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DEPARTMENT OF MINES

Hon. Martin Burrell, Minister; R. G. McConnell, Deputy Minister.

GEOLOGICAL SURVEY

William McInnes, Directing Geologist.

Summary Report, 1917, Part E

CONTENTS

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SUMMARY REPORT, 1917, PART E.

CANADIAN NORTHERN RAILWAY BETWEEN NIPIGON AND LONGUELAC, NORTHERN ONTARIO.

By T. L. Tanton.

CONTENTS.

INTRODUCTION.

Field work, during the summer of 1917, was carried on in an area approximately 30 miles wide and 130 miles long, traversed by the Canadian Northern railway between Nipigon and Longuelac, northern Ontario. The boundaries of the major geological divisions were determined in a general way, and in certain areas a short time was devoted to prospecting. All the principal water routes accessible from the railway were traversed, and micrometer or track surveys were made of those which were lacking or incorrectly shown on existing maps. Numerous land traverses were made in the region between Warneford and Jellicoe.

The writer was ably assisted in the field by T. T. Quirke and T. L. Gledhill.

GENERAL GEOLOGY.

The solid rocks of the region are of Pre-Cambrian age. Numerous problems as to age and correlation are presented by the metamorphic rocks and much detailed work is necessary before anything other than a tentative classification can be presented. However, the geological succession, in so far as it was determined by the work of the past season, is indicated in the following table, the younger formations being followed by the older in descending order.

Table of Formations.

Keweenawan diabase	Dykes and sills and possibly flow remnants.
Intrusive contact	
Keweenawan sediments	Finely banded, grey and red dolomite, red, buff, and green shales (some of these beds may be waterlain tuffs), red and buff, limy sandstone, white quartzite, and conglomerate.
Profound erosional unconformity	
Granite and related rocks	Batholithic intrusions and dykes.
Intrusive contact—found with schist complex and inferred with respect to Windegokan series.	
Windegokan series	Iron formation, greywacke, conglomerate.
Erosional unconformity—shown by pebbles of granite and several rocks from the schist-complex in the conglomerate. No granite was found in contact with the Windegokan series and its contact with the schist-complex shows very slight structural discordance.	
Granite	Not recognized in place but represented by pebbles in the Windegokan conglomerate.
Quartz porphyry	Dykes observed cutting rocks of the schist-complex, but not the Windegokan sediments. Pebbles of quartz porphyry occur in the Windegokan conglomerate.

Table of Formations.—Continued.

Intrusive contact

Schist-complex	Iron formation in stratified, argillaceous rocks of questionable origin: rhyolite—lavas and dykes; andesite, massive and ellipsoidal lavas and dykes; stratified tuffs and sediments of questionable origin; chlorite, sericite, and hornblende schists; banded mica schists and massive, fine-grained biotite and hornblende gneisses.

Distribution and Economic Significance of Formations.

Schist-complex. The schist-complex extends in a broad belt across the northern part of the mapped area and is crossed by the Canadian Northern Ontario railway between Octopus and Warneford.[1] At its western end it extends as far south as Parks lake, and to the north it extends beyond the limits of the explored area, probably connecting with the schist-complex area in the Kowkash district. At the eastern part of the explored area the schist-complex divides into two tongues; the northern one terminates in the granite area east of Devilfish lake, and the southern tongue crosses Long lake about 6 miles south of Longuelac station; its width as exposed on the western shore of the lake is 9 miles. Highly metamorphosed parts of the schist-complex occur in masses of various sizes through the granite to the south of the main schist-complex.

The schist-complex is favourable prospecting ground for gold, copper, lead, and iron. The most promising sections for gold, copper, and lead are: along the railway between Beardmore and Jellicoe; from the hills south of Windegokan lake to Attigogama lake, embracing a small granite area north of Paint lake; and the district immediately surrounding Little Long lake. In each of these places numerous quartz veins were observed, and traces of these metals were found in some of them. The country adjacent to the railway between Kinghorn and Langmuir is largely sand-covered, and, therefore, not easy to prospect.

Quartz porphyry and rhyolite dykes were observed cutting the rocks of the schist-complex in the vicinity of Jellicoe and to the south of Nezah.

Windegokan Series. The Windegokan series consists of highly folded sediments, and has been recognized in numerous narrow belts trending approximately east and west within that part of the schist-complex which extends from Poplar Lodge and the mouth of Sturgeon river to Little Long lake. It is most extensively developed between Corrigan and Wawong lakes.

Since it is believed that the gold, copper, and lead deposits which occur in the rocks of the schist-complex are derived from granites which may also be younger than the Windegokan series, the veins which cut these sediments should be examined with the same care as those in the schist-complex. No workable deposit of iron ore has been found in the iron formation of this series.

Keweenawan Sediments. Keweenawan sediments were observed only in the vicinity of Nipigon village. They are flat-lying, with a thickness of about 200 feet. At the mouth of Nipigon river they are visible on the lower part of cliff faces whose upper parts consist of diabase. They were found east of the northern end of Helen lake, not capped by a diabase sheet.

Certain of the more thickly-bedded, impure sandstones of the series are of value as building stone. Veins carrying silver, copper, or lead derived from the younger diabase might be expected to occur in these sediments. A small occurrence of copper minerals was observed this season in the cliff face on the east side of the mouth of Nipigon river.

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[1] The railway through this district is shown on Standard Topographic Sheet No. 20, 1917, published by the Department of the Interior.

Keweenawan Diabase. Diabase occurs in nearly flat-lying sills and capping sheets from 4 to 500 feet thick, throughout the greater part of the basin of lake Nipigon and the district bordering Nipigon bay. The erosion remnants of these sheets now form high mesas bounded by steep cliffs. A thick dyke, or series of dykes, with low dip toward the west, has been traced in a northerly direction from Parks lake to Mungo point on lake Nipigon. Numerous small diabase dykes were found at wide intervals throughout the explored area. An acidic differentiate of the diabase magma also forms small aplite dykes in the diabase and older rocks. Dykes of this sort were noted in the diabase on the south shore of Parks lake near the Nipigon Forest Reserve boundary, and in the Windegokan sediments 18 chains south of the northwest corner of claim H. F. 9 west of Windegokan lake.[1]

The diabase of this district is lithologically similar to the diabase of the Cobalt and Port Arthur districts, and is believed to be of the same age. Veins and dykes in the diabase should be carefully prospected. Deposits of silver, copper, and lead may be expected. Pectolite-calcite veins in the diabase 1 mile south of Nipigon village carry small amounts of galena and bornite.

MINERAL OCCURRENCES.

Iron. Numerous long, narrow belts of banded iron formation have been found in a zone about 4 miles wide and 65 miles long between Poplar Lodge and Long lake; but sand and gravel deposits and swamps cover the greater part of this zone, especially to the east of Nipigon Forest Reserve. Although many claims have been staked, and a considerable amount of assessment work done, no deposits have been found, so far, which justify mining operations. The most highly ferruginous parts of the formation observed were on claims A. L. 414 and A. L. 416, south of lake Eva; H. F. 12 and 13, west of Windegokan lake; and H. F. 33 on the north shore of Watson lake. All of these belts belong to the schist-complex except that at Windegokan lake the stratigraphic position of which was not ascertained.

At Watson lake the iron formation is an argillaceous schist containing narrow bands of jasper and hematite. Both the schist and the hematite beds contain magnetite, but the hematite, which is finely interlaminated with the jasper, is the predominating iron mineral. The jasper-hematite beds range from 1 to 4 inches in width and occur so closely together in the schist for a thickness of 25 feet as to make up one-half of the rock by volume. Outside of the 25-foot belt of iron formation the jasper-hematite bands in the schist are few and far between. The iron formation has been folded and crumpled and now strikes north 76 degrees east and dips 75 degrees to 85 degrees toward the north. It has been mapped along its strike for approximately 4 miles.[2] An average analysis of the iron formation taken across the richest part (25 feet) gives:

Fe	P	S	Mn	SiO_2	Al_2O_3
30·10	0·105	0·018	0·14	48·10	4·49

A carefully picked specimen of the best ore runs:

Fe	P	S	Mn	SiO_2	Al_2O_3
65·55	0·093	0·011	0·09	5·30	0·57

It is impossible to mine the narrow beds of good ore without including an equal or greater volume of lean schist.

