surrounded by some of the best producing wells of the field, has never been drilled. If further work is to be done in the field, this appears to be the logical place to start. This field was not drilled as closely as the shallow fields, about ten wells to 100 acres appearing to have been an average number.

GLENWOOD OIL FIELD.

A number of gas wells south of Glenwood have produced oil as well as gas. Seven wells on the south half of lot 10, con. IV, Tilbury East tp., are producing both oil and gas at the present time, the oil production being small.

The records of four of the wells indicate that the productive horizon varies from 1,385 to 1,408 feet below the surface or 752 to 776 feet below sea-level, the dip being to the north. The structure of the Onondaga limestone in this area appears to be a narrow terrace or nose extending to the northeast from the higher structure to the south and west; but sufficient data are not available to indicate the structure of the oil-bearing strata. The area around the oil pool has been extensively drilled, and the pool is, in consequence, clearly outlined. Although descriptive logs of these wells are not at hand, the correspondence between these wells and those of the field to the north would indicate that the gas horizon is at the top of the Guelph dolomite. The gas and oil evidently come from the same horizon. In general this little pool is closely related to the Fletcher field.

[1]Sixteenth Report, Ont. Bur. of Mines, 1907, p. 103.

WHEATLEY OIL FIELD.

The Wheatley oil field was opened up between 1902 and 1904; in 1904, four wells on lot 11, con. II, Romney tp., were producing forty barrels per day. In the same year the production was reported by the Ontario Bureau of Mines as being about 4,490 barrels. By 1906 the production had fallen to 775 barrels.

The four wells mentioned appear to have been the principal producers, the oil being found in the Guelph formation at a depth of 1,290 to 1,300 feet from the surface, or 690 feet below sea-level. No reliable log of this field is available, but Malcolm reports that "400 feet of salt is said to have been passed through in the drilling." So little information from the surrounding region is available, that the structure of the Guelph formation here is not known. The Onondaga limestone rises to the southwest, and may be represented in this field by a nose or terrace.

LEAMINGTON OR MERSEA OIL FIELD.

The well-known oil field in Mersea township, Essex county, extends from a short distance south of the Talbot road, due north to the Mersea-Tilbury West line. The length is 8 miles and the width less than one-quarter mile, the field being mostly confined to lots 10 in concessions IV to IX, and the corresponding lots numbered from the Talbot Street road. Two extremely small areas on lot 8, concessions V and VI, were also productive, and the area to the south, in the vicinity of Leamington, produced a considerable amount of gas. A part of this area, viz., lots 236 and 237 south of the Talbot road, is still producing some gas. Some oil production also occurred near Comber in Tilbury West, directly north of the Leamington field.

The Mersea field was discovered in 1902, produced 39,655 barrels in 1906, according to the supervisor of petroleum bounties, and dropped to 141 barrels in 1910. There is no oil production at the present time, but a number of wells are supplying farmers with gas.

Very little information is available outside of the oil field and it is not possible to define the general structure. The character of the field, however, strongly suggests a long, narrow anticline.

The oil-bearing horizon, probably in the lower part of the Salina formation, lies at a depth of 1,068 feet in concession IV, 1,107 feet in concession VIII, 1,109 feet in concession IX, and 1,307 feet north of Comber.

PELEE ISLAND OIL FIELDS.

Pelee island was first prospected about 1895, when seven wells were drilled on Grove avenue, near the eastern side of the island, for the Kingsville Oil and Gas Company of Canada. The first two produced some oil, the third flowed 400 barrels and the last four were dry. The total estimated production was 450 barrels. In 1907, seven more wells were drilled in the same locality by the New York, Lake Erie, Oil and Gas Company. Mr. Wm. J. Hussey, who drilled the wells, reports that they started with a production of four to twelve barrels per day, and held up well for the twelve months during which they were pumped. He estimates the production for this time at from 3,000 to 4,000 barrels. Shipping was expensive and difficult and with unduly large operating expenses the field was forced to close down.

The field suffered little from water troubles, and the gas supply was sufficient for drilling and operating purposes. There was little production before shooting, but a steady production afterwards. At the present time, nearly all the wells

[1] Malcolm, W., Geol. Surv., Can., Mem. 81, p. 76.

show oil at the top of the fluid in the casing, and several flow at times. The oil rock lies about 742 to 762 feet below the surface which is here about 575 feet above sea-level. According to a log given in the Fourteenth Report of the Bureau of Mines of Ontario, the section is as follows: surface 58 feet, Corniferous limestone 222 feet; measures unrecorded 44 feet (probably representing the Oriskany sandstone); yellow, grey, and bluish grey dolomites containing gypsum in part, 458 feet; giving a total thickness of 782 feet. The last division clearly contains the Bass Island series and a part of the Salina formation. Unless the overlying formations on Pelee island are about 300 feet thinner than on the mainland in the vicinity of Leamington, this well did not reach the Guelph. As already stated the oil was struck at from 742 to 762 feet from the surface and so must occur in the Salina.

Another small oil field was opened up near Pelee Island South, about one mile west of Mill point. Little could be learned of this field, but the production is said to have been obtained from an horizon 780 feet below the surface. This would suggest that possibly there are two producing horizons. The Corniferous limestone outcrops at the shore west of Mill point, whereas it was struck in the oil field to the north at a depth of 58 feet. However, the difference in elevation of the surface of the Corniferous may be due to glacial erosion. The Corniferous limestone outcrops on the north side of the island about one mile west of Scudder, where notable glacial erosion is evident, and also near the old pier at the northwest point of the island, where considerable quarrying was formerly carried on. In the northern outcrops the limestone lies in a horizontal position, but on the shore at Pelee Island South, the strike is parallel to the shore, the dip being several degrees to the southeast. Other wells have been drilled on the island, but large areas have not been explored.

According to the Report of the Bureau of Mines of Ontario, Pelee island produced 1,023 barrels of oil in 1904 and 378 in 1906. The quality of the oil is reported to have been good.

Future Prospects.

The Pelee Island oil field was never troubled with water and as little drilling has been done, the field may be considered pretty much as new territory, the past development indicating that fair quantities of oil and gas may be found.

The attitude of the rock at Pelee Island South taken together with that on the northwest corner of the island indicates that a dome or at least a terrace exists somewhere between the two localities. This structure will probably continue downward to the oil-bearing strata.

Pelee island has a population of 700 people who have to import fuel, and five pumping stations are operated by the community to empty the ditches which unwater the land, the fuel costing $12,000 per year. It is plain that under these conditions a considerable amount of gas could be consumed profitably on the island and the present high cost of oil, and the demand for it, would make it possible to arrange for the shipment of the oil from the island on much more favourable terms than formerly.

RECENT DEVELOPMENTS IN MOSA TOWNSHIP, MIDDLESEX COUNTY.

After reaching the high production of 108,988 barrels in 1918 and 9,083 barrels for January, 1919, the Mosa field rapidly fell off during the following months, the production for April being 4,526 barrels. This was only partly due to the failure of the oil supply, as litigation so hampered the operations of the Ontario Petroleum Company, the largest producer in the field, that the normal development work was not kept up. On the other hand some extension of the field was made by the holders of the adjoining leases. For example, by July 17, two good producing wells had been drilled by Mr. Neil Gillies on his

farm on the south half of lot 5, concession V, and two fair wells were drilled on the Holgate lease to the east (lot 4, concession V). The well drilled a short distance to the east of these wells, however, produced much water but no oil. It is quite clear that the field is well-defined and the production from now on will be from new wells within its ascertained limits.

OIL OCCURRENCE IN A SYNCLINE IN THE TRENTON FORMATION OF KENT COUNTY, ONTARIO.

By M. Y. Williams.

CONTENTS.

Illustrations.

INTRODUCTION.

In the spring of 1917, an oil and gas pool was discovered in the Trenton limestone of Dover West township, Kent county, Ontario.[1] To date, ten wells have produced gas and oil, and eight are still producing in commercial quantities. No. 1 well of the Union Natural Gas Company struck gas under 1,250 pounds pressure per square inch, the initial flow being estimated at 6,000,000 cubic feet per 24 hours. So much oil occurs with the gas that the gas is passed through long lengths of "drips" that catch the oil before the gas is allowed to enter the pipe-lines. Other wells have produced oil and gas in varying proportions, but in several the oil production has increased as the gas production has fallen off.

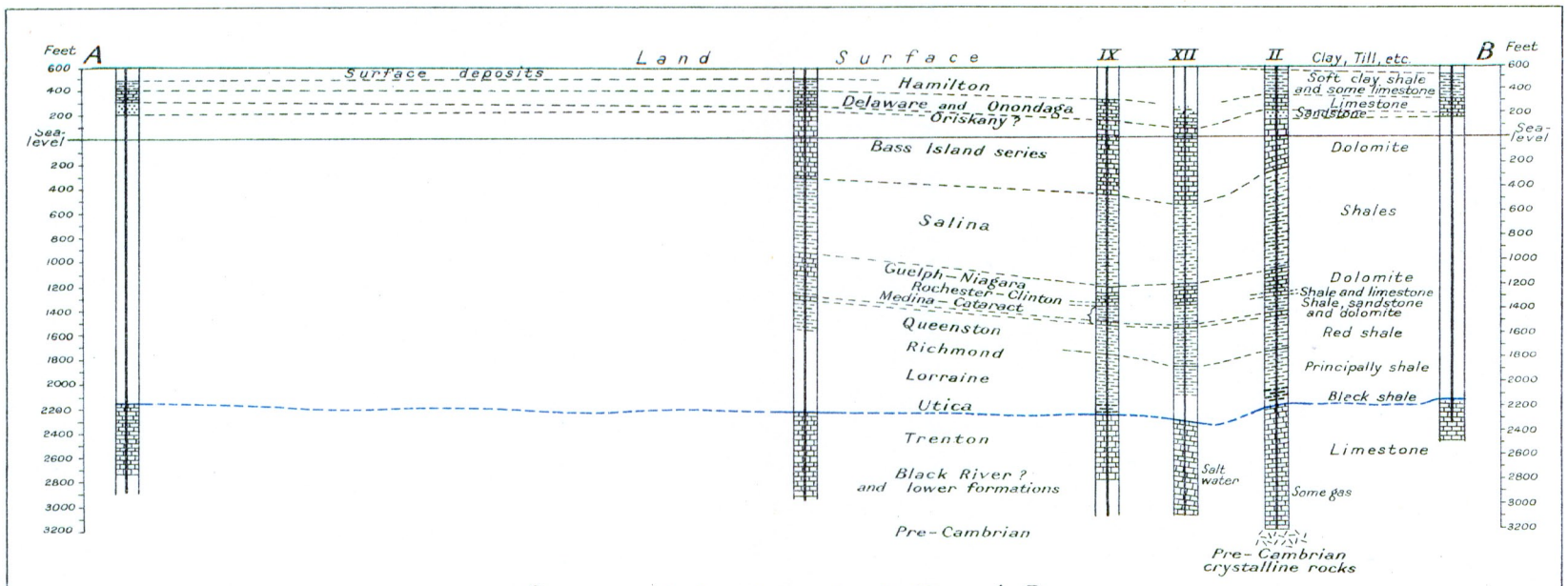
The unusual character of the production of gas from this field is indicated by a recent statement from Mr. F. W. James, manager of the Union Natural Gas Company, of which the following is a summary. No. 13 well had an initial production May 31, 1919, of 7,500,000 cubic feet of gas per 24 hours, from an horizon 100 feet in the Trenton. By April, 1920, this production had fallen to 1,500,000 cubic feet open flow, but there was a decided variation within a period of three or four weeks, sometimes falling to a small production, then suddenly breaking loose and increasing. Shut in under either condition, however, the rock pressure was only about 385 to 395 pounds per square inch, suggesting a pocket which was very rapidly being exhausted.

IMPORTANCE OF OCCURRENCE.

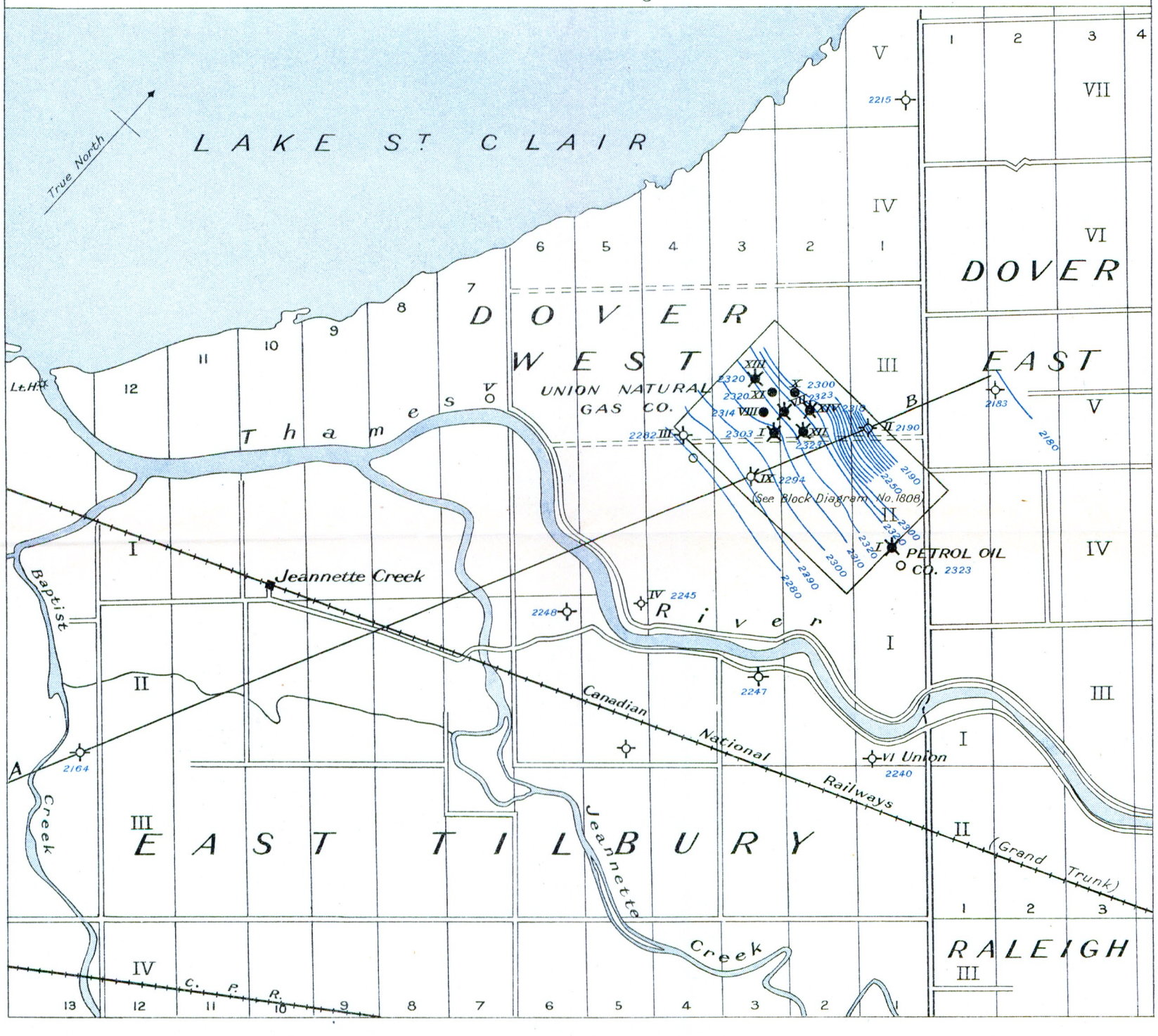
The oil production from the Trenton formation of Dover West township, Kent county, Ontario, is of interest for two important reasons: first because it is the only commercial production from the Trenton in Canada, and second because the oil is known to occur in a syncline, as was pointed out in an earlier report.[2]

When this unusual mode of occurrence was first recognized, only three or four scattered wells had been drilled to the Trenton in this field, and the structure was determined from the records of the wells which had penetrated the Onondaga limestone, the assumption being that the Trenton was approximately parallel

[1] Geol. Surv., Can., Sum. Rept., 1917, pt. E, p. 25; 1918, pt. E, p. 39.
[2] Geol. Surv., Can., Sum. Rept., 1917, pt. E, p. 25.



Structural Section along line A-B



Legend

- Unfinished well
- Showing of gas
- Oil well
- Gas and oil
- Dry hole
- Figures and contours showing depth of top of the Trenton Limestone below sea-level

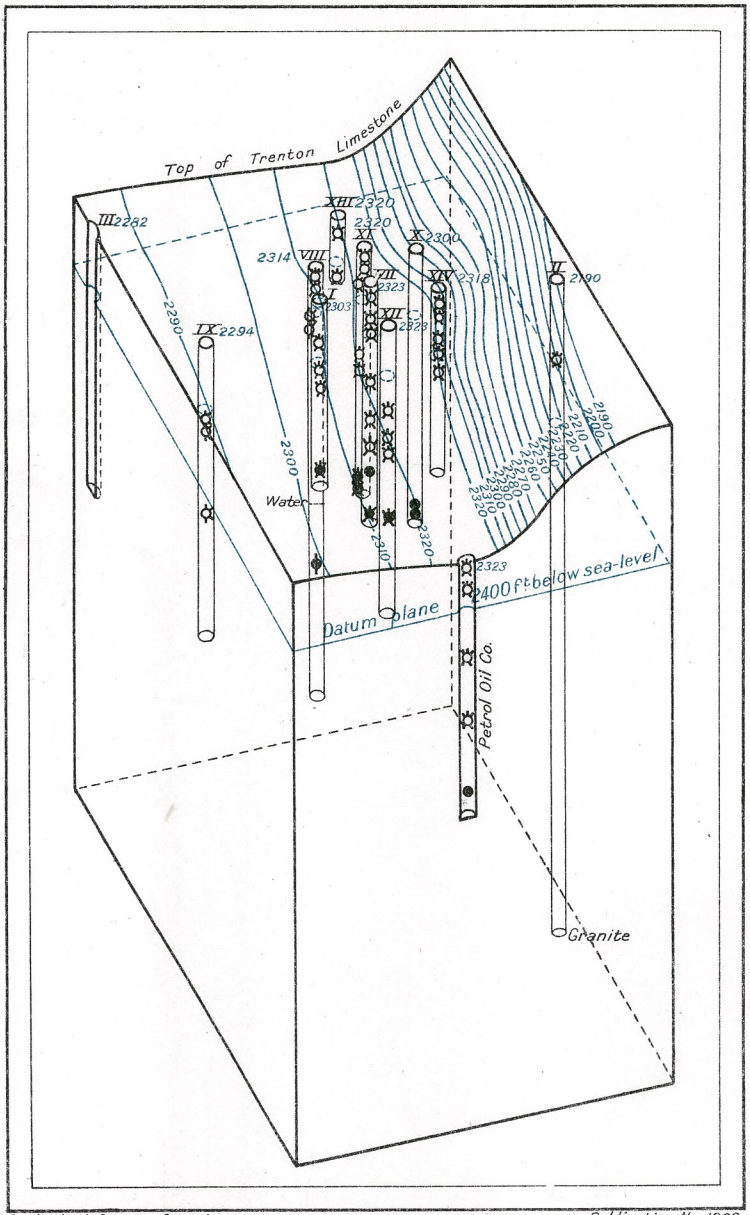
Geological Survey, Canada.

Publication No.1807

Diagram showing location and structure of
Dover Oil and Gas Field, Kent County, Ontario.

Scale of Miles

To accompany Part E, Summary Report, 1919;
by M.Y. Williams.



Legend

- 2270 / 2280 — Contours showing depths of the top of Trenton formation below sea-level
- Occurrence of Gas
- Occurrence of Oil
- Occurrence of Gas and Oil
- "Showing" of Gas
- "Showing" of Oil

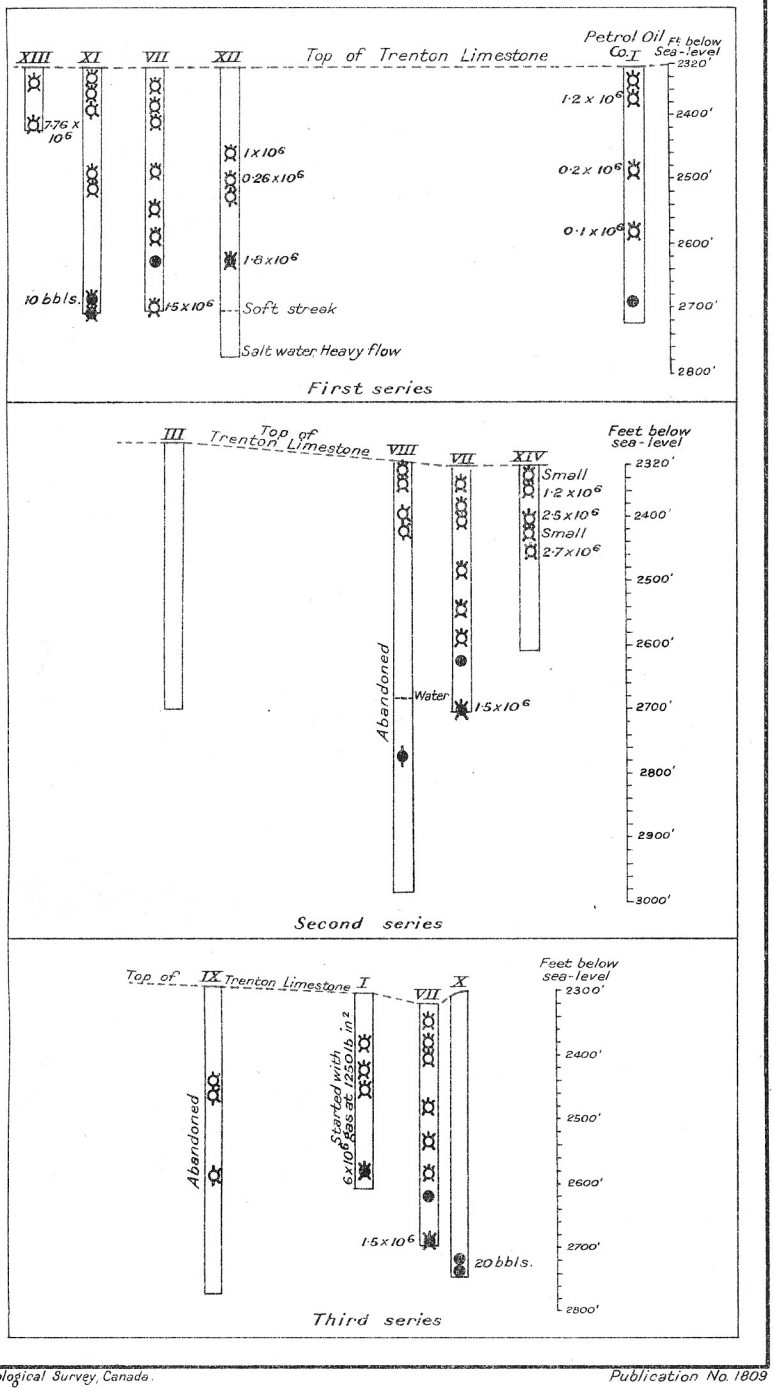
Geological Survey, Canada. Publication No. 1808

Block diagram (30° from the horizontal) illustrating the occurrence of Gas and Oil in the Trenton Limestone of Dover West Tp., Kent Co., Ontario.

Horizontal Scale of 1 mile
0 ¼ ½ ¾ 1

Vertical Scale of feet
200 150 100 50 0 200 400 600

To accompany Part E, Summary Report, 1919; by M.Y. Williams.



Legend

- Occurrence of Gas
- Occurrence of Oil
- Occurrence of Gas and Oil
- "Showing" of Gas
- "Showing" of Oil

Gas stated in million Cu. Ft. per 24 hours.

Oil in barrels per 24 hours.

Geological Survey, Canada. Publication No. 1809

Three series of wells, showing relative depths in Trenton of occurrences of Oil and Gas

Horizontal scale between centres of sections

0 1/4 1/2 3/4 1 mile

To accompany Part E, Summary Report, 1913; by M. Y. Williams.

with the Onondaga. To date, eighteen wells have been drilled to the Trenton, within a circle of 3 miles radius, and the information thus obtained amply proves that the oil pool lies in the very bottom of a well-marked syncline. This may be best understood on examination of the accompanying structural map and diagrams.

OIL IN SYNCLINE.

It has long been recognized that in cases where water is nearly or totally absent from the oil-bearing stratum, oil may occur in synclines, but few examples of such occurrence are known. The conditions in the Trenton of southwestern Ontario are suitable for this kind of accumulation, for, although more than sixty wells have been drilled into the Trenton, water is known to occur in but few and even in these the oil and gas horizon is not generally flooded. Union well No. 7 (see Map 1807 for locations) produced at the start a little water along with oil and gas; No. 8 struck water in a mud vein between the oil and gas; No. 12 struck a strong flow of salt water 458 feet in the Trenton, and 158 feet below the lowest gas and oil; and No. 14 is producing considerable quantities of salt water probably from one of the gas horizons. The water occurring in these wells is not definitely associated with oil or gas, and as it was not struck in the nearby wells, it appears to have been confined to rock channels, which are not connected with the oil accumulation. Water occurring in the Trenton in eastern Ontario and on Manitoulin island, appears to have been surface or lake water absorbed by the outcrops of the formation, which are exposed over large areas of the country. This water should not be confused with the sea water which, trapped in marine sediments, remains in them even on their solidification into rock. Presumably it is this old sea water which is commonly associated with oil occurrences, and which by its greater specific gravity assists in oil accumulation.

Where water is absent, or present only in small amount, the accumulation of oil and gas depends upon the action of gravity, and the accumulations are located below the source of the oil, either in structural depressions, such as synclines and basins, or else in porous lenses of rock.

In well-defined folding, it can be shown that the crests of anticlines and the bottoms of synclines suffer less compression than do the limbs of the folds, where the strata are commonly much reduced in thickness. Consequently, rock porosity is likely to be greater along the tops of the anticlines and on the bottoms of synclines than elsewhere. During folding, fluids such as oil and gas suffer differential pressure along with the containing rock and tend to migrate to zones of less pressure and greater porosity. Thus accumulations may be expected along the crests of anticlines and on the bottoms of synclines. There is this difference, however, that in the case of synclines, gravity operates to facilitate accumulation, and in the case of anticlines gravity hinders accumulation.

As the differences in compression in different parts of folds depend upon the strength of the rock materials affected, it follows that in weak structures such as broad, low folds, no important differences of pressure or porosity will result.

Applying the hypothesis as stated above to the Dover oil field, we find a well-defined, although rather gentle syncline, with the oil and gas pool limited to its axial area. As shown by the diagrams (Maps 1808, 1809) gas and oil occur at different horizons, neighbouring wells being quite unlike, although the occurrences may be roughly grouped. Such water as occurs appears to come from crevices or mud veins and is for the most part unconnected with the occurrence of oil and gas. All these conditions harmonize with what might be expected under the action of differential pressures due to folding assisted by gravitative accumulation into porous horizons located in structural depressions.

The next consideration is that of gas pressure. The initial pressure in well No. 1 was 1,250 pounds per square inch. This unusual pressure might be expected

to drive gas long distances into the rock adjoining the pool, and yet No. 2 well, one-quarter mile to the east of the axis, had only a showing of gas and No. 3 well one-half mile to the west, was totally "dry." It appears that only the lack of continuous rock porosity can account for this. However, in order properly to evaluate this rock pressure, the actual rock pressure at the gas horizon must be taken into account. Assuming the average specific gravity of shale and limestone to be a little less than 2·5, the pressure per square inch exerted by a column of such rock 3,180 feet deep (the depth to the gas and oil horizon in well No. 1) would be in round numbers 3,000 pounds. But the pressure was less than half this, which proves that the rock is not filled with fluid. Thus direct evidence supports the proposed explanation for the accumulation of oil and gas in the Trenton formation of the Dover field.

To recapitulate—the oil and gas occur only in the bottom of the syncline (knowledge used successfully in locating wells, both by the Union Natural Gas Company and by the Petrol Oil Company); water occurs in small quantities only, and in only four wells; and the extent of the pool, and the initial gas pressure, favour the hypothesis that the accumulation has taken place in porous rock under the action of gravity.

BEARING ON FUTURE DEVELOPMENT.

In the autumn of 1919, the Petrol Oil Company completed a well near the middle of the north end of lot 1, concession I, Dover West township, which had an initial production of 1,500,000 cubic feet of gas, accompanied by considerable quantities of oil. This location was made by Mr. E. P. Rowe, and was based on his knowledge of the bearing of the axis of the syncline, in which the oil pool is located. How well he succeeded in locating the syncline and the extension of the oil pool may be seen from results, and Map 1807. The limit of the syncline and the oil pool has not yet been determined, and is well worth consideration.

The bearing of the facts learned in the Dover Oil field, on the exploration of the Trenton elsewhere in Ontario, is obvious. So long as the formation is free from water or only partly saturated, the synclines should be sought, rather than the anticlines.

EXPLORATION OF THE TOWNSHIPS WEST OF KIRKLAND LAKE, ONTARIO.

By H. C. Cooke.

The mapping in 1918 of Matachewan district did not include a strip of territory 12 miles in width between the Matachewan and the Kirkland Lake districts. It seemed desirable to complete at once the geological mapping of this intermediate area, in order to determine if it contained the gold-bearing porphyries of Matachewan and Kirkland lake. The area has no good water routes and accordingly was covered by traversing the north and south lines of Holmes and Burt townships, and the country for a distance of 3 miles on each side of them. A strip 12 miles in width was thus mapped, including the whole of Holmes and Burt townships, the south halves of Dunmore and Bompas, and the north halves of Flavelle and Gross. In addition, the north halves of Blain and Marquis townships were mapped.

The geological work proved disappointing from an economic standpoint. The north halves of Blain, Marquis, and Gross townships are underlain almost entirely by granite, overlain by swamp and sand-plain. Much of this land if

drained would be as good farming land as any in northern Ontario. Burt township, the southern half of Bompas, and northern Flavelle are underlain in great part by Cobalt series, barren of mineral, and by granite. Holmes and southern Dunmore are largely granite and sand-plain. The only localities favourable for prospecting in the entire area are: a small area of Keewatin rocks, mainly in concession 1, Burt township; and an area surrounding George lake, in Holmes and Flavelle townships. The map shows three or four smaller areas of Keewatin rocks in the area, but they are so small, being of the nature of large inclusions in the granites, that it is doubtful if they will prove of any importance to prospectors. No body of the gold-bearing porphyry of Matachewan and Kirkland lake was found at any point within the area, although it was carefully searched for.