The banded iron formation in the vicinity of Eva and Windegokan lakes contains little or no magnetite except near the margins of diabase dykes, but is otherwise similar to the Watson Lake occurrence.

[1] For other localities see Mem. 1, Geol. Surv., Can., 1910, p. 101.

[2] Ont. Bureau of Mines, 17th Ann. Rept., 1908.

The significant feature about all the known iron ranges, which probably explains why no rich ore deposit has been found, is that the bands of iron oxide and silica are intercalated with beds of grey schist, and throughout the greater part of the iron formation the grey schist makes up more than half of the rock. The schist has not been carefully studied, but in some localities it has the appearance of slate, elsewhere arkose or tuff—in all cases an alumina-bearing rock. The concentration of iron ore from iron formation is normally brought about by the solution and removal of the non-ferruginous constituents which are more soluble than iron oxide; but in this district both the aluminous material and the iron oxide in the iron formation are insoluble, and a concentration of iron by selective solution is, therefore, checked. If the iron formation in this district were of the same character as that of northern Michigan and Minnesota (only iron oxide and silica) the main problem would be to work out the structure by detailed geological investigation and to prospect the synclinal troughs where a circulation of underground waters might have operated But, since it is not, a preliminary step should be taken, namely, to find a considerable thickness of iron formation devoid of grey schist.

Gold. On the Edie claim, near Main narrows, Little Long lake, gold occurs in angular fragments of quartz, up to 3 inches in diameter, in the drift along the shore. Quartz veins occur in place at this locality, but no gold has been found in them. Considering the angularity of the gold-bearing fragments and their localization, and knowing the direction of the latest advance of the ice-sheet, it is reasonable to suppose that the gold-bearing quartz vein from which the fragments were derived, occurs only a short distance to the northeast of the locality where the gold-bearing fragments are now found.

Mr. Kline, of Keemle, reports that gold values were found by assay in a quartz vein carrying abundant pyrite, on the northeast shore of the west bay of Little Long lake. A grab sample taken by the writer from this vein showed no gold content.

In 1884, an unsuccessful attempt at gold mining was made by C. S. Morris[1] on some quartz veins in the Poplar Lodge district.

Silver. A trace of silver was found in a small calcite vein carrying chalcopyrite and cutting sericite schist, at Canadian Northern Railway mileage 139 + 10 chains, west of Hornepayne.

Copper. The largest copper deposit now known in the district occurs on the railway 6 chains east of mile-post 145, west of Hornepayne. Quartz veinlets filling a fractured zone 2 feet wide can be traced for 20 feet. The quartz carries pyrite and chalcopyrite, and on the weathered surface malachite and azurite. The country rock is chlorite schist, sericite schist, and intrusive diorite. These rocks near the margins of the fracture zone are slightly mineralized. An average sample taken across the fracture zone was assayed and showed a copper content of 1·52 per cent.

Other occurrences of copper minerals were noted at the following localities: 20 chains southwest of Canadian Pacific Railway mile-post 66 (west from Schreiber); east shore Nipigon river due east of above locality; 4 chains north of mile-post on Canadian Pacific railway 1 mile southwest from Nipigon; 1 mile + 10 chains south from Canadian Northern Railway mileage 10 + 30 chains west of Jellicoe; these four localities being on diabase cliffs. Also on the Devanney claim 1¼ miles southwest of Jellicoe; the north shore of Partridge lake east of Kinghorn; the west end of Paint lake; the east shore of Kenogamisis river 1 mile north of the Canadian Northern Railway crossing; the south shore of West bay, Little Long lake; the Hayne claim at Longuelac station; these occurrences being in quartz in pegmatite veins that cut the schist-complex.

Lead. Small amounts of galena occur in the quartz veins at the following localities: Devanney claim 1¼ miles southwest of Jellicoe; the west end of Paint lake; the

[1] Geol. Surv., Can., 1910, Mem. 1, p. 137.

east shore of Kenogamisis river 1 mile north of the Canadian Northern Railway crossing; in calcite veinlets at Canadian Northern Railway mileage 143½, west of Hornepayne; and in a calcite-pectolite vein cutting the diabase on the Canadian Pacific railway, 1 mile southwest from Nipigon.

Zinc. Small quantities of sphalerite were observed in the quartz veins on the Devanney claim 1¼ miles southwest of Jellicoe, and at the west end of Paint lake.

Molybdenite. Several crystals of molybdenite were observed on the Hayne claim at Longuelac station. The mineral occurs in pink syenite dykelets which cut coarse-grained amphibolite. The discovery was made on a small, low-lying exposure on the shore of Long lake. Further prospecting or stripping is greatly hampered in this locality by a thick mantle of sandy clay.

There are no mines in the district and none of the observed mineral occurrences appear to warrant mining operations; but there is a strong probability that valuable mineral deposits exist, and that careful prospecting is warranted. This belief arises from the following considerations: (1) the general rock assemblage and the geological relationships are similar to those of the mineral producing districts of northern Ontario to the east of this region; (2) the study of the small mineral deposits observed in the explored area shows that mineralizing agencies have been active more than once; (3) the great variety of minerals, other than iron, discovered by a very little casual prospecting, indicates that many more discoveries might be made if prospecting were carried on intensively.

AGRICULTURAL POSSIBILITIES.

The greater part of the district is unsuitable for agriculture, its surface being chiefly sand, gravel, or bare rock. The only areas along the railway where the soil appears to be sufficiently clayey to be of agricultural value are situated (1) north of Nipigon village to the west of Helen lake, and (2) between Longuelac and Keemle. In the latter section, except in the immediate vicinity of lakes and streams, drainage would be necessary before the land could be worked. Hay and root crops are successfully raised at Longuelac.

FORESTS.

An efficient system of fire protection is in operation and the areas of burned forest in the district are comparatively small. The largest was found to the north of Partridge lake extending to the upper part of Dumas creek; another extends along the railway in the vicinity of Nezah. The scorched trunks of the standing jack-pine trees at Nezah were being cut last summer and shipped to Port Arthur for fuel. Muskegs are numerous, but they occupy only a small percentage of the total area. On the sand-plains and rock ridges, jack-pine forests and mixed woods prevail, the latter being made up chiefly of jack-pine, white spruce, balsam, poplar, and birch. The trees are less than 12 inches in diameter, for the most part, but are suitable for pulpwood. The eastern boundary of the Nipigon Forest reserve crosses the railway 1 mile + 26 chains east of Nezah.

WATER-POWERS.

By far the most important sources of water-power in the district are the falls and rapids on Nipigon river, as shown by the following table taken from "Water-powers of Canada."[1]:

Nipigon river.	Minimum.	
	Head, in feet.	Horse-power.
Cameron rapid	39	19,500
Split rock	15	7,500
Island portage	9·5	4,750
Pine Portage rapid	......	......
White chute	12	6,000
Flat-rock rapid	38	19,000
Victoria rapid	10	5,000
Camp Miner rapid	7	3,500
Virgin fall	25	12,500

Namewaminikan or Sturgeon river, one of the largest streams flowing into lake Nipigon, descends more than 200 feet in the last 15 miles of its course, in a series of falls and rapids. The more important are as follows:

Miles from the mouth.	Fall.
3½	9 feet.
5½	38 "
11½–12½	78 "
15	21 "

Many falls and rapids also occur on the upper Sturgeon river to the south of Kinghorn.

NORTH SHORE OF LAKE HURON, ONTARIO.

By W. H. Collins.

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Illustrations.

INTRODUCTION.

The field season of 1917 was spent in examining a number of small areas within 60 miles of Sudbury. The main object of the work was to estimate the character and probable importance of mineral deposits that have been found in these localities; but incidentally a considerable amount of country was mapped geologically and some further information gained regarding the stratigraphy of the region. The latter results

[1] Commission of Conservation, 1911.

need not be related here, for a report upon the geology of this and other parts of northeastern Ontario will be undertaken which will furnish a more suitable medium for their discussion. Some of the ore deposits, however, are being developed at the present time, so this opportunity is taken to present such information obtained as may aid in their valuation and exploration.