A hurried examination was made of the reported platinum finds in the western part of Otto township. The reported discoveries are in lot 12, in the south part of concession 5, and the north part of concession 4. The country rock is a band of tuffs, about 1,300 feet in width at this point, lying between basalt flows of Keewatin age. The strata strike about 30 degrees north of east, and have almost vertical dips; the upper side is to the north. The band was traced for about 2 miles southwest into Eby township, where it was lost beneath a sand-plain and eastward as far as the middle of lot 6, concession 5, Otto township, where it is faulted to the north about a mile. It was picked up on the other side of the fault, and traced southeast to the eastern boundary of Otto township, in concession 5, and beyond, across Boston township, for about 2½ miles, as far as Fox lake, where it is cut off by an intrusion of granite. The tuffs consist on the south or lower side of rather fine-grained, thin-bedded rocks, frequently light in colour. On the north side they contain a banded iron formation in places, together with coarse agglomeratic phases. The tuff beds, particularly the finer-grained phases, are locally impregnated with pyrite and pyrrhotite. In one or two places the impregnation was observed to have converted the whole rock into an almost solid mass of sulphides; but the impregnation is commonly much less than this. Prospectors claim that in picked samples they obtained values in gold, silver, platinum, and nickel, none of them singly high enough to constitute an ore, but together giving a good return. No attempt had been made at the time of the writer's visit to sample the deposits systematically. The locality would seem to be a good field for prospecting, in the hope of obtaining a good sized body of high grade ore; but the great number of these bodies are of too low grade and too small in size to be of any value for mining purposes.

MINERAL DEPOSITS IN THE OTTAWA VALLEY.

By M. E. Wilson.

CONTENTS.

Illustrations.

5866—3½

INTRODUCTORY STATEMENT.

The geological field work carried on during the past six years in the lower Ottawa valley, was continued in 1919. This work has included: (1) the study of a large part of the most important mineral deposits occurring in the lower Ottawa valley; (2) the preparation of geological maps of the territory adjacent to the most important mineral deposits; and (3) the study of the character and relationships of the principal rocks represented in the areas mapped.

Since the Pre-Cambrian rocks occurring in the lower Ottawa valley have a regional structural trend in a northeasterly direction, it is probable that the principal changes in the character and relationships of the formations represented occur in a direction at right angles to this structural trend, and for this reason the areas chosen for detailed mapping have been selected, as far as practicable, in an east-west direction from one another. By this procedure a maximum amount of data regarding the geology of the Ottawa valley was obtained in a minimum interval of time.

The areas of which regional geological maps have been prepared up to the present time, named in succession from east to west, include the following:

Map 1680. Portions of Grenville, Chatham, Wentworth, and Harrington tps., Argenteuil co., Que.

Map 1681. Portion of Amherst tp., Labelle co., Que.

Map 1691. Buckingham map-area, Ottawa and Labelle cos., Que.

Map 1795. Portions of Maniwaki, Kensington, Egan, and Aumond tps., Ottawa co., Que.

Map 1739. Portions of Onslow and Bristol tps., Pontiac co., Que., and Torbolton, Fitzroy, and McNab tps., Carleton co., Ont.

Renfrew and Calabogie map-areas, Renfrew co., Ont. (unpublished).

The greater part of the field season of 1919 was spent in continuing the work in the Renfrew-Calabogie district, commenced in 1918. This investigation included the placing of the geology on the map of the Renfrew district surveyed by W. H. Boyd and K. G. Chipman of the Topographical Division of the Geological Survey in 1917, and on the map of the Calabogie district surveyed by C. H. Freeman in 1919; and in the examination of the principal mineral deposits that occur within the Renfrew and Calabogie map-areas or in the adjacent region.

The writer wishes to express his indebtedness to the mine owners and mine officials of the district, and especially to Mr. R. F. Bunting, president, and Mr. J. G. Patno, superintendent, of the Black Donald graphite mine, to Mr. D. S. Tovey, manager of the Caldwell pyrite property, and to Mr. Chas. Spearman, manager of the Renfrew Molybdenum Mines, Ltd., when the writer examined this property in 1917. All of these gentlemen very kindly placed the data in their possession at the writer's disposal and furnished every possible assistance in making the examination of the properties of which they were in charge.

In making the traverses necessary for the delimitation of the geological boundaries on the map the writer was assisted by J. F. Wright and T. L. Gledhill, to whom credit is due for the collection of a great part of the data upon which the geological map of the Calabogie district is based.

GRAPHITE DEPOSITS IN THE RENFREW DISTRICT.

General Statement.

The most important graphite deposit so far discovered in the Renfrew district and from the standpoint of production at least, the most important graphite deposit in Canada, is that occurring on the property of the Black Donald Graphite Company, Limited. This deposit is situated adjacent to the south shore and beneath Whitefish lake, on lots 17 and 18, con. III, Brougham tp., and approximately 25 miles southwest of the town of Renfrew and 12 miles

west of the village of Calabogie on the Kingston and Renfrew branch of the Canadian Pacific railway. The mine is connected with Calabogie by a road 14 miles in length.

The discovery of graphite in this locality is said to have been made by the late John Moore in 1889, but actual mining was not commenced until the year 1895 when the Ontario Graphite Company purchased the property. This company continued operations until 1908, when the Black Donald Graphite Company took over the holdings of the Ontario Graphite Company and have since carried on active operations.

Geology.

Rock Formations. The rocks occurring in the vicinity of the Black Donald mine consist chiefly of Grenville crystalline limestone, in which parallel bands of hornblende schist, rusty sericite schist, pegmatite, and aplite are included (Map 1799).

The limestone is a coarse white to grey variety with which an abundance of lime silicate minerals are associated. The grey phases of the rock are generally banded, dark grey bands one-eighth to one-half of an inch wide, alternating with light grey bands from one-quarter to several inches in width. The white "marble" phases of the limestone generally contain a large proportion of white pyroxene (diopside) either in the form of disseminated grains or in irregular nodular masses up to 5 feet in diameter. The masses of diopside are especially abundant in the limestone outcropping adjacent to the graphite ore-body and on the islands in Whitefish lake directly north of the mine. On the surface of the freshly broken rock the diopside masses resemble the limestone in appearance, but can be easily distinguished on the weathered surface of exposures by the manner in which they stand up above the enclosing matrix. In some of the diopside masses geodal cavities containing crystals of pyroxene can be observed. The impurities associated with the limestone vary somewhat in different outcrops. The white variety of limestone most commonly contains in addition to the white diopside a light amber mica and disseminated graphite, whereas the grey phases generally contain disseminated pyroxene, dark amber mica, pyrite, pyrrhotite, and graphite. In a few localities scattered grains of quartz, orthoclase, plagioclase, or scapolite are present. At some points in the vicinity of the mine, as for example near the top of the face of the low scarp of limestone that adjoins the south side of the road directly south of the main shaft, and in the limestone outcrop situated about 100 feet southeast of the mill, zones of quartz up to 3 feet in diameter are present. These quartz zones appear to be elongated parallel to the bedding of the limestone and are possibly recrystallized beds of sandstone interstratified with the limestone; on the other hand, since the quartz occurs associated with masses of diopside which have evidently been formed as a result of the reaction of siliceous igneous emanations with the limestone, it is also possible that the quartz was deposited in the limestone secondarily at the time this reaction occurred.

The hornblende schist which occurs in bands intercalated in the limestone is a grey to greenish-grey rock that in places contains an abundance of scattered grains of red garnet. A thin section prepared from a specimen of the garnetiferous schist outcropping as a knob at the west end of the swampy depression situated on lot 18 to the south of the mine (Map 1799), when examined under the microscope was found to consist of quartz, plagioclase, pale green to pale yellow hornblende, magnetite, pyrite, and pale pink garnet containing poikilitic inclusions of quartz and plagioclase. The bands of the hornblende schist as indicated on Map 1799 trend in a northeasterly direction and apparently conform in strike and dip to the bedding of the crystalline limestone in which they are included.

The rusty sericite schist is a peculiar, variable rock which appears to be especially abundant adjacent to the ore deposit. Its composition indicates that

Canada
Department of Mines

HON. SIR JAMES A. LOUGHEED, MINISTER; CHARLES CAMSELL, ACTING DEPUTY MINISTER

GEOLOGICAL SURVEY

WILLIAM McINNES, DIRECTOR.

Issued 1920

LEGEND

EARLY PRECAMBRIAN

QUATERNARY

GLACIAL

Q — *Boulders, gravel, and boulder clay*

5 — *Outcrop of graphite ore body*

4 — *Continuation of ore body in mine workings beneath lake*

3 — *Pegmatite and aplite*

2 — *Rusty graphitic sericite schist*

1 — *Hornblende schist*

GRENVILLE SERIES

Al — *Crystalline limestone*

Symbols

Geological boundary

60° — *Dip and strike*

Vertical strata

80° — *Dip and strike, foliation*

Vertical foliation

Roads and buildings

Roads (not well defined)

Mine and elevated tramways

o — *Shafts*

⊙D.D. — *Diamond-drill holes*

800 / 700 — *Contours (showing land forms and elevations above sea-level)*

Depression contours

Approximate magnetic declination, 10°20' West

WHITEFISH LAKE

High Water, 753 feet
Low Water, 749 feet

True North

Tailings dump
Filled ground
Pier
Mill
Office
Pit
Powder House
Path
Prospect
P.O.
Black Donald
to Black Donald
Scales
Post
Concession IV
Concession III
Power Line
River
to Madawaska
Church
Powder House
to Calabogie
LOT 16
LOT 17
LOT 18
Low Water
High Water

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

Publication No. 1799

GRAPHITE DEPOSIT, LOTS 17 AND 18, CONCESSION III, BROUGHAM TOWNSHIP, RENFREW COUNTY, ONTARIO.

Scale of Feet
100 0 100 200 300 400 500

To accompany Summary Report, Part E, 1919, and Memoir by M.E. Wilson.

Sources of Information
Geology by M.E. Wilson, 1919.
Topography by C.H. Freeman, 1919.

it is probably a phase of the pegmatite and aplite, but because of its peculiar rusty appearance and association with the graphite ore-body it has been separately described. Although the various outcrops of this rock resemble one another in appearance, and are alike in that they are all composed of a large proportion of salic minerals (feldspar or feldspar and quartz) they vary considerably in the proportions of these minerals which they contain. Thus the schistose band that parallels the south side of the Matawatchan road a few hundred feet to the southwest of the mine consists chiefly of granular quartz and plagioclase (having the optical properties of oligoclase) in which graphite, pyrite, and tourmaline are disseminated; another mass of the rock exposed on the roadside about 100 feet southeast of the blacksmith shop contained, on the other hand, no quartz, and consists of microcline, scapolite, muscovite, pyrite, and tourmaline; a third exposure of the schist situated about 25 feet south of the Patno shaft also contains no quartz, but in addition to orthoclase includes a considerable proportion of albite with pale yellow to colourless mica, colourless amphibole, pyrite, and tourmaline as less abundant constituents. The rusty sericite schist, similarly to the hornblende schist, apparently conforms in strike and dip to the structure of the enclosing limestone.

The pegmatite and aplite associated with the limestone are massive pink to white rocks which consist mainly of quartz and feldspar (microcline and albite), but also contain some mica and tourmaline. The texture of the rock, as the names pegmatite and aplite imply, is variable. The pegmatite on the whole is comparatively fine-grained, the feldspar crystals being generally not more than 2 or 3 inches in diameter. The aplite is a fine-grained rock type resembling a granite in appearance except that it contains a very small proportion of ferromagnesian minerals. Like the hornblende schist and the sericite schist the pegmatite and aplite bands trend in a northeasterly direction and are apparently conformable in strike and dip with the adjacent limestone.

Structure. The rocks occurring in the vicinity of the mine (Map 1799) have, on the whole, a remarkably uniform structural trend in a northeasterly direction, and the dip of the bedding in the limestone as well as the dip of the foliation in the included bands of schist is, on the whole, generally to the southeastward. This does not necessarily indicate, however, that the structure is monoclinal, for the limestone, together with the igneous masses which it includes, has been subjected to intense deformation and, possibly, numerous folds are present that have been overturned into an isoclinal position. Near the graphite ore-body the strikes and dips in the limestone and schist appear to be less uniform than in localities farther away. This feature may possibly owe its origin to the greater amount of re-adjustment that, owing to the comparative incompetence of the soft, easily deformed graphite, occurred at this point.

Character of Graphite Ore.

The graphite ore-body in the Black Donald mine consists for the most part of dense, fine-grained graphite, in which coarse flake graphite occurs here and there in aggregates. In addition to this predominant phase, however, there are considerable masses of ore, especially along the foot-wall of the deposit, which consist of flake graphite disseminated in a matrix of calcite or pyroxene. The aggregates of coarse flake graphite associated with the dense fine-grained phase of ore consist partly of coarse flake enclosed in a matrix of the fine-grained, dense graphite, partly of flakes projecting edge-wise from the walls of geodal cavities, and partly of flake disseminated in small masses of calcite. The principal gangue minerals associated with the graphite are calcite (Figure 1), pyroxene (diopside), mica (Figure 2), and scapolite. The ore, except where it adjoins the sericite schist, which forms the hanging-wall of the deposit, is singularly free from pyrite. Those phases of the ore in which pyroxene is the dominant gangue mineral were observed to have a porphyritic appearance in places, owing to the

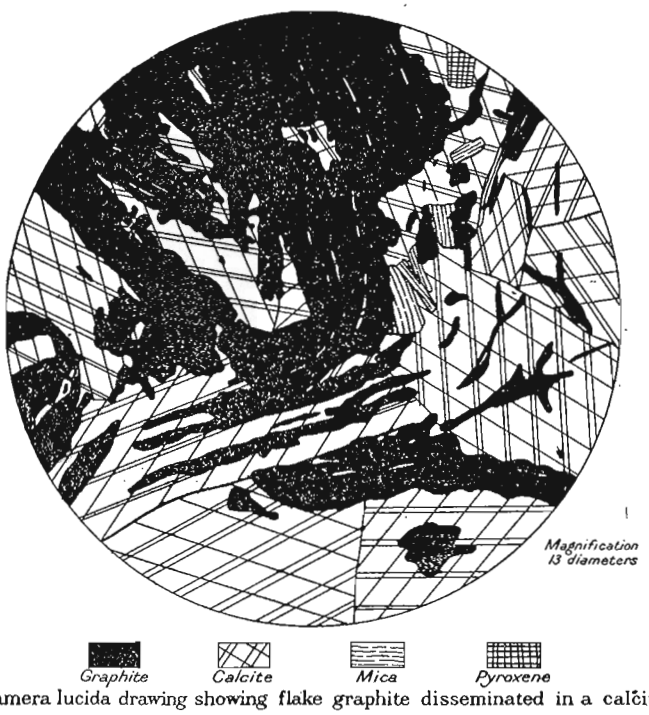


Figure 1. Camera lucida drawing showing flake graphite disseminated in a calcite matrix.

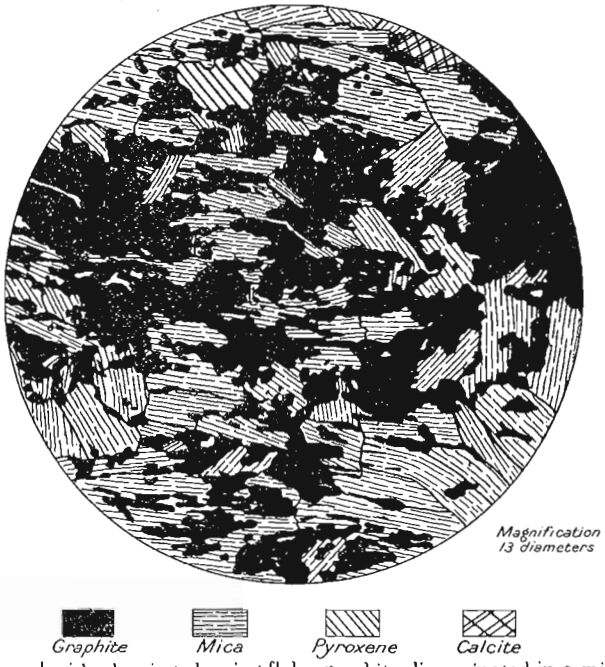


Figure 2. Camera lucida drawing showing flake graphite disseminated in a mica matrix.

presence of scattered crystals of pyroxene up to one-half inch in diameter. The mica associated with the ore is a bright green muscovite, which generally occurs in masses of exceedingly fine flake, although in places crystals up to 2 inches in diameter can be observed. The relationship of the fine muscovite to the associated graphite is shown in Figure 2. The lean phases of the ore, consisting of graphite disseminated in calcite or pyroxene, very commonly present a banded appearance owing to variations in the abundance and coarseness of the flake occurring in alternate parallel zones. The fine-grained phases of the graphite ore when examined in thin section under the microscope are observed to have a fine-grained, dense black appearance, in which, except for a few small, scattered grains of pyroxene, calcite, or scapolite, little of interest can be seen. It might be pointed out in this connexion, therefore, that the camera lucida drawings shown in Figures 1 and 2 were not inserted to illustrate the most typical phases of the graphite ore, but to show the relationship of the graphite to calcite and mica where these minerals are present.

Chemical Composition of Ore.

Analyses of the ore in which the graphitic content ranges from 71·46 to 85·75 per cent, are included in Cirkel's report[1] 1907, and in reports of the Bureau of Mines of Ontario.[2] It is probable, however, that these analyses were made from samples taken from the high grade portions of the ore mass, and do not represent an average of the mass as a whole. The percentage of graphite estimated to be present in the ore mass is dependent, of course, on the proportion of the deposit that is classed as ore, but if in accordance with the present practice at the mine practically the whole of the graphitic mass be included, then the average graphite content of the deposit is probably not less than 55 per cent, and not more than 65 per cent. A number of analyses of the ore are included in the following table:

[1] Cirkel, F., "Graphite, its properties, exploitation, and use."
[2] Rept., Ont. Bur. of Mines, vol. V, p. 30; vol. X, p. 24; vol. XXVIII, p. 162.

Analyses of Graphite Ore from Black Donald Mine, Lots 17 and 18, Concession III, Brougham Township, Renfrew County, Ontario.

—	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Graphitic carbon	84·12	84·06	76·75	79·20	84·12	85·75	79·63	73·33	71·46	89·50	61·28	52·88
Silica	1·98	3·90	2·46									
Alumina	1·56	0·05	3·64									
Iron oxide	1·85	0·70	1·59	0·63								
Lime	3·42	10·05	8·70									
Magnesia	2·41	1·00	3·36									
Volatile matter	4·66	.....	3·55									
Water	.....	0·32	.....	.....	2·34	1·38	1·12	0·84	0·96			
Carbonate of lime	.....	.....	.....	9·14								
Soluble in HCl	.....	.....	.....	.....	.....	.....	.....	7·99	8·48			
Insoluble in HCl	.....	.....	.....	.....	.....	.....	.....	17·84	19·10			
Total soluble and insoluble	.....	.....	.....	.....	13·54	12·87	19·25	25·83	27·58			
	100·00	100·08	100·05	88·97	100·00	100·00	100·00	100·00	100·00			

I. Analysis by J. T. Donald, Ont. Bur. of Mines, Ann. Rept., vol. 5, 1895, p. 30.
II. Analysis by Crescent Steel Company, Ont. Bur. of Mines, Ann. Rept., vol. X, 1900, p. 37.
III and V. Analyses by Fritz Cirkel, "Graphite, its properties, exploitation, and use," Mines Branch, Dept. of Mines, Can., 1907, pp. 99 and 102.
IV. Average of five analyses, Ont. Bur. of Mines, Ann. Rept., vol. VI, 1896, p. 37.
VI, VII, VIII, and IX. Analyses by G. C. Hoffmann, "Graphite, its properties, exploitation, and use," p. 102.
X. Analysis by J. T. Donald and Company.
XI. Analysis by Toronto Testing Laboratories.
XII. Analysis by A. Sadle, Chemistry Division, Mines Branch, Dept. of Mines.

Structural Features.

Deformation. The principal features indicating that the graphite ore mass on the property has been subjected to deformation are the crumpling of the flakes seen in some of the thin sections of the ore when examined under the microscope (Figure 1), and the presence of numerous polished and striated fracture surfaces intersecting the ore. So far as could be observed these planes of movement cut the ore in every direction; it is possible, however, that if it were practicable to determine the strike and dip of all the fractures traversing the ore it would be found that they were related in their development to the structure of the graphite mass at the particular point where the observations were made.

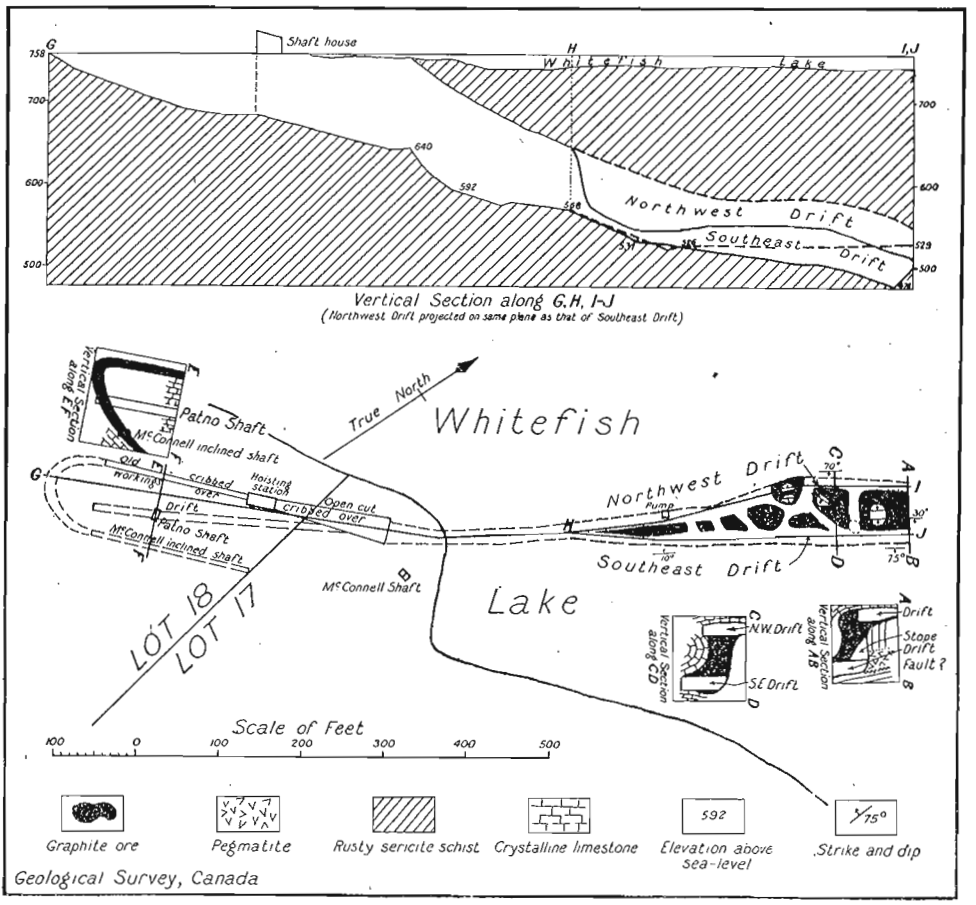


Figure 3. Plan and sections showing structural relationships of graphite ore-body in underground workings, Black Donald mine, lots 17 and 18, con. III, Brougham tp., Renfrew co., Ont. (Underground surveys by G. Johnson, Renfrew.)

Form and Structural Relationships of Graphite Ore-body. Since the graphite ore-body, and the containing rocks have been intensely deformed, and since throughout a considerable part of the accessible underground workings the ore has not been entirely removed where it adjoins the wall rock it is exceedingly difficult to determine either the form or the structural relationships of the deposit. Such data as were obtained, however, are indicated in Figure 3.

The portion of the graphite deposit lying to the west of the main shaft as shown in cross-section E-F has apparently the form of an unsymmetrical syncline. The principal data upon which the determination of this structure is based are the following:

The outcrop of the graphite lead (as shown by the trend of the excavation now partly filled in or inaccessible) extended for a distance of 200 feet in a southwesterly direction from the main shaft and from this point curved first to the south and thence eastward to the entrance of the McConnell inclined shaft[1] (see plan in Figure 3).

At the entrance to the McConnell inclined shaft the graphite ore-body is exposed. Here it strikes north 75 degrees east and dips 45 degrees to the north. It has a thickness, measured at right angles to the dip, of approximately 10 feet.

The ore-body was followed in this shaft at an angle of 30 degrees from the horizontal for a distance of 210 feet in a northeastward direction[2] (Figure 3).

In the Patno shaft situated midway between the outcrops of the northwest and southwest limbs of the syncline (Figure 3) the deposit was encountered at a depth of 80 feet and had a thickness in the shaft (measured diagonally across the lead) of 16 feet. From the bottom of this shaft the lead was followed in drifts for a distance of 70 feet in a southwesterly direction and for a distance of 200 feet to the northeastward where a break into the floor of the main workings was made.

During the early operations on the property a shaft was sunk to a depth of 34 feet at a point 210 feet to the southwest of the main shaft and from this point the ore was followed for 46 feet horizontally, to the south and thence up an inclined raise 32 feet to near the surface.[3]

The part of the deposit lying beneath the lake to the northwest of the main shaft continues for a distance of approximately 400 feet between vertical walls, and with a width ranging from 15 to 30 feet. Beyond this point, however, the ore mass appears to have been folded over in the direction of the foot-wall so as to form an S-shaped mass. Thus near the bottom of the pillar of ore adjoining the foot-wall in the northwest drift at a point about 125 feet from the end of the workings (Figure 3) the limestone together with the overlying graphite can be seen to have the form of an anticline pitching to the northeastward. Similarly, in December, 1919, the rusty sericite schist forming the hanging-wall of the deposit could be seen in the roof of a stope at the extreme northeastern end of the underground workings to change from a dip of 30 degrees to the southeast to a dip of 25 degrees to the northwest as indicated in Figure 3. In places within the deposit masses or bands of country rock were observed to occur as inclusions in the graphite. These in some cases consist of granite or pegmatite, but are more commonly composed of limestone. The limestone inclusions are generally graphitic and poorly defined. One mass of this type occurring in the northwest wall of the southeast drift was observed to lie in an approximately horizontal position, whereas the schist forming the hanging-wall directly opposite stood in a nearly vertical attitude. The schist in this locality is much slickensided and it may be possible, as indicated in the cross-section A-B, that the hanging-wall at this point lies on a fault.

Diamond Drilling Operations.

A considerable number of diamond drill holes were put down in the vicinity of the graphite ore-body by the Ontario Graphite Company, the results of which if accurately recorded might be of some value in future development work, but very little definite information with regard to the results of these operations is

[1] See also Ont. Bur. of Mines, Ann. Rept., vol. V, 1895, pp. 30–31.
[2] Information supplied the writer by Mr. J. G. Patno.
[3] Ont. Bur. of Mines, Ann. Rept., vol. XII, 1903, p. 132.

now available. A number of drill holes—the positions of two of which are shown on the accompanying map, No. 1799—were put down adjacent to the landward part of the deposit; others were drilled through the ice in winter in the direction of the continuation of the ore-body beneath the lake, and a third group of holes was drilled from the workings beneath the lake. No records of the operations on land are now available, but since no mining was attempted at these points, it may be inferred that workable graphite ore was not cut. The drill holes through and beneath the ice were carried to a depth of only 157 feet and hence did not penetrate below the depth of the present workings. Furthermore, since the positions of the drill holes were not definitely determined their relationship to the present workings and the ore mass already mined is unknown. Hence, it cannot be ascertained whether the thicknesses of graphite mentioned in the records of these drill holes were intersected in passing through the known ore mass or in penetrating a possible parallel deposit. The diamond-drill holes drilled from the workings beneath the lake are said to have been put down at intervals of 50 feet towards the northeastward from the bottom of the main shaft to the extremity of the workings, a total distance of 200 feet. It is reported that graphite was found at depth in these holes but the only definite record of the results of these operations so far as is known to the writer is that ore was shown to extend to a depth of 122 feet beneath the surface.[1] This depth would correspond approximately to the bottom of the present workings beneath the extreme northeastern end of the workings at that time.

Origin of Graphite.

In other publications in which the origin of Canadian graphite deposits is discussed, it is pointed out that there are three principal sources from which the graphite present in the deposits might have been derived: (1) it might represent recrystallized carbonaceous material deposited contemporaneously with the Grenville limestone; (2) it might have been derived from the igneous rocks that have penetrated the Grenville limestone; or (3) it might have been formed by the reduction of the carbon dioxide set free at the time the silication of the limestone to form diopside and other lime silicates occurred.[2]

It is not the writer's intention to discuss these hypotheses in full, but merely to point out some of the most important features exhibited by the graphite deposit in the Black Donald property that might have a bearing on the problem. The presence of masses of limestone included in the graphite ore mass; the indefinite character of the contact of the graphite ore with the limestone both around these inclusions and along the foot-wall of the deposit; and the manner in which the ore passes into the limestone by a gradual decrease in the proportion of graphite present are all features suggesting that the graphite was not originally present in the limestone but has been introduced into the limestone secondarily. Furthermore, of the principal gangue minerals associated with the graphite, diopside, scapolite, calcite, and muscovite, the diopside and scapolite belong to the class generally formed where emanations from igneous rocks have reacted with limestone (contact metamorphic deposits). The muscovite, on the other hand, is more generally characteristic of igneous rocks themselves and is most commonly found in pegmatites. On the whole, therefore, the characteristics of this ore mass seem to indicate its derivation either directly from the igneous rocks intruded in the limestone or from the carbon dioxide of the limestone through the contact metamorphic action of the emanations derived from the igneous rocks.

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[1] Ont. Bur. of Mines, 1902, pp. 292–294.

[2] Trans. Can. Min. Inst. vol. 19, 1916, pp. 349–370; Geol. Surv., Can., Sum. Rept., 1917, pt. E, p. 40; Geol. Surv., Can., Mem. 113, 1919, p. 41.

Future Development Work.

Owing to the inaccessibility of the older workings, the few localities in the mine where structure of the wall rock can be observed, the complex structure of the ore deposit, and the limited time at the writer's disposal, it was impossible to determine the structural relationships of the graphite ore mass except in favourable localities. No attempt will be made, therefore, to discuss the future possibilities of the graphite deposit in this connexion but some of the more obvious features having a bearing on future development operations may be mentioned. These include the following:

The graphite deposit at its western end has the form of an unsymmetrical syncline pitching towards the northeastward in the direction of Whitefish lake.

The graphite deposit at the extreme northeastern end of the underground workings has the form of a minor anticline or drag fold (sections A-B and C-D, Figure 3).

Although the ore deposit conforms in the main to the structure of the enclosing rock the contact of the ore with the limestone extends transversely across the bedding of the limestone in places. It is also found, that in some places where the wall of the deposit has apparently been reached this apparent wall is merely an included band of limestone, beyond which the ore continues.

The presence of numerous slickensided surfaces in the graphite and the form of the ore mass indicate that the deposit has been folded into its present form.

Since the graphite is comparatively soft and more easily deformed than the adjacent limestone, it would tend to accumulate at the crests of folds or at other points where pressure was least, and to thin out or disappear on the limbs of the folds where pressure was greatest when subjected to folding; hence the greater thickness of ore at the crest of the minor anticline which occurs at the present extremity of the underground workings.

The preceding data seem to indicate:

(1) That the graphite ore-body on the property of the Black Donald Mining Company cannot properly be defined either as a bed or as a vein but rather as a lead that trends approximately parallel to the bedding of the enclosing limestone merely because the planes of bedding afforded the channel along which the siliceous emanations that transformed the limestone could penetrate.

(2) That since the graphite ore-body has been subjected to folding, the determination of the structural relations of the deposit may be a most important aid in carrying on developments.

Milling Process.