During part of the season Paul Bourret acted as assistant, performing his duties capably and willingly.

COPPER DEPOSITS OF THE NORTH SHORE OF LAKE HURON.

Sulphides of copper—principally chalcopyrite, but also chalcocite and bornite—have been mined along the north shore of lake Huron intermittently since 1846. With the exception of Bruce mine, the deposits are small and rather low-grade and can be operated profitably only when conditions are unusually favourable. Consequently the industry has had an interrupted and uncertain existence. At present, with copper worth 25 to 30 cents a pound, the Bruce mine is again producing. The Massey mine has been equipped with an oil-flotation concentrating plant and is practically ready to renew mining, and fresh attention is being given to the more promising prospects, of which dozens occur between Sudbury nickel district and Sault Ste. Marie.

The recently developed oil-flotation process for concentrating sulphide ores, because of its cheapness and great efficiency, may be the means of converting some of these prospects into workable mines. On the other hand, they have no convenient ore market. The ore from the Bruce mine, which consists of a few per cent chalcopyrite in quartz and is, therefore, well adapted for mixing with the basic copper-nickel ore of Sudbury district, is shipped without concentration to the Mond Nickel Company's smelter at Coniston. But, in the case of the Massey mine and many of the undeveloped prospects, the gangue is not high enough in silica to find favour at the Sudbury smelters. It is at present necessary to concentrate these ores and ship the concentrates either to New Jersey or Virginia, or to Trail, B.C., at a transportation cost of $5 or more a ton. Apparently the only hope of removing this handicap lies in the development of enough small mines in the district to supply a local furnace at Sudbury or some other convenient point.

To some extent, then, the future of copper mining along the north shore will be made clearer by a census of the known ore deposits and an estimate of the probable productivity of each. One contribution to this was made by C. W. Knight in the Annual Report of the Ontario Bureau of Mines, 1915, part I, pages 230-237, and another by A. P. Coleman in the same publication, 1913, part I, pages 146-160. The descriptions given here for the same purpose are intended to supplement those by Coleman and Knight.

Wilmot Claim. This property lies in the south half of lot 11, concession V, Galbraith township. It is 12 miles in a direct line north of Bruce Station on the Canadian Pacific railway and 3½ miles north of the projected line of the Lake Huron and Northern Ontario railway. Discovered eleven years ago by John Wilmot, no development was done until the autumn of 1916 when it was purchased by the present owners, the Hudson Copper Company, Limited. Development work was in charge of Mr. John Black when the property was visited last May. A camp capable of housing about thirty men has just been built, surface exploration of the property begun, and a shaft sunk 60 feet on the principal vein.

The property is underlain by conglomerate and greywacke belonging to the Cobalt series and by dykes and irregular masses of diabase intrusive in these sediments. All these formations are traversed by the ore-bearing veins, of which five had been partly uncovered. The veins are roughly parallel in an east-west direction, dip from 60 to 90 degrees, and occur within a space 700 feet by 400 feet. The principal vein has been stripped for 300 feet, showing a mineralized width of 1 to 5 feet. One shaft has been sunk 60 feet on this vein, and another 18 feet, exposing ore of the same character all the way from the surface. The other veins are narrower and have been exposed for distances of only 50 feet or less. The ore in the main vein consists of chalcopyrite, chalcocite, pyrite, and some bornite and specular iron in a gangue of quartz and partly schistified country rock. The dump made in sinking the shaft appears to contain not over 2 or 3 per cent of copper, though some handsome samples of massive chalcopyrite and chalcocite have been taken from it.

Ore of the same character is reported to occur in lot 5, concession I, McMahon township, on the shore of Patten lake. The vein, which has been traced for 150 feet, is mineralized for 60 feet.

Whiskey Lake Group. The copper and gold deposits near Whiskey lake have been known for about fifteen years. They have been prospected and sampled before, but the recent high price of copper has revived interest in them to the point of doing further development work. As it is planned to develop several of the discoveries under one management the relative positions of these are indicated on the accompanying sketch map (Figure 1). The claims lie 16 miles north of Spanish station on the Canadian Pacific railway, but the only route over which supplies or ore can be hauled at present is a 25-mile wagon road to Massey.

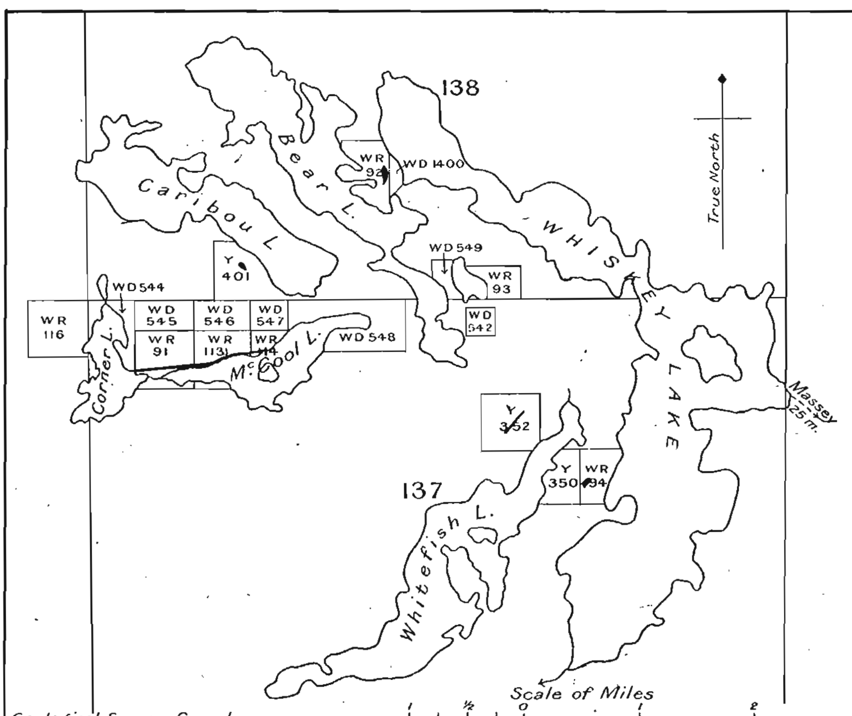

Figure 1. Sketch map of Whiskey Lake copper-bearing area showing the location of the mining claims and principal ore-bodies (in heavy line).

The ore-bodies are in Huronian (Bruce series) sediments close to intrusive bodies of diabase, or in the diabase itself. They are either veins occupying fractures in the country rock or, in the case of the Reynolds, the country rock is impregnated with disseminated sulphides and silica.

Reynolds. Mining location W. R. 92. On this claim a large mass of diabase abuts against the older conglomerate, argillite, and impure limestone of the Bruce series. The contact is nearly vertical and the argillite close to it is greatly contorted, somewhat schistose, and so fractured that it breaks readily into small, wedge-shaped fragments. For abou: 100 feet away from the diabase the deformed argillite is also silicified, traversed by a plexus of veinlets and irregular patches of quartz, and impregnated irregularly with pyrite, chalcopyrite, and a few specks of galena. It appears to have served as a fixing agent for the mineral matter expelled from the diabase during the cooling of the latter.

This mineralized contact-zone, extending north 30 degrees west, is exposed at two places 500 feet apart, between which lies a soil filled ravine. The larger and more richly mineralized of the two outcrops, situated on the eastern edge of the ravine, is about 80 feet wide and 200 to 300 feet long. Sulphides are not entirely lacking in any part of this outcrop, but are chiefly concentrated in a number of patches and belts that altogether make up 15 to 20 per cent of the whole outcrop. These richer portions are of minable size, but so distributed that a large amount of rock will have to be removed with them, if they prove to be rich enough in copper. To help ascertain this latter point, several of the best looking patches were roughly sampled by Mr. R. A. Teasdale, one of the joint owners of the property. A sample fairly representative of the richer bodies, which was collected by Mr. Teasdale, was found upon assay to contain 4·57 per cent copper.