The milling process in use at the Black Donald at present consists in first passing the ore through a jaw crusher and stamps and then through a revolving 18 by 4-mesh screen. By means of this screen the small grains of graphite are separated out and sold as grade 17X, whereas the flake graphite passes through the screen and is concentrated in Callow flotation cells. The flake concentrates are conveyed from the flotation cells to dryers, then polished in buhr-stones and finally classified by screening into various grades of flake.

Products.

The grades of graphite produced by the Black Donald Mining Company are as follows:[1]

Grade.	Percentage of graphitic carbon.[2]
Number 1	97·84–98·50
Number 2	96·90–97·39
Number 33	89·60–91·12
Number 3X	82·17–84·60
Number 4	71·16–73·10
Number 10	65·50–66·76
Number 17X	65·42–66·25

PYRITE IN THE CALABOGIE DISTRICT.

The principal deposits of pyrite, so far discovered in the Calabogie district, occur on lots 1 and 2, con. I, Blithfield tp., and on lot 5, con. IV, Darling tp. The first of these ore masses was developed by Mr. T. B. Caldwell of Lanark, and hence is known as the Caldwell deposit. The second occurrence is called the McIlwraith after its discoverer.

Caldwell Pyrite Mine.

The Caldwell mine, belonging to the Grasselli Chemical Company of Hamilton, Ontario, is situated in lots 1 and 2, con. I, Blithfield tp., about 6 miles south of the village of Calabogie and approximately $1\frac{1}{4}$ miles to the east of Clyde Lake siding on the Kingston and Renfrew branch of the Canadian Pacific railway. The mine is connected with the siding by a road and a narrow-gauge railway.

The discovery of the deposit is said to have been made about the year 1885 by prospectors for gold, whose attention was attracted by the masses of iron rust and honeycomb quartz which characterize the outcrops. The deposit carries practically no gold and no attempt was made to develop it until Mr. T. B. Caldwell became interested in the occurrence and after some preliminary prospecting purchased the property from Mr. William Mackie, of Arnprior, the original owner.[3]

When, owing to the World War, an increased demand for pyrite arose Mr. Caldwell commenced developing the deposit and sank a shaft (95 feet) from the bottom of which some drifting was done. In the autumn of 1917 the Grasselli Chemical Company obtained an option on the property and after completing 2,500 feet of boring purchased it outright. Since 1918 the Grasselli Chemical Company have carried on active mining operations and development work. The manager of the mine at present is Mr. D. S. Tovey.

Geology. The rocks exposed in the vicinity of the Caldwell mine, if classified according to age, fall into three groups each of which outcrops in separate belts. The oldest rock in the area is the crystalline limestone belonging to the Grenville series. This occurs in a northwesterly trending band a few hundred feet in width which crosses the road leading from the railway to the mine at a point about one-quarter mile west of the mine. The Grenville limestone is followed in the geological succession by a group of rocks consisting of gabbro and of hornblende or hornblende-biotite schist. These rocks outcrop in a belt several miles in width which extends in a southeasterly direction from Calabogie lake through the southwestern part of Bagot township and the adjacent parts of Blithfield township. The rock next in age to the gabbro and schist is a fine pink to grey aplitic gneiss with which a considerable proportion of pegmatite is

[1] Information given the writer by Mr. R. F. Bunting, President, Black Donald Mining Company
[2] Analyses by Toronto Testing Laboratory, Limited.
[3] Information given the writer by Mr. C. M. Forbes of Lanark.

Canada
Department of Mines

HON. SIR JAMES A. LOUGHEED MINISTER., CHARLES CAMSELL, ACTING DEPUTY MINISTER.

GEOLOGICAL SURVEY
WILLIAM Mc INNES, DIRECTOR.

Issued 1920

LEGEND

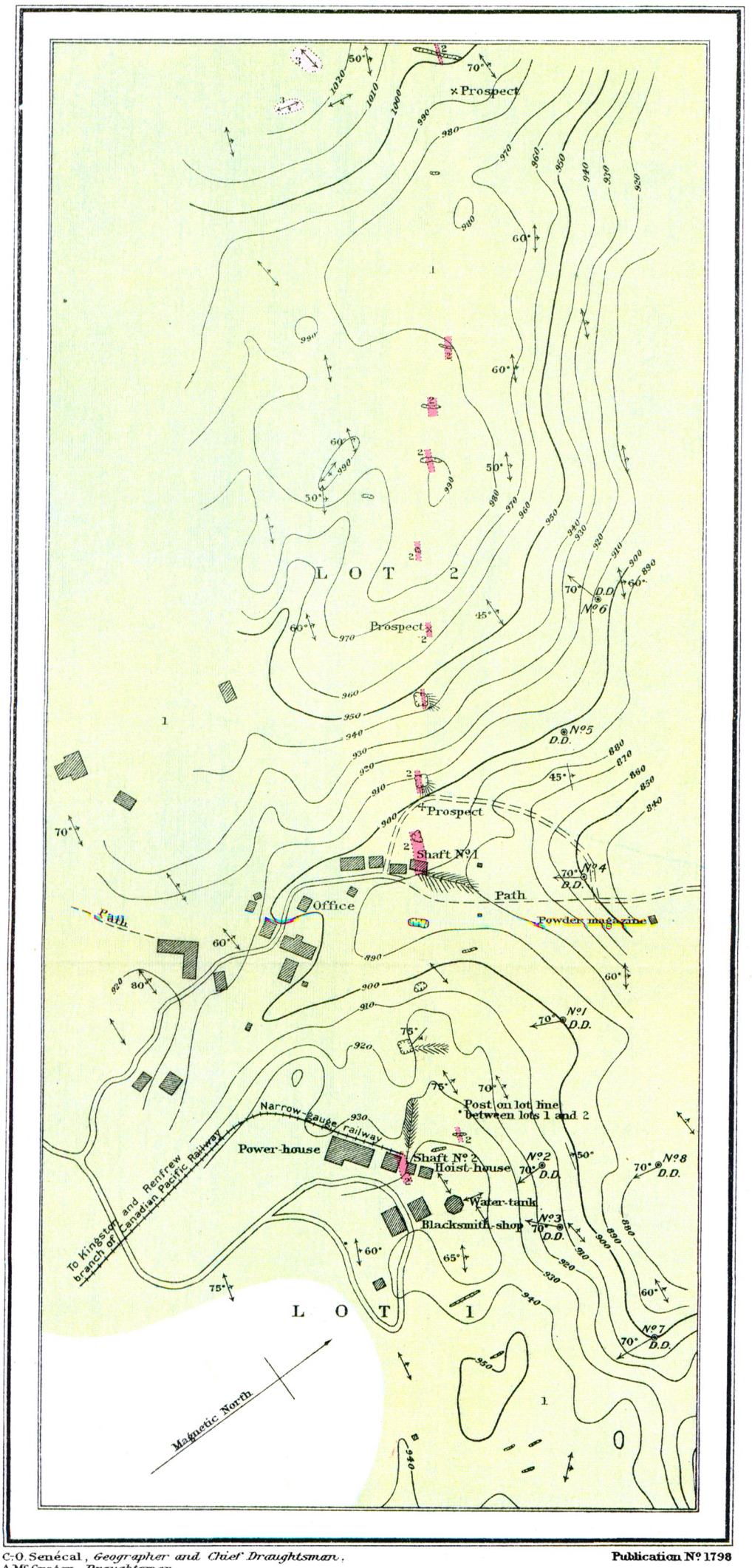
EARLY PRECAMBRIAN

- 3 — *Granite gneiss*
- 2 — *Outcrop of pyrite ore bodies*
- 1 — *Hornblende schist or hornblende biotite schist*

Symbols

- *Geological boundary*
- 65° — *Dip and strike, banding and foliation*
- *Vertical banding and foliation*
- 70° — *Direction and dip of diamond-drill hole*
- *Roads and buildings*
- *Roads (not well defined)*
- *Mine tramways*
- *Pits and trenches*
- ⊙D.D. — *Diamond-drill holes*
- 900 / 850 — *Contours (showing land forms and elevations above sea-level)*
- *Mine dumps*

Approximate magnetic declination, 10°30' West.



C. O. Senécal, *Geographer and Chief Draughtsman.*
A. Mc Gregor, *Draughtsman.*

Publication No 1798

PYRITE DEPOSITS (OUTCROPS), LOTS 1 AND 2, CONCESSION 1, BLITHFIELD TOWNSHIP, RENFREW, COUNTY, ONTARIO.

Scale of Feet
100 50 0 100 200 300

Sources of Information
Geology by M.E. Wilson, 1919.
Topography by Grasselli Chemical Company, *with additions by* M.E. Wilson.

To accompany Summary Report, Part E, 1919, and Mémoir by M.E. Wilson.

associated. This outcrops chiefly in a broad northwesterly trending belt lying to the west of the railway, but along the contact of this belt and the adjacent hornblende schist to the eastward there is a zone over a mile in width in which the granite has been injected parallel to the foliation of the schist in bands and masses ranging from a fraction of an inch to several hundred feet in width. The Caldwell mine is situated almost at the eastern border of this contact zone.

The rock lying directly adjacent to the pyrite ore masses is mainly a fine-grained green to grey, highly foliated and banded hornblende or hornblende-biotite schist, but includes some parallel bands or masses of fine grey granite in places, all of which, with the exception of a single mass situated near the northwest end of the zone in which the deposits occur, are too small to indicate on the accompanying map (No. 1798). On the whole the hornblende or hornblende-biotite schist is an exceedingly uniform type, but in places it was observed to contain an abundance of red garnet. Outcrops of this garnetiferous phase can be seen at a number of points to the north and northeast of the No. 2 shaft. The strike of the foliation and banding in the schist varies greatly from point to point, but in the main trends approximately north 75 degrees west, magnetic, and hence makes an angle of approximately 20 degrees with the northeastward facing slope on which the mine is situated. The dip of the foliation and banding on the average is approximately 60 degrees to the northeastward. The banding exhibited by the rock arises mainly from variations in the relative proportions of feldspar and ferromagnesian minerals present in alternate zones, but differences in the colour of the bands due to variations in the relative proportions of the hornblende and biotite present can also be observed in places. The width of the bands ranges from $\frac{1}{32}$ to $\frac{1}{4}$ of an inch. In some localities the schist is intersected by numerous fine seams of quartz or of quartz and feldspar. These trend in various directions, some lying parallel to the foliation, and others intersecting it transversely or obliquely. In its most typical occurrences the schist is a fine-grained foliated type consisting of parallel elongated grains of pale yellow to pale green hornblende alternating with similar elongated grains of plagioclase having the optical properties of oligoclase or andesine. In the zone adjoining the ore deposits, however, dark yellow to pale yellow biotite is also an abundant constituent in the rock. The common accessory minerals present are pyrite, apatite, and titanite, but in some of the rock specimens collected from the dumps adjoining the No. 1 shaft calcite and zoisite are abundant constituents, the zoisite being apparently an alteration product derived from the hornblende.

Character and Relationships of Deposits. The ore composing the pyrite deposits at the Caldwell mine consists partly of pyrite associated with quartz or quartz and calcite and partly of pyrite mingled with various proportions of the hornblende or hornblende-biotite schist that forms the country rock. The ore of the first type has the appearance of a breccia, the pyrite occurring as broken fragments enclosed in a matrix of quartz or of quartz and calcite; and it is owing to this relationship of the pyrite and quartz that where the ore outcrops at the surface the quartz from which the pyrite has been weathered away has a honeycomb or sponge-like appearance. The ore of the second type is merely a phase of the hornblende schist in which pyrite is included in all proportions, ranging from schist in which the pyrite is sparsely disseminated or present in small aggregates extending along the planes of foliation, to ore in which the schist is present in only scattered masses throughout thicknesses of several feet. Since there are thus considerable masses of rock in association with the pyrite deposits, which, although containing a considerable proportion of pyrite, are too low grade to be mined at a profit, the proportion of ore present in the mineralized zone would vary greatly according to the grade of the material classed as ore. In preparing the accompanying diagrams (Figures 4, 5, and 6), therefore, only those parts of the zone were classed as ore which in practice would be mined either for shipment as taken from the mine or for shipment after concentration in the mill. In addi-

tion to the quartz, calcite, and pyrite composing the ore the only other mineral observed to be present was pyrrhotite, which occurs here and there in the ore but is not an abundant constituent.

As indicated in the preceding description of the character of the deposits, the relationship of the ore and the enclosing hornblende-biotite schist is most indefinite, the ore generally passing into the schist transitionally. The deposits appear to have in the main an approximately lenticular form and trend parallel to the strike of the foliation of the enclosing schist.

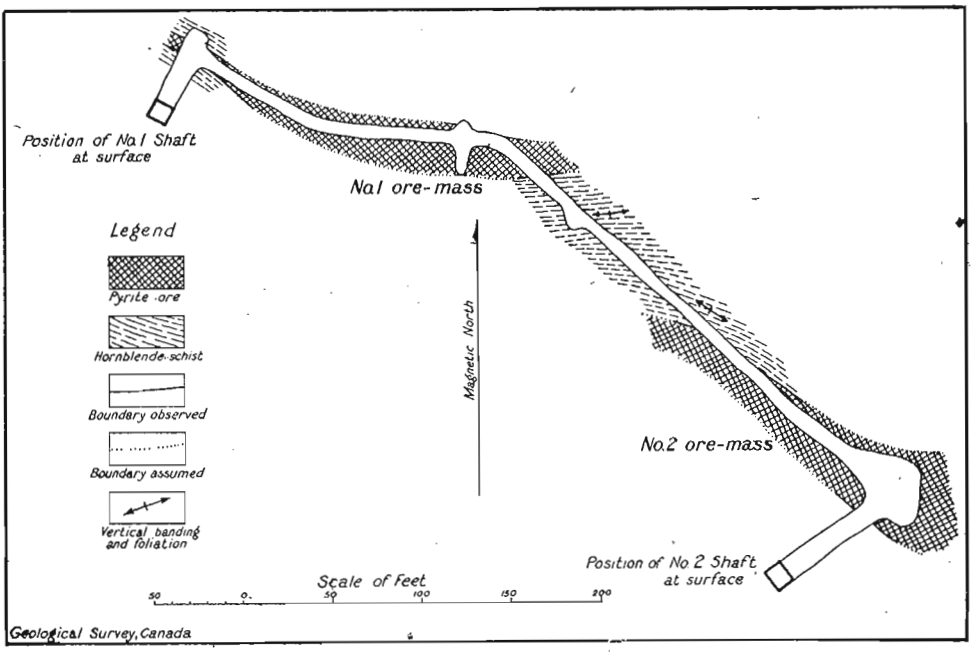


Figure 4. Plan showing relationships and approximate form of pyrite ore masses, No. 1 level, Caldwell pyrite mine, lots 1 and 2, con. I, Blithfield tp., Renfrew co., Ont.

Distribution of Deposits. The accompanying map (No. 1798) and Figures 4 and 6 show that the pyrite deposits are not distributed in alignment with one another but in parallel overlapping or echelon arrangement. Since the principal ore masses are not well exposed at the surface this echelon distribution is not fully shown on the map but can be observed, in the case of some of the smaller ore masses, exposed in pits and trenches at the northwestern end of the mineralized zone. In Figure 4 the relationships of the No. 1 to the No. 2 deposit as determined in the No. 1 level are shown. Here the relationships clearly indicate that the deposits lie parallel to one another and conform approximately to the strike and dip of the enclosing schist. In Figure 5 the positions of portions of the ore masses as determined by diamond drilling and in underground operations are shown as they appear when projected onto a plane situated 190 feet below the head of the No. 2 shaft. The distribution of the ore masses shown in this plan also illustrates their echelon arrangement and shows that the No. 1 deposit connects at depth with a larger ore mass intersected in the No. 1 diamond drill hole. Furthermore, since the foliation and banding of the schist in the core from diamond drill hole No. 7 trends transversely across the core it is probable that the ore deposit encountered in this hole also trends transversely as indicated in Figure 6 and hence does not connect with deposit No. 2 but forms a part of a separate pyrite mass.