Caribou. Mining location Y 401. This claim is situated on the eastern side of a high ridge that parallels Caribou lake. The ridge consists of a core of diabase intruded through and flanked by a white feldspathic quartzite belonging to the Serpent quartzite, or uppermost member of the Bruce series. A heavy talus of quartzite blocks embedded in soil covers the lower slope. Some of the talus blocks are mineralized with chalcopyrite and pyrite.

In the expectation of finding the source of these mineralized blocks deeper in the side of the ridge a trench was made into the talus. A mass of quartzite so large that it was taken to be the undisturbed Serpent formation, was found about 8 feet below the surface. However, on comparing the dip and strike of such bedding planes as are recognizable in this mass, with those in the quartzite higher up the hill, it appears that the former is not in place, but has been displaced, though probably only a few feet or yards, down-hill. This quartzite mass contains splashes of chalcopyrite as much as 2 feet long and 3 or 4 inches wide. A careful inspection of the face exposed—40 square feet—indicates an average copper content of slightly over 2 per cent. A carload of hand-picked ore taken from this place last winter and sent to a smelter in the eastern United States yielded 7¼ per cent copper.

The present trench exploration seems to be well located. As long as it continues in ore like that now exposed it can be done at little or no net expense. It is likely, also, that the huge block uncovered by trenching has not moved more than a few feet down the side of the ridge, consequently whatever remains of the original deposit is the same short distance away. If as rich ore can be found in quantity at that depth in the side of the ridge, it should, under present market conditions, be profitably minable. However, the mineralized quartzite block affords a doubtful clue to the size and shape of the ore-body from which it was broken. Because other blocks have been found at intervals along the slope for a total distance of 500 feet they might be assumed to have come from a continuous ore-body of that length, or longer, but if this deposit originated from the diabase, like the other copper deposits near Whiskey lake, it is more likely to consist, like them, of several comparatively small fissure deposits.

Whitefish. Mining location Y 352. The copper deposits on this claim are situated near the top of the southwest slope of a diabase ridge, 200 feet high, that extends along the southwest side of Whitefish lake. They form a series of lenticular mineralized fractures in the diabase. Each fracture strikes about 100 degrees and is offset about 25 feet south from its neighbour to the west, so that a line passing through the middle of each runs at 160 degrees. They dip 45 to 50 degrees southwest, being only 10 to 15 degrees steeper than the side of the diabase ridge. Three lenses have been uncovered, 35 feet apart, each of which has been test-pitted for 1 to 4 feet deep and can be traced along the surface for a few yards. The largest shows ore for a maximum width of 8 feet and a length of 25 feet. They are filled with angular fragments of diabase cemented together by a mixture of quartz, ankerite, chalcopyrite, and pyrite deposited in the order in which they are named. This ore carries about 2 per cent copper but can be concentrated by hand-sorting to about 10 per cent. A general sample taken from the largest of the three lenses and assayed by Thos. Heys and Son, Toronto, yielded 0·16 ounce gold per ton, in addition to the copper.

These mineralized lenses are probably unconnected parts of a single fracture system that coincides approximately with the southwestern face of the diabase ridge, and it is quite possible that further exploration along the ridge will result in the discovery of other lenses. None of those already discovered appears to be extensive either horizontally or in depth.

Long. Mining locations W. R. 91, 113, 114. A vertical fracture plane mineralized in much the same manner as the Whitefish property has been traced from Corner lake eastward along the north side of McCool lake for over a mile. It is in Huronian sediments, but diabase occurs just to the south and east. Chalcopyrite is found more or less continuously along this fracture, for widths ranging from a few inches to 5 feet. Quite recently the more promising part of it was examined by Mr. C. H. Hitchcock, mining engineer, of Sudbury, who has kindly allowed the general results of his examination to be given here. Samples taken at intervals of 25 to 50 feet along the vein for several hundred feet yielded average values of 1½ per cent copper and from 0·02 to 0·04 ounce of gold and of silver per ton.

The length of this deposit may be taken to indicate a considerable depth, but the values in copper, gold, and silver are rather low for profitable mining, even at the present time.

Payton. Mining location W. R. 94. Unlike the properties already described the Payton contains gold-bearing veins. One large quartz vein and several smaller ones have been found intersecting an argillite member of the Mississagi quartzite, or basal formation of the Bruce series. The argillite is an extremely weak material and has been crumpled, schistified, and fractured to an extraordinary degree by the deformational forces which have affected the Huronian rocks in this region. The veins are consequently faulted and bent so much that their general attitude and probable underground extension are scarcely determinable in the present state of development of the property. The large vein is 6 feet wide in one place where a shallow open-cut has been made diagonally across it. Only a few feet away a trench 40 feet long has been made along what is probably a bent or faulted extension of the same vein. In this distance it ranges from 36 to 60 inches in width. A shaft has also been sunk 30 feet in the argillite near by, exposing another body of quartz of unknown but seemingly small size.

The veins are composed of white quartz containing occasional disseminated patches of pyrite. Fine specimens of free gold have also been obtained from them. The average gold content is reported, however, to be rather low.

HOWRY CREEK GOLD-ARSENIC DEPOSITS.

Gold was found near Howry creek in 1911, the discoverers being James and Charles Bousquet. In the next two years about one hundred claims were staked and some additional discoveries made. Since then the more promising claims have been examined and partly developed by prospective buyers; but mining operations have not followed, although it is expected that a small mill will be built this winter to treat ore from Bousquet property for the extraction of arsenic as well as gold.

The deposits occur on the north side of Howry creek, a tributary of Whitefish river, all being included in an area 6 miles long from east to west by 1 mile wide. They are conveniently reached from Sudbury by way of the Algoma Eastern railway, from mileage 64 on which a canoe trip of about two hours is necessary to cross Charlton lake and ascend Howry creek (See Figure 2).

The mineralized area is underlain by quartzite, greywacke, and conglomerate belonging to the upper part of the Gowganda formation and lower part of the Lorraine quartzite (Cobalt series). These formations lie on edge, strike east and west, and are intersected by a few dykes and larger bodies of diabase (Keweenawan). The ore

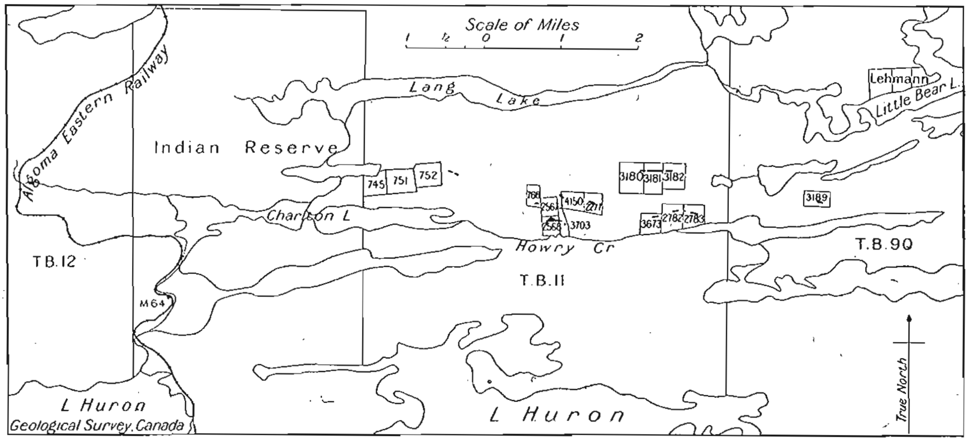

Figure 2. Sketch map of Howry Creek gold-bearing area showing the location of the more important mining claims and more promising ore-bodies (in heavy black lines).

deposits are chiefly well-defined quartz veins with a general east-west strike and nearly vertical dips. They are composed of white quartz and ankerite carrying arsenopyrite and free gold as their chief constituents of possible commercial value. The wall rock, especially if it is greywacke or conglomerate, is bleached, heavily impregnated with ankerite, and slightly mineralized with the same ore-minerals as the vein-stuff for 2 or 3 feet on either side of the veins. One of the deposits (mining locations 3180-81-82) is simply a broad sheared zone in conglomerate which has been hydrothermally altered and filled with a plexus of quartz veinlets.