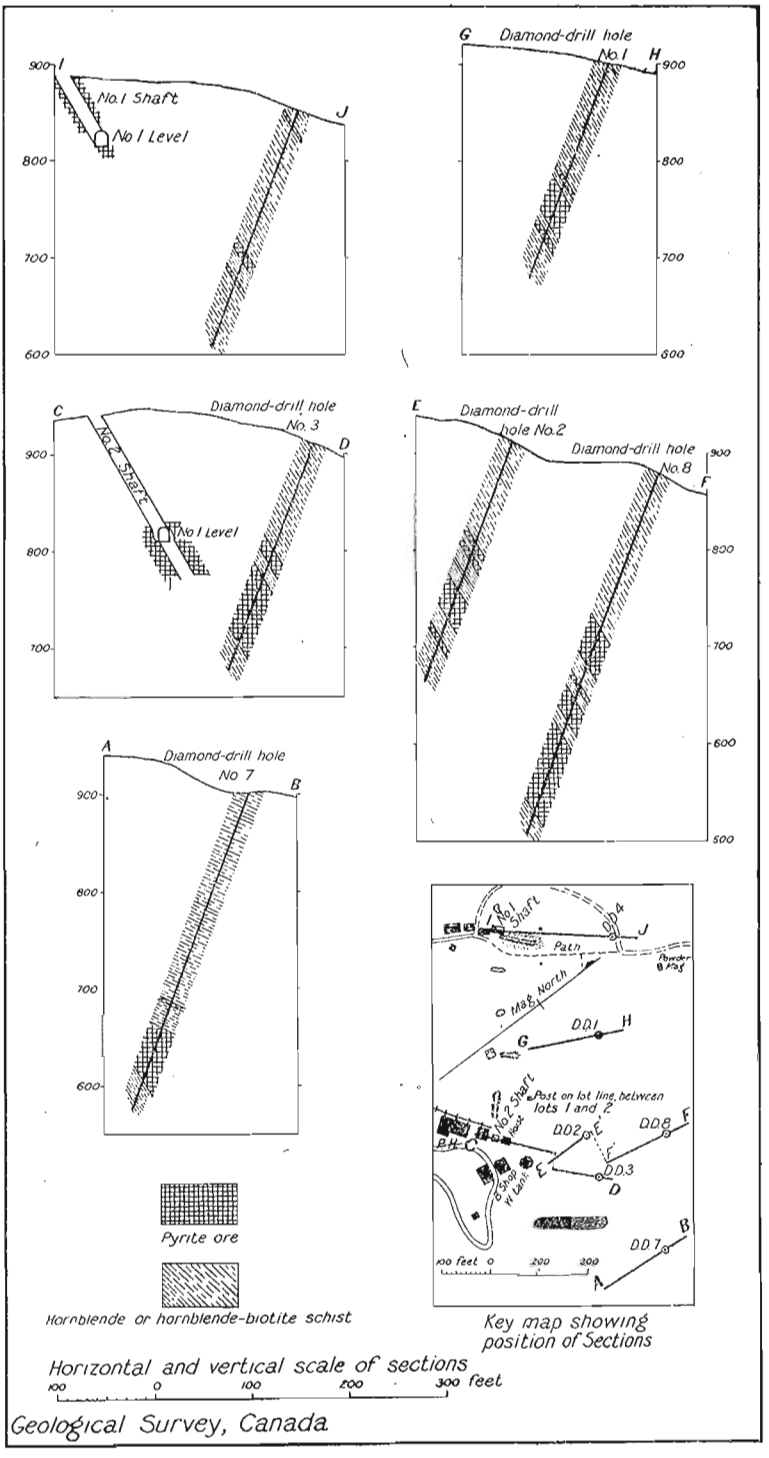


Figure 5. Vertical sections showing relationships of pyrite ore, Caldwell pyrite mine, lots 1 and 2, con. I, Blithfield tp., Renfrew co., Ont.
(Plotted from diamond-drill intersections.)

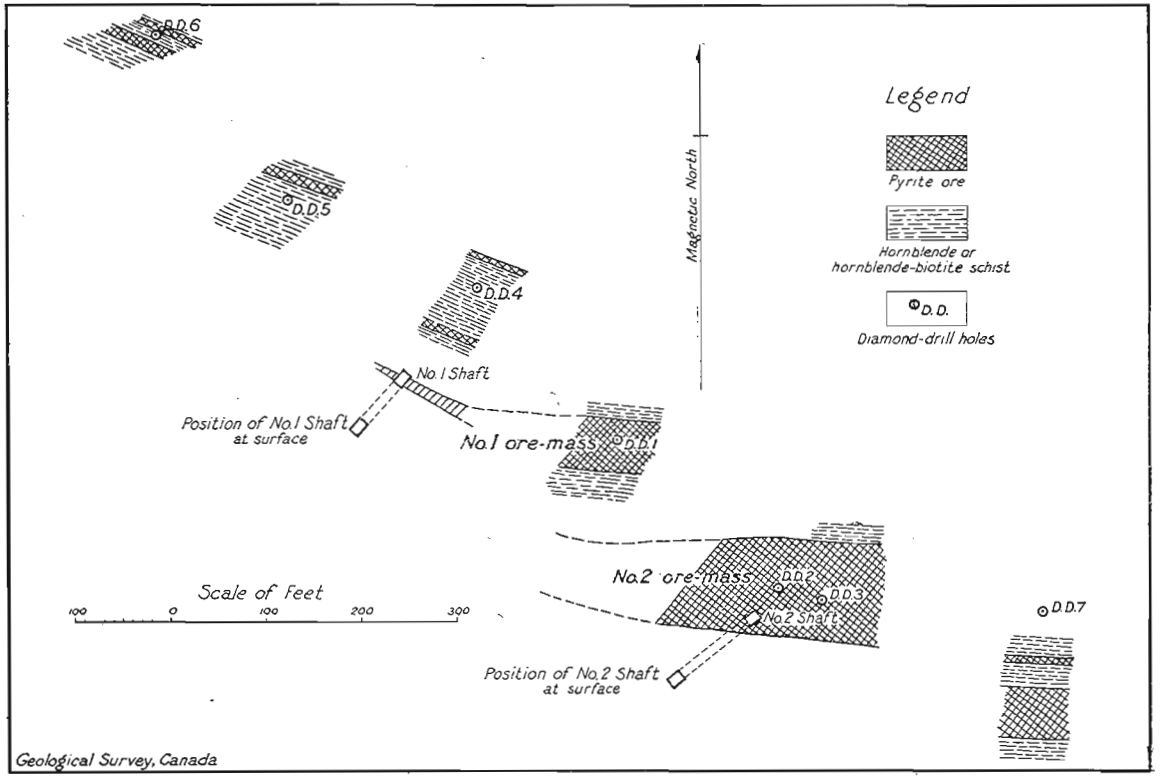


Figure 6. Plan showing trend and relationship of parts of pyrite ore masses at a vertical depth of 190 feet below the head of No. 2 shaft, Caldwell pyrite mine, lots 1 and 2, con. I, Blithfield tp., Renfrew co., Ont. (Plotted from diamond-drill intersections.)

Canada
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HON. SIR JAMES A. LOUGHEED, MINISTER; CHARLES CAMSELL, ACTING DEPUTY MINISTER

GEOLOGICAL SURVEY

WILLIAM McINNES, DIRECTOR.

Issued 1920

LEGEND

EARLY PRECAMBRIAN — QUATERNARY

GLACIAL
- Q — *Boulders, gravel, and sand*

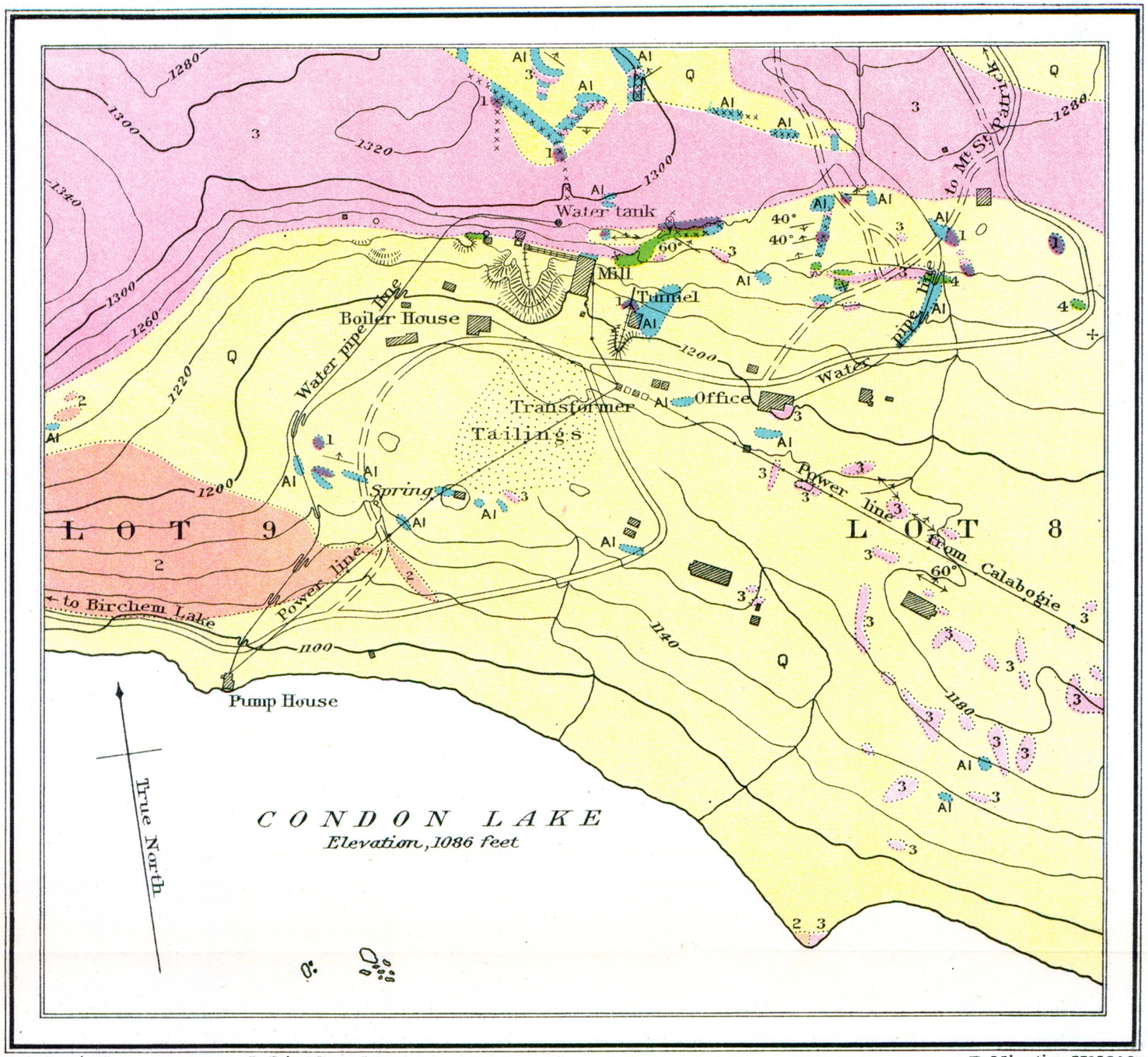
EARLY PRECAMBRIAN
- 4 — *Molybdenite-bearing pyroxenite*
- 3 — *Pegmatite*
- 2 — *Hornblende syenite*
- 1 — *Diorite*

GRENVILLE SERIES
- Al — *Crystalline limestone*

Symbols

- *Geological boundary*
- 60° — *Dip and strike*
- 60° — *Dip and strike, foliation*
- *Roads and buildings*
- *Roads (not well defined)*
- *Mine tramways*
- *Elevated tramways*
- *Trenches*
- *Shafts*
- *Prospects*
- 1200 / 1100 — *Contours (showing land forms and elevations above sea-level)*
- *Mine dumps*

Approximate magnetic declination, 10°20 West.



C. O. Senécal, *Geographer and Chief Draughtsman.*
A. Mc Gregor, *Draughtsman.*

Publication No. 1800

MOLYBDENITE DEPOSITS, LOTS 8 AND 9, CONCESSION XI, BROUGHAM TOWNSHIP, RENFREW COUNTY, ONTARIO.

Scale of Feet
100 0 100 200 300 400 500

Sources of Information
Geology by M.E. Wilson, 1919.
Topography by C.H. Freeman, 1919.

To accompany Summary Report, Part E, 1919, and Memoir by M.E. Wilson.

Structural Features. That the pyrite ore masses have been subjected to intense deformation since they were deposited is indicated by the foliated condition of the ore in places, by the crumpled condition of the calcite and quartz composing the ore as seen in thin section under the microscope, and by the presence of numerous polished and striated surfaces traversing the deposits. These surfaces trend in various directions and appear to have been formed by minor movements of the rock rather than by faults of large displacement.

It has been previously noted that the pyrite ore masses conform approximately in strike and dip to the banding and foliation of the schist and are lenticular in form. The echelon distribution of the principal ore masses and the highly deformed condition of the deposit are features that suggest that possibly some of the ore-masses are disrupted portions of larger ore masses and have been displaced into their present positions by faulting or planes trending approximately parallel to the foliation of the schist.

Origin. It has been previously noted that the pyrite deposits are closely associated with the Calabogie schist and gabbro, but that these rocks have been intimately intruded by granite gneiss. It seems probable, therefore, that the pyrite deposits are related in their origin either to the hornblende-biotite schist or to the granite gneiss. Such evidence as the writer was able to collect in the field, however, indicates that the deposits have been derived from the schist in which they occur. Some of the observations that lend support to this hypothesis are the following:

The deposits are intimately associated with the schist, all variations from highest grade of ore to schist in which the pyrite is sparingly disseminated being present.

The foliated condition of the ore in places suggests that the ore deposits were present before the Calabogie gabbro and schist were foliated into their present condition, whereas the granite gneiss was evidently intruded subsequent to the development of the foliation.

McIlwraith Property.

The McIlwraith pyrite deposit is situated on lot 5, con. IV, Darling tp., a few miles to the southeast of the Caldwell mine. It was first opened up as a gold prospect in the eighties but was mainly developed by the Nichols Chemical Company which carried on operations on the property under an option during the winter of 1899-1900. The work performed by this company included the sinking of a vertical shaft said to be 75 feet deep[1], and the excavation of an adit situated down the hillslope from the shaft and connecting with the shaft at depth.

With the exception of a small mass of the ore exposed adjacent to the shaft the ore deposit cannot be seen at the surface and since the workings are inaccessible the extent of the mass cannot be determined from an examination of the property. The ore lying on the rock dumps, however, like that at the Caldwell mine, consists of fragments of pyrite enclosed in a matrix of quartz. The position of the workings indicates also that the deposit lies on the margin of a mass of gabbro that has intruded the Grenville limestone and hence like the Caldwell ore mass is very probably related to the gabbro in its origin.

MOLYBDENITE IN THE RENFREW-CALABOGIE DISTRICT.

General Statement.

The molybdenite deposits occurring in the Renfrew-Calabogie district in common with molybdenite deposits generally, are all associated with granite, syenite, granite gneiss, syenite gneiss, or pegmatite, but at some points the molybdenite occurs in veins or aggregates within the granite, syenite, or pegmatite, whereas in other localities it is disseminated in a zone of metamorphic pyroxenite developed along the contact of the granite or pegmatite with crystalline lime-

[1]Wilson, A. W. G., "Pyrite in Canada, its occurrence, exploitation, dressing, and uses", Mines Branch, Dept. of Mines, Can., 1912, p. 61.

stone. The deposits occurring on the Morin or Ross, the O'Brien, and the Spain properties are the most important examples of the first class and that on the Hunt property (Renfrew Molybdenum Mines, Limited) the most extensive ore mass of the second class.