All the deposits are probably the result of a single process of mineralization, since they resemble one another closely in mineral composition. One vein at least occurs in the diabase, so mineralization must have taken place after the intrusion of that rock. Further than this, however, the age and source of the ore have not been ascertained.

The relative positions of the various deposits are shown in Figure 2. Specific descriptions of the best looking deposits are given on page 12.

Steep. Mining location S3189. A system of sharply defined veins, represented in plan in Figure 3, has been found on this claim. The veins are composed mainly of quartz and ankerite, with sparing amounts of pyrite, arsenopyrite, hematite

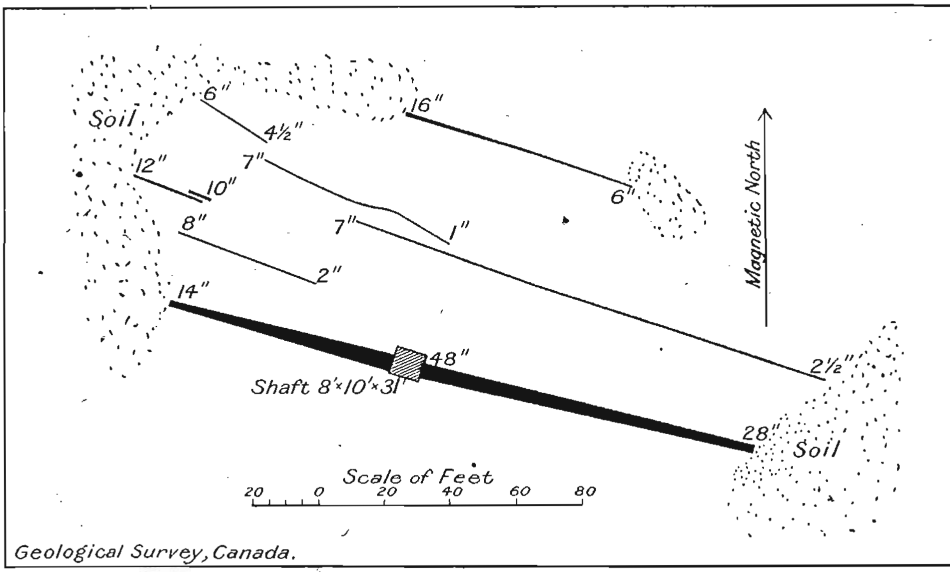

Figure 3. Plan of veins on the Steep property (mining location S 3189).

(specularite), and, it is said, some free gold. The greywacke wall rock between the veins is bleached, heavily impregnated with small crystals of ankerite, and probably slightly mineralized with the same metallic ores as are found in the veins. Very little trenching has been necessary to expose the veins, but in addition to this work a shaft 8 feet by 10 feet has been sunk on the largest vein to a depth of 30 feet. A representative sample from the dump made in sinking this shaft was assayed by H. Leverin of the Mines Branch and found to contain only 0·02 ounce of gold per ton.

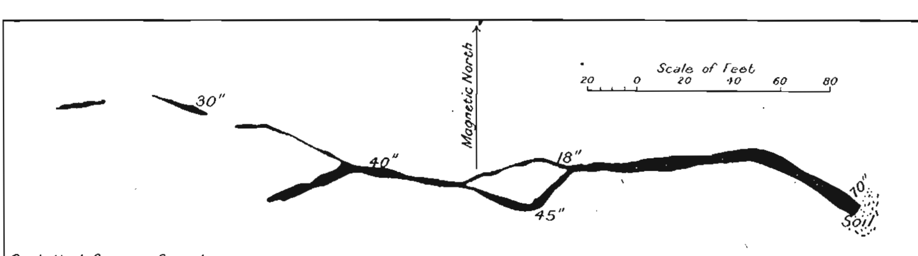

Figure 4. Plan of veins on the Bousquet property (mining location S 2783).

Bousquet. Mining locations S 2782, 2783, 3673. Near the middle of S 2783 an irregular vein shown in plan (Figure 4) has been trenched for 300 feet, and shallow test pits sunk in several places on it. The mineral association composing this vein is like that of the Steep veins, but it differs from the Steep veins in most other respects. Instead of a series of parallel, sharply defined veins there is a single, crooked, branching vein with rather indefinite walls and composed of vein stuff and schistified country rock. The wall rock is feldspathic quartzite instead of greywacke. The gangue of quartz, ankerite, and schistified rock carries free gold, pyrite, and arsenopyrite. The arsenopyrite occurs as the usual greyish-white variety and also as a darker iron-grey variety. It is the most abundant metallic constituent, being continuously exposed in massive form, 2½ to 18 inches wide, for a distance of 150 feet.

This vein was sampled systematically in 1916 by Mr. J. S. Wilson and Mr. A. L. Kemp. Some very high values in gold were obtained, but the average from all the samples taken indicates a gold content considerably under $10 a ton. At present, milling experiments are being conducted with a view to recovering the arsenic as well as the gold.

Six hundred feet west of this vein and approximately in line with it is another of the same character 3 inches to 48 inches wide, which has been stripped for 190 feet. There is much less arsenopyrite present, but good gold values are reported.

Near the north line of S 3673 two smaller exposures of the same character have also been found.

Black Fox. Mining locations S 2568, 2703. These claims are underlain by massive white quartzite (Lorraine), through which extends from east to west a series of parallel quartz veins. The veins are from a few inches to 50 inches wide and are exposed at intervals for 400 feet at least, and according to report, for a much greater distance. Individual veins, however, appear to be short. Even the wide veins are only 100 to 150 feet long, terminating in a multiplicity of small stringers. They consist of pure white quartz, with a little ankerite; but, except for a few scattered patches of disseminated pyrite, no metalliferous minerals were seen and a sample collected from the walls and dump of a 10-foot test pit, when assayed by Mr. Leverin yielded no gold.

Other Deposits. A vein of the same general character as the Bousquet vein occurs on mining location S 2277. It occurs partly in quartzitic greywacke, partly in diabase. It varies in width from 3 inches to 6 feet and has been stripped for 280 feet. The wall rock is bleached and impregnated with ankerite, arsenopyrite, and pyrite, but the vein itself is not so well mineralized as the Bousquet vein. It is reported to carry $6 in gold per ton.

Another vein 10 to 36 inches wide was seen on mining location S 766. It has been traced through the quartzite and along a quartzite-diabase contact for 270 feet. Gold is reported to have been found in it, and arsenopyrite is present in considerable quantity.

An ore-body somewhat different in character from any of the preceding was seen on locations S 3180-81-82. It is a schistified zone in Cobalt conglomerate which has been hydrothermally altered by vein-solutions and filled with many veinlets of the same general composition as the larger veins already described. Some of the veinlets cut across granite pebbles in the sheared conglomerate, indicating that mineralization took place after the rock had been schistified. The mineralized shear-zone is at least 40 feet wide and extends, according to information obtained, for half a mile east and west.

No quantitative determination was made of the gold content in the schist, but samples of the quartz veinlets were crushed and panned, yielding a small amount of gold. From the standpoint of size and convenient mining this deposit is much superior to any of the others, but the average gold content is probably too low to be profitably extracted.

The genesis of the Howry Creek veins is unknown, but their general similarity in composition to the ores of the Long Lake gold mine, which lies 25 miles towards the northeast, has been remarked by many persons acquainted with these properties. It is not improbable that other gold-arsenic deposits may occur in this 25-mile interval which approximately parallels the contact between the Huronian sediments and the younger Killarney granite to the south.

MICA AND FELDSPAR.

A line extending northeast from Killarney and passing a few miles southeast of Sudbury corresponds fairly closely with the boundary between two notably different parts of the Pre-Cambrian region in Ontario. Northwest of this line are the Keewatin schists, granite batholiths, and Huronian sediments. Southeast of it is a great area of highly foliated gneisses, partly igneous, partly sedimentary, which continue to the St. Lawrence. The boundary between these two terranes, so unlike geologically, is drawn more exactly on the French River, Sudbury, and Nipissing map-sheets issued by the Geological Survey.

Very little detailed information is available concerning the banded gneisses in the southeastern area or their economic possibilities. A few years ago Coleman[1] examined the rocks along the Canadian Pacific and Canadian Northern railways 15 to 20 miles southeast of Sudbury and concluded that a part of them at least is equivalent to the Grenville series of eastern Ontario. As the Grenville series in eastern Ontario is the home of an important and varied group of non-metallic minerals—mica, apatite, graphite, feldspar, etc.—a visit was paid this year to the reported Grenville area near Sudbury to get further evidence regarding the age and relationships of these rocks, and to ascertain whether they are accompanied by mineral deposits like those of eastern Ontario.

The results obtained have led to the conclusion that the mica-gneisses, quartzite, and crystalline limestone in question are not Grenville, and no graphite, apatite, etc., are known to be associated with them. Mica and feldspar do occur, but the mica deposits at least are not of the same character as those of eastern Ontario and Quebec. The mica is found together with feldspar in pegmatite dykes that represent late stages in the solidification of granitic intrusions in this region. Both these minerals, however, were found in amounts which hold some promise for their eventual commercial exploitation in this part of Ontario.

The pegmatite is composed of feldspar, quartz, and mica, but in proportions which vary widely in different dykes. Quartz is always present in considerable amount, and in some cases so predominates over feldspar that the rock is intermediate between ordinary pegmatite and quartz vein-stuff. Usually, however, orthoclase and albite form two-thirds or more of the whole. The orthoclase is deep pink, the albite white in colour, and they are found together in some of the dykes. Both occur as crystals up to a foot in diameter, unmixed with quartz, and also graphically intergrown with that constituent. In many of the pegmatite bodies a few per cent of mica is present in plates 1 to 2 inches in diameter. Most of it is a black biotite variety, the balance being muscovite. In fewer cases muscovite occurs alone in crystals 1 to 15 inches in their greatest diameter. The muscovite is free from inclusions, but has a smoky colour which reduces its transparency somewhat and gives it the appearance of amber mica.

Pegmatite dykes of this sort appear to be especially numerous where granite and granite-gneiss occur with mica-gneiss, quartzite, and other older rocks of sedimentary origin. They were less frequently seen where the granite and granite-gneiss occurred alone. A large number were seen near the Canadian Pacific and Canadian Northern railways in the vicinity of Wanup and Quartz stations, on the main line of the Canadian Pacific railway between Wanipitei and Markstay, and also south of the main line of the Canadian Northern railway near Ess Creek and Chudleigh stations. They are from a few feet to 90 feet wide and probably several times as long, though, owing to the soil covering, none of them was traced for more than 500 feet.

The largest mass containing a high percentage of feldspar, that was seen, lies 200 yards north of the main line of the Canadian Pacific railway and 3½ miles west of Markstay (mining location S 4194). A portion 500 feet long and 60 to 90 feet wide is exposed, but the whole mass, elsewhere soil covered, is probably much longer and rudely lenticular. It intrudes a dark, highly foliated gniess. Feldspar, quartz, and black mica are practically the only mineral constituents, forming roughly 70, 25, and

[1] Ann. Rept., Ont. Bureau of Mines, vol. xxiii, pt. I, pp. 208-211.

2 to 3 per cent respectively of the rock mass. The feldspar (orthoclase) is either white or flesh-red, and either in large individuals unmixed with quartz or graphically intergrown with that mineral. About 50 per cent of the pegmatite could be quarried as feldspar, and conveniently separated into one part nearly free of quartz or other impurities and another part containing 20 per cent or more of quartz.

Smaller dykes of the same character are numerous throughout the region underlain by the foliated gneisses, and it is highly probable that other large dykes can be discovered if the feldspar ever becomes of commercial value.

Pegmatite dykes containing mica in important amounts are much less numerous than those with high feldspar contents. One occurs in lot 7, concession 1, Davis township, about 1¼ miles southeast of Ess Creek siding on the Canadian Northern railway. It is from 1½ to 7 feet wide and has been exposed by trenching and test-pitting for about 40 feet. It consists of about 90 per cent orthoclase, 2 or 3 per cent muscovite, and 7 or 8 per cent quartz, being similar to the other pegmatite dykes of the region except that the mica crystals grow to a large size. They are 1 to 4 inches thick and up to 15 inches in diameter. Some of them are bent and others so ragged in outline that about three-fourths of the whole would be wasted in trimming. Moreover, the mica has a smoky colour which reduces its market value considerably. Several hundred pounds obtained from the test pit made in this dyke, when trimmed to about 4 inches square, sold for 90 cents per pound.

This deposit is owned by D. J. Finlan of Markstay. A somewhat larger muscovite-bearing dyke is reported to have been found near the middle of the adjacent township of Henry. A third occurs in concession IV, Dill township, about one-half mile west of the Canadian Pacific railway, and in all probability many others could be found if the country were thoroughly prospected.

BRICK CLAYS.

For distances up to 20 miles north of lake Huron the Pre-Cambrian rocks are covered, up to a height of 180 to 190 feet above lake Huron, by gravel, sand, silt, and clay deposited there at a time in the glacial history of the region when lake Huron stood far higher than it does now. Clay and sand are found up to about 725 feet above the sea, or 150 feet above lake Huron. From that elevation to 775 feet above sea the deposits are principally shore deposits of sand and gravel.

The clay is usually finely laminated, grey or reddish in colour, free from boulders or pebbles, and where it is not mixed with too much sand, appears to be suitable for brickmaking. Clay of this sort is common from Dean Lake westward to Bruce Mines and from Massey east to Espanola. In order to test the value of this clay for brick or tile manufacture, two samples were taken from the farm of Mr. R. J. Hoath just south of Rydal Bank in concession 1, Plummer township. A small creek has cut banks 10 to 30 feet high at this place, affording a good section of the clay deposit. One sample, of reddish colour, was taken from the bank 8 feet above the water; another, of bluish colour, from the water's edge. The two samples were submitted to Mr. J. Keele, chief of the Ceramics division, Mines Branch. Mr. Keele's report is given below.

Laboratory No. 587. From upper part of stream bank. Reddish brown, laminated, non-calcareous clay, free from pebbles or coarse grit.

It is very plastic and rather sticky when wetted; its working qualities are good. It dries slowly after moulding, with a high shrinkage. It burns to a compact red body at cone 010 (1742 degrees F.), becomes vitrified and shrunken at cone 03 (about 2000 degrees F.), and fuses at cone 1 (2100 degrees F.).

Laboratory No. 587a. From lower part of stream bank. Grey clay with an occasional brown layer, non-calcareous, and free from pebbles.

This sample contains a considerable amount of silt and consequently is not so plastic as the upper clay. It dries readily after moulding into shape, and the shrinkage on drying is much less than the upper clay. It burns to a light red, porous body at cone 010 and does not become dense and hard until burned as high as cone 03. It stands a little more heat than the upper clay before softening, but the colour at any temperature is not so good.

The following results were obtained in burning the samples at various temperatures:

Laboratory No.	Per cent total shrinkage. Cone 010.	Cone 05.	Cone 03.	Per cent absorption. Cone 010.	Cone 05.	Cone 03.
587...	9	9	17	17	17	0
587a..	4	4	11	15	14	7

These clays are useful for the manufacture of common brick and field drain tile. The upper clay when used alone is hard to dry and has too much shrinkage. It is also liable to check in the firing, which results in too many broken brick. The lower clay stands drying and firing well and has low shrinkages, but its working qualities, especially for the manufacture of tile, are not good.

A mixture of equal parts of the two clays will be found to give good results, as the defects of one are offset by the good qualities of the other.

If for any reason the lower clay can not be worked to advantage, either on account of drainage or other causes, then about 25 per cent of sand should be added to the upper clay in order to assist in the drying and reduce the shrinkage.