Renfrew Molybdenum Mines, Limited.

Location. The property belonging to this company is situated in lots 8 and 9, con. XI, Brougham tp., in the elevated area lying directly southwest of the northeastward-facing escarpment (known at its southeasterly end as mount St. Patrick) that extends in a northwesterly direction across the southern part of Renfrew county. It lies approximately 3 miles southwest of the village of Mount St. Patrick and 20 miles southwest of the town of Renfrew. The nearest railway station, 12 miles distant, is Ashdod on the Kingston and Renfrew branch of the Canadian Pacific railway.

History. The discovery of molybdenite on this property is said to have been made by Cornelius Hunt, son of Daniel Hunt, to whom the farm on which the molybdenite occurs belonged. A specimen of the molybdenite was taken to the Black Donald Graphite mine where it was identified by the provincial mining inspector. Shortly after the discovery an option on the property was sold to American capitalists who shipped a small quantity of ore but later allowed the option to drop. In the winter of 1912 a second option was taken on the property by F. R. Aufhammer who sold the option to a Belgian syndicate operating in Canada under the title Algunican Development Company. This company afterwards purchased the property and had completed some drilling and other development work when owing to the outbreak of the World War all work was stopped. In the autumn of 1915, a new company known as the Renfrew Molybdenum Mines, Limited, was formed and operations were again undertaken and continued from that time until the mine was finally closed down in the autumn of 1918. During this last period of operation a mill having a capacity of approximately 25 tons per day was erected and an electrical transmission line was built to connect the mine with the power plant of the M. J. O'Brien Company on Madawaska river at Calabogie.

Geology. The molybdenite deposits so far discovered on this property outcrop on the southwesterly slope of a northwesterly trending ridge that parallels the northeast side of Condon lake. The portion of the hill slope above the outcrops of the deposits is occupied mainly by pegmatite, whereas the rock exposed beneath the outcrops is mainly crystalline limestone. Farther down the slope, however, hornblende syenite occurs.

The study of the areal geology adjacent to the Hunt mine has shown that the pegmatite exposed on the hill top above the mine workings forms the eastern end of a mass of pegmatite extending continuously in a northwesterly direction from the east boundary of lot 8, concession XI, to the west boundary of lot 11, concession XII. The mine is thus situated near the extremity of the pegmatite mass where it has been intruded more or less irregularly into the limestone. The position of the pegmatite mass on top of the limestone and its approximate conformity in strike and dip to the structural trend of the limestone indicates that the pegmatite mass has the relationship of a sill. It is possible, however, that this apparent structural conformity might have been brought about by the adjustment of the limestone around the more competent mass of pegmatite as a result of the regional deformation to which the rocks of this district have been subjected.

The pegmatite is a medium to coarse-grained pink rock exhibiting a graphic structure. It is generally massive but in some of its fine-grained phases a foliated structure can be observed. It consists chiefly of microcline (in which some albite is perthitically included) and quartz, but also contains some disseminated muscovite and magnetite.

The limestone exposed on the property is the normal banded type in which masses and bands of pegmatite and diorite are included. The disseminated constituents observed in the rock were mica, pyroxene, graphite, pyrrhotite, and pyrite. The banded structure which it exhibits arises partly from variations in the colour of the limestone but mainly from variations in the proportions of disseminated mica and pyroxene. The pegmatite bands and masses included in the limestone are similar in character to the main mass occupying the top of the hill and in some cases are 20 feet or more in width and several hundred feet in length. The inclusions of diorite are granular dark or black rocks containing an abundance of mica and hornblende or pyroxene. A dark mica-hornblende phase of the rock said to have been blasted out in excavating the mill-site occurs on the rock dump to the south of the mill. This when examined under the microscope was found to consist chiefly of olive green to yellow hornblende, red brown to pale yellow mica, and plagioclase having the optical properties of andesine. The less abundant constituents observed were apatite and pyrite.

The hornblende syenite outcropping at the base of the hill is a medium-grained speckled rock traversed by dykes and dykelets of pegmatite. It is composed of orthoclase, microcline, albite, a few grains of quartz, deep green to yellow hornblende, and scattered grains of titanite.

Character and Geological Relationships of Deposits. The deposits vary considerably in composition, consisting chiefly of green pyroxene or green pyroxene and scapolite at some points and of granular pyrite and pyrrhotite at others. On the whole the molybdenite is most abundant where pyrite and pyrrhotite occur and is only sparingly present where these minerals are absent. In some places, as in the shallow pit situated on the slope directly above the adit, the pyroxenite contains a considerable proportion of microcline so that all the intermediate types between a pyroxenic pegmatite and a feldspathic pyroxenite are present.

The mode of occurrence of the deposits as zones following the contact of the pegmatite and the limestone is illustrated in Figures 7 and 8. An examination of these diagrams shows that the molybdenite-bearing zones occur partly along the under side of the main pegmatite mass that occupies the top of the hill above the mine and partly along the upper side of a second mass of pegmatite included in the limestone below. The zone on the under side of the upper pegmatite mass, however, does not carry sufficient molybdenite to be profitably mined except in a drift on the No. 1 level directly north of the No. 1 shaft, whereas the zone overlying the lower pegmatite mass is mineralized throughout (Figure 9).

Structural Features. The pegmatite and limestone exposed in the No. 1 shaft at the point where the shaft connects with the No. 3 level, is intersected by an approximately horizontal fracture plane which has probably been the locus of a fault (Figure 7). The opening lying along the plane of the fault is occupied in places by pyrite which occurs partly in the massive form and partly in crystal aggregates associated with a white platy variety of stilbite.[1] A specimen of the massive pyrite taken from the fault zone was observed to be striated on one of its surfaces and to be traversed by fractures that had been partly recemented. These features indicate that the massive pyrite was present before the faulting occurred. The crystallized pyrite and the stilbite, on the other hand, lie on top of the striated surface in places and were evidently developed subsequent to the faulting.

Where the limestone is in proximity to the included masses of pegmatite the banding in the limestone bends around the pegmatite masses, indicating that the folding to which the limestone has been subjected occurred in part at least after the pegmatite was intruded. It follows, therefore, that the contact zones along the margins of the pegmatite masses have also been subjected to folding.

[1] Identified by Eugene Poitevin, Mineralogical Division, Geological Survey.

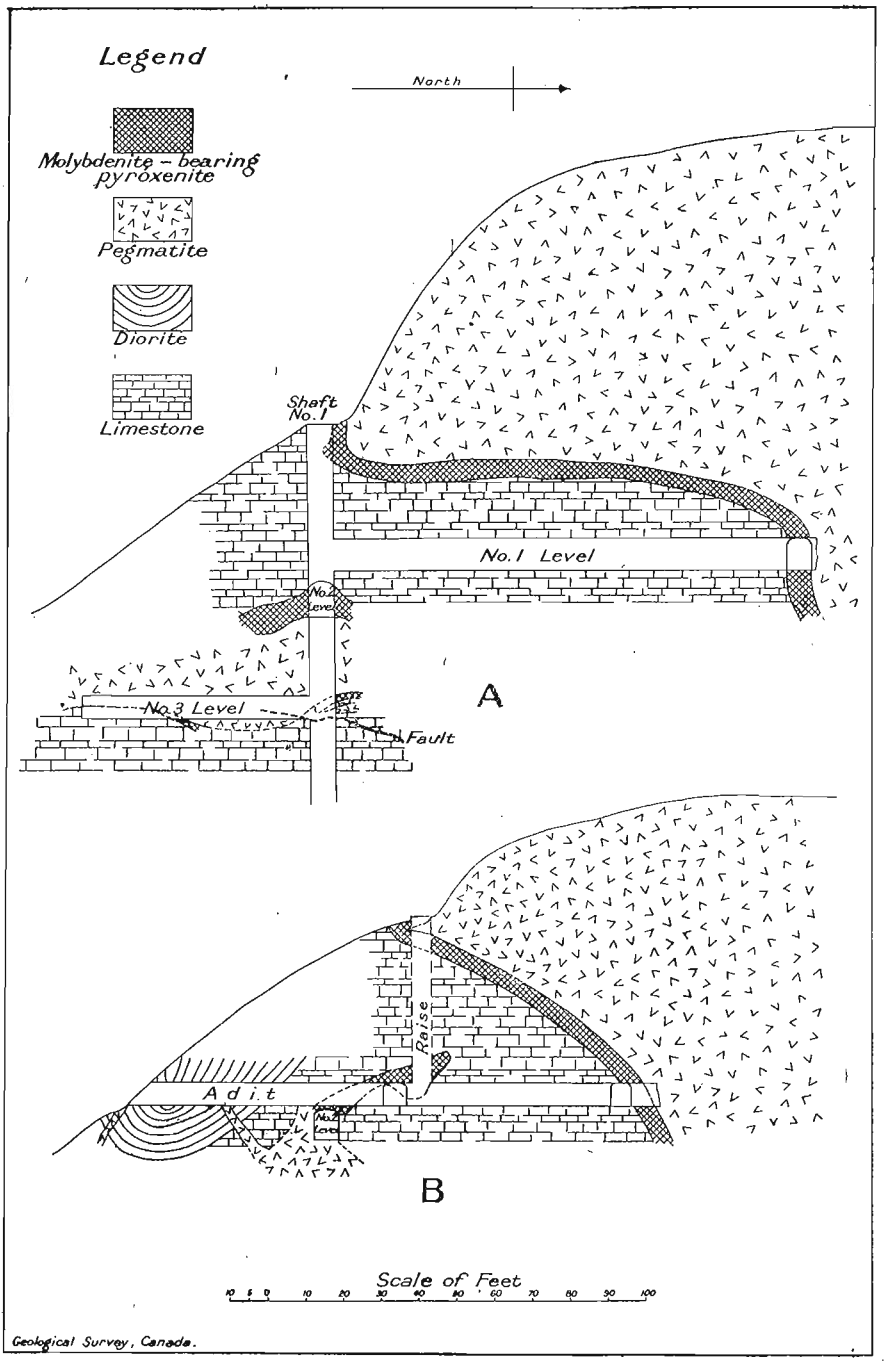


Figure 7. North-south cross-sections showing contact relationships of molybdenite ore masses, Hunt molybdenite mine (Renfrew Molybdenum Mines, Ltd.), lots 8 and 9, con. XI. Brougham tp., Renfrew co., Ont.

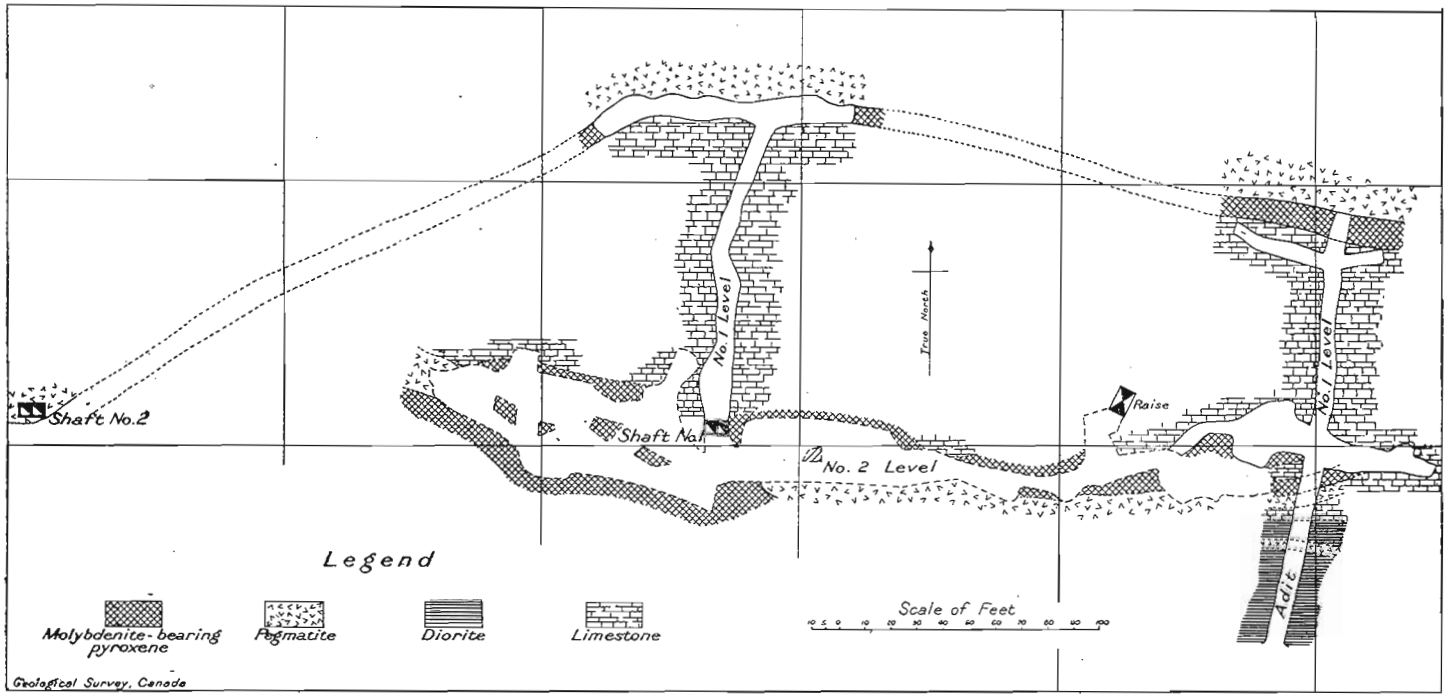


Figure 8. Plan of No. 1 and No. 2 levels showing contact relationships of molybdenite ore masses, Hunt molybdenite mine (Renfrew Molybdenum Mines, Ltd.), lots 8 and 9, con. XI, Brougham tp., Renfrew co., Ont.

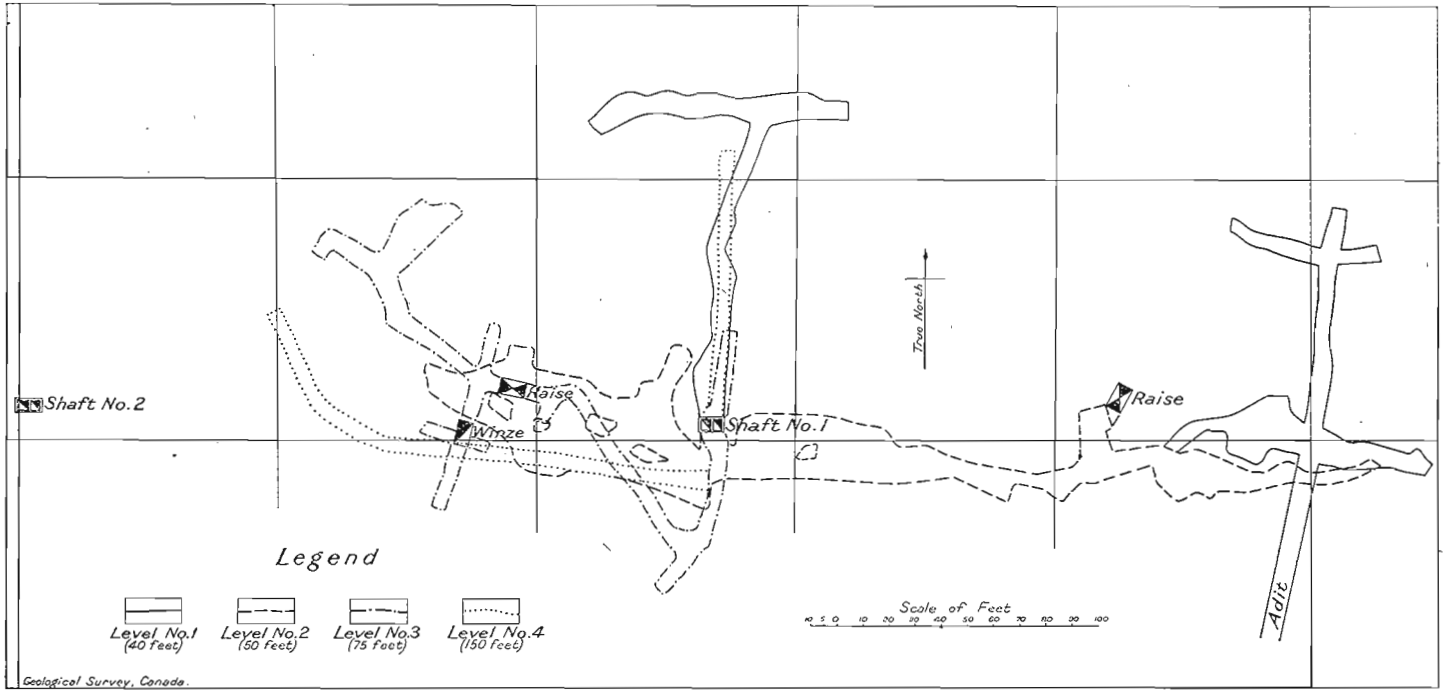


Figure 9. Plan of underground workings, Hunt molybdenite mine (Renfrew Molybdenum Mines, Ltd.), lots 8 and 9, con. XI, Brougham tp., Ont.