From what the writer has seen of the Pleistocene deposits along the north shore of lake Huron, clays equally suitable for brick or tile making can be obtained in many places between Echo Bay and Blind River, and between Massey and Espanola. Maple, birch, and other woods for fuel are abundant within easy reach of the clay areas and can be obtained for little more than the cost of cutting and hauling. The Canadian Pacific and the Lake Huron and Northern Ontario railways furnish convenient means of transportation.

MONTREAL RIVER DISTRICT, NORTHERN ONTARIO.

By H. C. Cooke.

CONTENTS.

INTRODUCTION.

The field season of 1917 was spent in an exploration in the district of Nipissing, west of the Montreal river. The exploration was undertaken on account of the interest aroused by the Matachewan gold discoveries, which rendered it probable that prospecting would soon be carried into the adjoining districts. Micrometer and prismatic compass surveys of the water routes were made through the townships of Midlothian, Montrose, Hincks, Argyle, Bannockburn, Doon, Yarrow, and Powell; and since returning from the field the results of these surveys have been compiled and a photographic copy of the map issued on a scale of 1 mile to 1 inch. Geological mapping of the townships mentioned was carried on as long as time permitted.

GENERAL CHARACTER OF THE DISTRICT.

Very little information of any kind as to the territory covered has hitherto been available to prospectors or travellers. This general lack of information is due to the fact that there are no large streams or lakes in it to render travel or survey easy. The district is the source of many streams, whose drainage basins interpenetrate one another complexly. Duncan creek, flowing into Montreal river through Duncan lake, drains Doon, most of Bannockburn, and the eastern part of Midlothian townships. Smaller creeks, also flowing to Montreal river, drain the eastern parts of Doon, Bannockburn, and Argyle, with the adjacent parts of Yarrow and Powell townships. Whitefish creek, which falls into Nighthawk lake, drains the remainder of Argyle township, and rises in small lakes in Montrose and Hincks townships. Nighthawk creek, which also flows to Nighthawk lake, paralleling Whitefish creek a few miles to the west, drains the western half of Hincks township; and the western part of Montrose and Midlothian township is drained through two main creeks to Grassy river. The district may be described, therefore, as characterized by numerous small creeks and lakes. The portages connecting these were in many places dim and poorly marked Indian trails, difficult both to find and to follow; so that travelling was reduced to a minimum.

The district includes the northern boundaries of the large area of the Cobalt series of sediments which extends southwards for many miles. Within the limits of the Cobalt series the country is very rugged, with a relief in places of as much as 500 feet. Beyond the limits of the Cobalt series, to the north and west, where older rocks prevail, the general elevation is much lower, with an average relief of not more than 100 feet, except in a few places where a knob or ridge of unusually resistant rock protrudes. Much of this flatter country has been made the depository of accumulations of glacial moraine, and now presents the usual topographic characteristics of such.

GENERAL GEOLOGY.

Dykes of quartz diabase and olivine diabase.
    Intrusive contact.
Cobalt series.
    Unconformity.
Granite.
    Intrusive contact.
Kiask series.
    Unconformity?
Igneous complex.

The preceding table outlines the succession of the rock formations of the district. At the base lies the complex of altered igneous rocks commonly known as Keewatin. That name is not applied here, as it appears probable that some of the units at present mapped with the igneous complex may eventually prove to be much younger. The igneous complex consists of basalts, andesites, rhyolites, and other volcanic flows. Some or all of these are cut by later dykes of diabase, which in hand specimens strongly resemble the Cobalt gabbro, but are nevertheless older than the Cobalt series. The relations of these dykes, some of which are highly porphyritic, with phenocrysts of feldspar an inch or more in diameter, are well shown on the Davidson claims in Powell township. The volcanic flows are also cut in the western part of the district by sill-like bodies of peridotite, now altered more or less completely to serpentine. It is within these serpentine bodies that the deposits of asbestos have been found. The serpentinized peridotites appear to be of common occurrence, but many of them contain no trace of asbestos.

The Kiask series overlies the basement complex in Midlothian, Doon, Bannockburn, and Powell townships. This series was first found by McMillan in Midlothian township, and was by him termed Timiskaming series. The writer prefers to replace this term by a local name, as the term Timiskaming implies an unproved correlation with the Timiskaming of Cobalt and vicinity. The Kiask series is, so far as observed, wholly sedimentary in origin. It consists of coarse conglomerates, grits, and slates.

Granite and syenite in large and small masses intrude the basement complex throughout the district studied. No locality was found during the summer's work where granitic rocks come in contact with the Kiask series, so that the relations between the two are not known. The granitic rocks are supposed to be the younger, because there were no pebbles of them found in the Kiask conglomerates. The absence of pebbles might, however, be due to the fact that erosion had not laid bare the granite batholiths when the Kiask series was being deposited.

The Cobalt series, cut by dykes of quartz and olivine diabase, overlies all the older rocks described. As the relations of these rocks have already been frequently and thoroughly described, they will not be touched upon further here.

ECONOMIC GEOLOGY.

The gold discoveries in Powell township on the Davidson and Otisse claims have excited much interest among prospectors and mining men. Although these claims are not included in the area examined by the writer during the past summer, they were briefly examined, with a view to determining the possibility of other discoveries of the kind in the townships to the west. The discoveries are of two types, those in porphyry and those in schist. On the Davidson claim the gold impregnates an irregular body of porphyritic syenite intrusive into the basement complex. The porphyry is cut by a network of closely spaced veinlets of quartz. The gold is usually found in or near these veinlets, although Mr. Davidson states that it is occasionally found in the porphyry, several inches from a veinlet. It appears probable that the gold was introduced by the solutions forming the veins. On the Otisse claims gold is found both in the porphyry and in schist. The occurrence in porphyry is similar to that on the Davidson claim. The principal schist occurrences appeared at the time of examination to be in beds of calcareous tuff, which has been heavily impregnated with small grains of pyrite. These have since been reported by engineers examining the property to carry very high values.

The area to the west, especially in Argyle, Hincks, and Montrose townships, may well yield similar discoveries if carefully prospected, especially in the neighbourhood of small granite masses. One such small mass crosses the Powell-Bannockburn line between the 3 and 4½ mile-posts. Another granite ridge runs north and south through the centre of Hincks township, and a third, much larger mass, crosses the southern parts of Cleaver and McNeill townships. It is probable that dykes of granite porphyry will be found in the neighbourhood of these masses, and that some of the dykes may have gold associated with them. With the exception of these granite masses, the townships mentioned are underlain largely by "Keewatin" rocks, in which may be expected tuffaceous beds of the type which occur enriched in Powell. The probability of the occurrence of gold in this area is indicated by the statement of Mr. J. Davidson, that he has panned gold in several places during one or two rapid prospecting trips.

Asbestos appears to be a valuable potential resource of the district, and one which would repay more attention from prospectors than it has received in the past. Asbestos deposits have been known for some years in Deloro township, and some mining has been carried on. Mr. George Rahn of Erie, Pennsylvania, and Haileybury, has held several claims for asbestos in the western part of Bannockburn for some years. The asbestos is of fair quality, if fibre of sufficient length can be obtained. It occurs in serpentinized peridotites. Such bodies are fairly common in the district, and careful prospecting might prove that many of them are asbestos-bearing. It seems reasonable to suppose that serpentinized bodies occur throughout much of the area between Bannockburn and Deloro, as this area is mainly occupied by the "Keewatin" series.

The attention of prospectors is also called to the possibility of finding chromite in the serpentines. Chromite, a valuable mineral used in the manufacture of steel, is characteristically associated with serpentine, as veins, nodules, or scattered grains. It is a black, heavy mineral, resembling magnetite in appearance, and yields a characteristic brown powder when crushed fine under the hammer.

OIL PROSPECTS OF SOUTHWESTERN ONTARIO.

By M. Y. Williams.

CONTENTS.

Illustrations.

INTRODUCTION.

From June 4 to October 5, the writer was engaged in geological work relating to oil prospecting in Halton, Wellington, and Kent counties, Ontario.