Origin. The mineralized contact zones that constitute the molybdenite deposits on the Hunt property so strikingly illustrate the type of ore deposits known as contact metamorphic that it is scarcely necessary to cite more than the principal data upon which their classification as such is based. Briefly stated these data are as follows:

The deposits lie in zones following the contact of the pegmatite and limestone and have been shown to have these relationships in the case of both the upper and lower ore masses for a distance of over 400 feet along the strike and in the case of the upper ore mass for a depth of 150 feet along the dip.

The principal minerals composing the deposits are diopside and scapolite, typical minerals that are generally found where the geological relationships indicate that siliceous emanations derived from igneous rocks have reacted with limestone.

The manner in which these molybdenite-bearing zones were formed was presumably, therefore, as follows:

Following the intrusion of the pegmatite into the limestone emanations containing silica, molybdenum, iron, sulphur, and other elements were evolved from the pegmatite along its margin, the siliceous portions of which reacted with the limestone to form diopside and scapolite whereas the molybdenum, iron, and sulphur were deposited as molybdenite, pyrite, and pyrrhotite.

Spain Mine.

Location and History. The Spain mine is situated in lot 31, con. IX, Griffith tp., Renfrew co., approximately 30 miles southwest of Renfrew and 8 miles southwest of the village of Dacre. The molybdenite deposit on the property was discovered in 1912 by Mr. Joseph Legris of Renfrew who purchased the surface rights to the lot from Mr. Timothy Donovan and the mining rights from the Crown, and after prospecting at intervals during the two succeeding years, sold the property to Mr. W. J. Spain of New York.

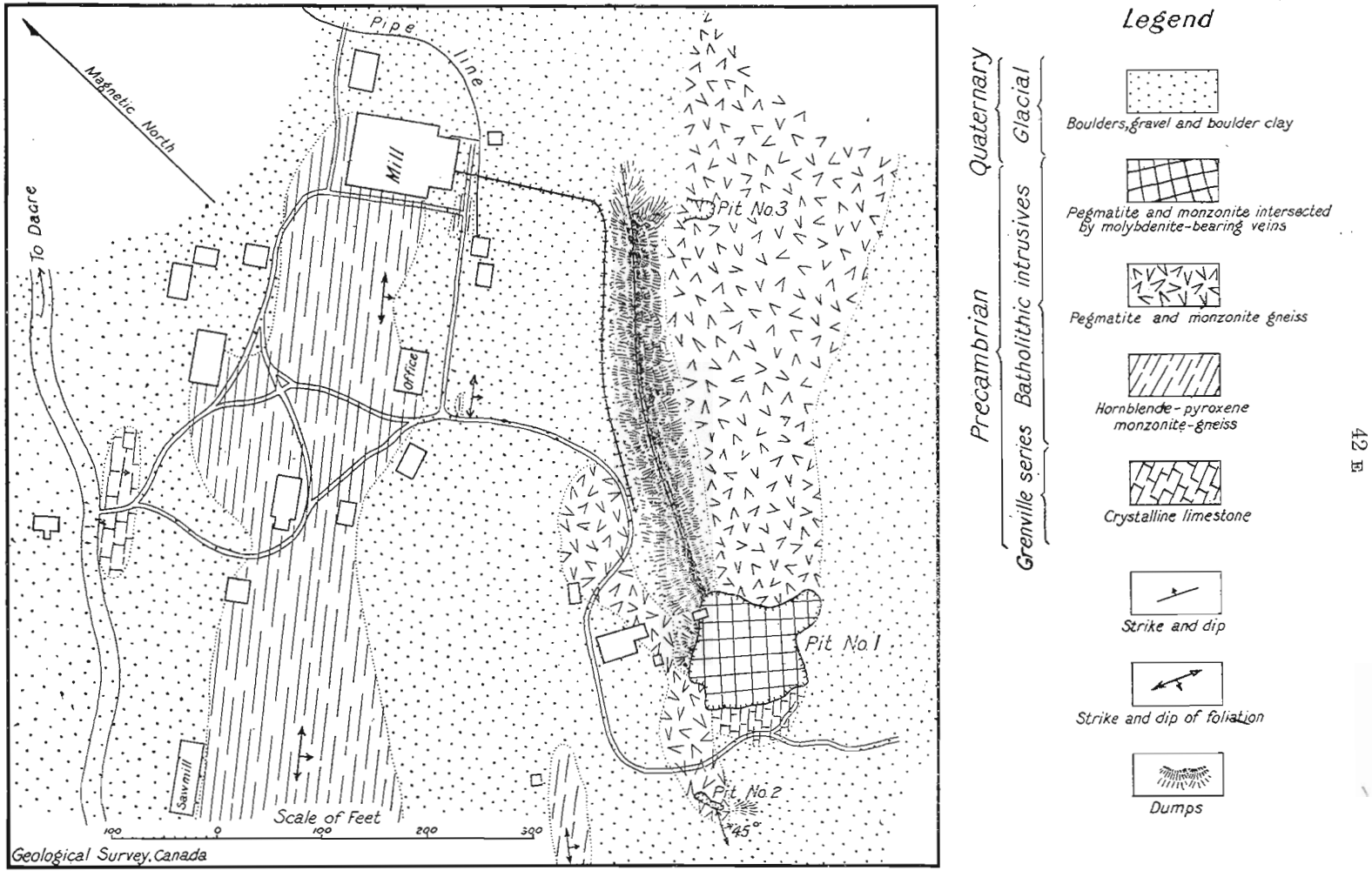
Work was continued by the new owner in 1915, and in 1916 a mill was erected on the property. The process for recovering the molybdenite according to the original design of this mill consisted in sorting out the large masses of flake by hand both before and after crushing, pulverizing the ore by passing it through a jaw crusher and rolls, and concentrating the molybdenite from the pulverized ore first by bolting and finally by means of a Hooper pneumatic concentrator. Later in the year, however, a Woods flotation machine was installed.[1]

In the meantime a shipment of one car-load (68,482 pounds) of ore from which 6,869 pounds of concentrates were recovered was treated in the ore testing laboratory of the Mines Branch.[2] During 1917 operations were continued at intervals in a small way but the production was quite nominal.

In 1918 the property was purchased from Spain by the Steel Alloys Corporation, owners of a nearby molybdenite deposit on lots 35 and 36, con. XIV, Brougham tp., known as the Sunset. Since acquiring the Spain mine the new owners have continued operations in a small way and have installed a set of Callow flotation cells in the mill, but up to the time the writer visited the property in September, 1919, this had not been operated for more than a few days. The superintendent of the property at present is Mr. J. E. Cole.

Geology. The rocks associated with the molybdenite deposits on the Spain property include crystalline limestone of the Grenville series, hornblende or pyroxene-hornblende monzonite, pegmatite, and aplite. The Grenville limestone was observed to occur in two outcrops (Figure 10), one extending along the main highway adjoining the property and the other extending westward from the west face of the No. 1 pit. The other rocks exposed consist of

[1] Parsons, A. L., Ont. Bur. of Mines, Ann. Rept., vol. XXVI, 1917, p. 280.
[2] Mines Branch, Dept. of Mines, Can., Sum. Rept., 1916, p. 86.



42 E

Figure 10. Plan showing geological relationships of molybdenite deposits, Spain mine, lot 31, con. IV, Griffith tp., Renfrew co., Ont.

grey monzonite gneiss into which pegmatite and aplite have been intruded in numerous small dykes or masses. Under the microscope the monzonite was found to consist mainly of pale green pyroxene partly or entirely altered into deep green to yellowish green hornblende, orthoclase, and plagioclase (andesine or oligoclase). The less common constituents in the rock included brown to pale yellow biotite, titanite, apatite, and magnetite.

Character, Relationships, and Grade of Deposits. With the exception of a small, irregular, discontinuous molybdenite-bearing zone having a maximum width of 2 feet and exposed only in the bottom of the No. 2 pit, all the molybdenite observed in the Spain property occurs in the No. 1 pit. This opening is a large, irregular excavation approximately 100 feet long, 75 feet wide, and 10 to 25 feet deep, at the northeast corner of which a shaft has been sunk to a depth of 35 feet. The west face of the pit is occupied by banded, impure pyroxenic limestone, the banding in which, except for minor undulations, appears on the face of the pit to lie in an almost horizontal position, although in reality it dips to the southeastward at a low angle. Elsewhere in the pit, the rock is the hornblende-pyroxene monzonite gneiss with which numerous dykes and masses of pegmatite and aplite are associated. Here and there in the pit irregular aggregates or veins consisting of molybdenite, pyrite, pyrrhotite, quartz, and feldspar occur traversing the gneiss and pegmatite. These veins and aggregates occur almost everywhere, but are most abundant along the north face and on the bottom of the pit at its west end.

Since in No. 1 pit the molybdenite-bearing aggregates and veins are most irregular and are nowhere more than 1 foot in width it is obviously impossible to mine these scattered deposits without excavating the intervening country rock; consequently in estimating the average percentage of molybdenite in the deposit, the proportion of molybdenite in the rock mass as a whole must be considered rather than the proportion of molybdenite in the small aggregates and veins. With this fact in mind, an attempt was made to estimate the percentage of molybdenite in No. 1 pit by measuring the proportion of vein material to country rock in selected areas on the faces and bottom of the pit. It is evidently not possible in this manner to determine, accurately, the percentage of molybdenite in a deposit of such irregularity, but nevertheless, the result obtained indicated that the molybdenite could not be more than 1 per cent of the deposit and might be considerably less. Since the writer examined the property, however, Mr. Cole, the superintendent, reports that considerably higher grade ore has been met in the west end of No. 1 pit.

CELESTITE.

An examination was made of a celestite deposit in lot 7, con. X, Bagot tp., Renfrew co. It is situated about one-half mile west of Virgin or Dempsey lake and approximately 4½ miles by road from Calabogie station, on the Kingston and Renfrew branch of the Canadian Pacific railway.

The celestite is exposed chiefly on the west and south faces of a pit 70 feet long by 25 feet wide, and from 5 to 25 feet deep, cut across an east-west trending ridge of crystalline limestone. North of the limestone ridge, the bedrock is hidden beneath a swamp and south of the ridge beneath glacial drift, so that practically nothing is known with regard to the extension of the deposit in these directions. A few scattered masses of celestite, the largest 3 feet wide by 4 feet long, are included in the crystalline limestone to the east of the pit, but no outcrops of the mineral could be seen to the west.

On the faces of the pit the celestite occurs partly in short, lenticular, vein-like masses from 3 to 6 feet long and from 1 to 2 feet wide and partly as a matrix enclosing broken fragments of the crystalline limestone. The bottom of the pit is partly hidden beneath rock debris, but where the rock is visible only a few scattered masses of the celestite appear to be present. All that is known,

therefore, with regard to the deposit may be summed up in the statement that it is a mass of celestite-bearing rock approximately 70 feet long by 15 feet wide and from 5 to 25 feet deep, and averaging approximately 30 per cent celestite.

Although the celestite thus appears to be present in an isolated mass, the broken character of the limestone included in the deposit and the fact that celestite is commonly associated with the veins of fluorite, barite, and galena that occur here and there in southeastern Ontario, suggest that in this deposit also, the celestite in reality fills a fault fracture which in this case would most probably trend in a north-south direction. At the time the writer left the district early in October, a core drill was being shipped to the property for the purpose of continuing exploration at depth.

INVESTIGATIONS OF CERTAIN PEAT BOGS IN ONTARIO AND QUEBEC.

By A. Anrep.

The table on page 45 briefly summarizes the results of investigations made during the summers of 1918 and 1919 of peat bogs in Ontario and Quebec. Edward M. Casey acted as field assistant.

Reconnaissance investigations were made also of a few bogs north of Port Arthur which proved to be entirely composed of peat litter. Owing to lack of time a proper survey could not be made of these bogs.

A very small peat bog about 6 miles south of St. Thomas looked over and drilled was found to contain very well humified peat fuel, but its area prohibits the manufacture of peat fuel on a commercial basis.

A preliminary investigation was also made of a bog near Bracebridge, Muskoka district, Ont.

This bog should be thoroughly investigated as it contains a very well humified peat fuel and judging from the appearance of the bog the erection of a peat plant would be justified.

A more detailed description will be available in a separately published bulletin containing maps and diagrams.

Certain Peat Bogs in Ontario and Quebec.

	Name of bog.	Location.	Area.	Contents.	Depth.	Remarks.
			Acres.	Tons.[1]	Feet.	
Ontario	Thedford	Four and one-half miles north-east of Thedford.	3,550	3,157,000	3 to 6	Fairly well humified fuel.
	Nellie Lake	One mile west of Nellie Lake, T. and N. O. railway.	2,090	3,050,000	4 to 11	Fairly well humified peat fuel, composition mostly sphagnum mosses.
	Maybrooke	Kerns and Harley tps.	1,281	1,388,000	4 to 10	
	Drinkwater	Matheson tp.	250	256,000	3 to 12	With proper treatment could be utilized for peat powder.
	St. John	St. John tp.	2,048	1,290,000	4 to 8	Very poorly humified.
	Brower	Brower and St. John tps.	2,206	1,176,000	5 to 8	
	Cochrane	Lamarche tp.	870	1,504,000	5 to 14	
	Clair	Ten miles east of Quebec.	2,600	3,051,000	4 to 16	With proper treatment will produce a comparatively good fuel.
Quebec	St. Joseph	Eight miles east of Quebec.	1,550	1,945,000	3 to 15	Average quality not high.
	Isle Verte (A)	One mile north of Isle Verte.	540	586,400	3 to 20	Top 10 feet fairly well humified; remainder not suitable for fuel or litter.
	Isle Verte (B)	Two and one-half miles north-east of Isle Verte.	220	165,000	3 to 15	At present unsuitable for fuel.
	St. Arsène	One mile north of St. Arsène.	1,720	1,135,000	3 to 16	Fuel.
			440	857,000	10 to 27	Very good litter.
	St. Anaclet	Seven miles east of Rimouski.	2,892	632,000	3 to 10	Central part and a small area at eastern end fit for fuel.
			360	278,000	5 to 12	Will produce a very good peat litter.

[1]Containing 25 per cent moisture except in peat fit for litter, when the moisture is 20 per cent.

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