Harold Bush and Vernon Kniewasser of Ottawa, and Edmond Normand of Montreal, acted as field assistants, and proved very satisfactory.

The writer is indebted to numerous gentlemen, most of whom are connected with the oil and gas business, for kind co-operation and assistance during the summer. Acknowledgments are especially due to H. F. Slater, A.M. McQueen, and E. P. Rowe of Toronto; W. I. Dick, Wm. Hume, and George S. Hume of Milton; Dr. C. O. Fairbank of Petrolia; F. J. Carman, John McLeod, Thomas Knight, Alex. Sussex, A. Elliott, and N. Wade of Bothwell; R. L. Pattinson and F. W. James, of Chatham.

FACTORS CONTROLLING OIL OCCURRENCE.

It is now generally recognized that in oil and gas formations, rock porosity and structure are the two factors responsible for the accumulation of oil and gas into pools of economic importance. Porous parts of a formation tend to accumulate the dispersed fluids and where gravity aided by structure is not effective, porosity is the controlling factor. In most cases, however, the porosity of an oil-bearing stratum does not change materially from place to place, and gravity under suitable structural conditions has determined the oil occurrences. In the oil fields, gas, oil, and salt water generally occur together, gas being the lightest and salt water the heaviest. If the three are present in a dome-shaped bed of porous rock overlain by an impervious bed, as a result of the action of gravity the gas will be at the top, the oil lower down, and the salt water will occupy the sides of the dome and the surrounding depressions. This has been shown to be the actual condition in many well known oil fields, including the Devonian oil fields of southwestern Ontario. In cases, however, where water is lacking in the oil-bearing formation, oil and gas gravitate to the basins and synclines and although lacking the impelling force of hydrostatic head, may form considerable accumulations.

The variability of rock porosity cannot be foretold, but rock structure can be determined in many cases, either from the attitude of rock outcrops, or from records of wells drilled in the vicinity.

The result of the work of the past season, as it bears upon the oil development of the region visited, follows.

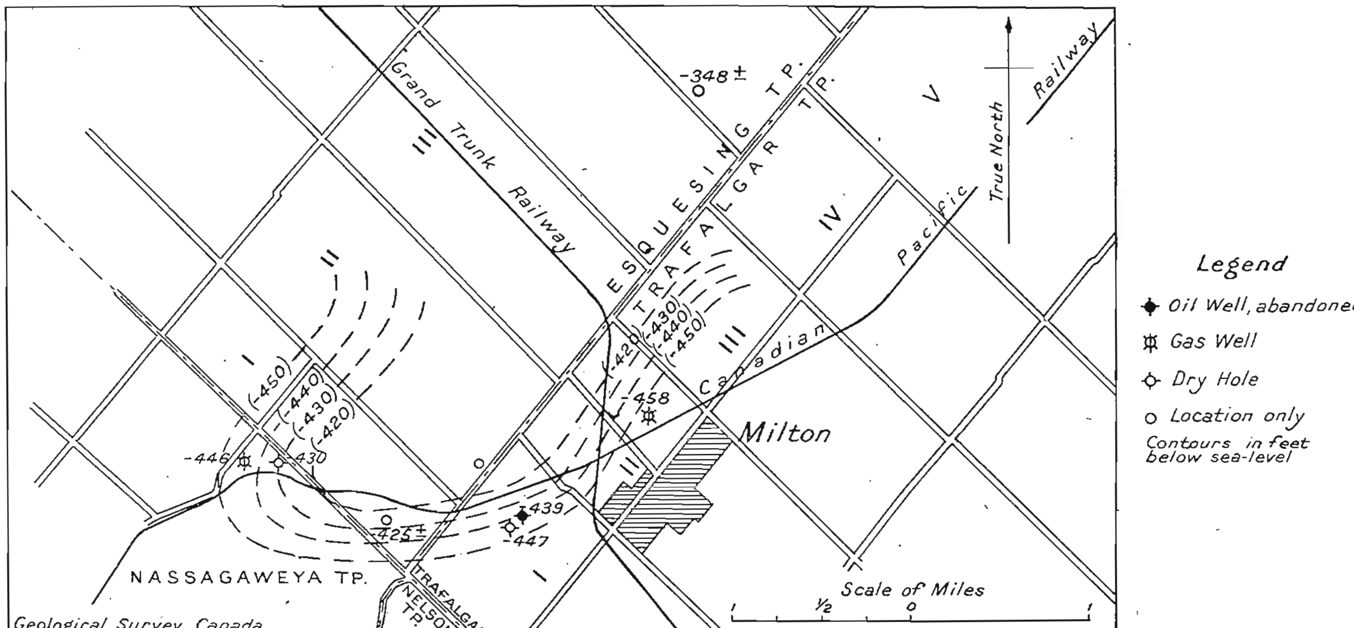

Figure 5. Structure diagram of the Trenton formation near Milton, Ont.

OIL PROSPECT NEAR MILTON.

A number of wells have been bored into the Trenton formation in the vicinity of Milton, one of which has produced some oil and two of which are producing small quantities of gas for domestic purposes. Records of these wells were finally obtained, and having taken surface levels an approximate contour diagram of the top of the Trenton formation was constructed (see Figure 5). The following logs are of some of the wells drilled west of Milton.

Log of Well, Brandon Brick-yard, East Half Lot 15, Concession I, Trafalgar Township, (new survey). (W. I. Dick, County Crown Attorney, Milton, Ont.)[1]

	Thickness. Feet.	Depth. Feet.
Surface	8	8
Queenston (Red Medina) shale	277	285
Richmond and Lorraine (Hudson River) shale	795	1,080
Utica (including Collingwood) shale	120	1,200
Trenton	265	1,465
Oil was struck at	....	1,443
or 247 feet in the Trenton.		

Another version of the record of this well is given by M. Crewson who was one of the drillers.

	Thickness. Feet.	Depth. Feet.
Surface	8	8
Queenston shale (Red Medina)	275	283
Richmond and Lorraine (Hudson River)	753	1,036
Utica shale (including Collingwood)	109	1,145
Trenton	322	1,467
Oil at	....	1,447
or 302 feet in the Trenton.		

The following logs were furnished by M. Crewson.

Log of Well, Brandon Brick-yard, about 500 feet Southwest of the Last, East Half Lot 14, Concession I, Trafalgar township.

	Thickness. Feet.	Depth. Feet.
Surface	5	5
Queenston (Red Medina) shale	305	310
Richmond and Lorraine (Hudson River)	753	1,063
Utica (including Collingwood) shale	109	1,172
Trenton limestone	640	1,812
"Potsdam" sandstone	5	1,817
Granite	3	1,820

A little gas at depth of 300 feet which was all gone on the second day.

Log of Greenles Bros. Well, Just North of Canadian Pacific Railway Station, Milton.

	Thickness. Feet.	Depth. Feet.
Soil, sand, and gravel	58	58
Queenston (Red Medina) shale	177	235
Richmond and Lorraine (Hudson River)	750	985
Utica (including Collingwood)	115	1,100
Trenton limestone	600	1,700
Red granite at bottom.		

Flow of gas at 1610-1620 feet, which is supplying three families for domestic use.

Unfortunately no record was obtainable of a well drilled on Mr. McCannell's farm near the Esquesing-Trafalgar boundary, on concession II, Esquesing. All that is known of this well is that it stopped at the Trenton.

From the records of the other deep wells, and by estimating the depth to the Trenton from the base of the Queenston (Red Medina) shale, as obtained from a drill-

[1] Ont. Bureau of Mines, 24th Ann. Rept., pt. II, p. 39. Modified by the author.

core at the brick-yard on lot 1, concession 1, Esquesing township, the accompanying structure diagram of a limited area of the Trenton has been drawn (Figure 5). This indicates a dome or terrace with its probable apex about $1\frac{1}{4}$ miles northwest of the centre of Milton, and not far from the McCannell well which did not penetrate the Trenton. In view of the fact that no water has been reported from the Trenton formation, it is probable that such accumulations of oil and gas as occur have been produced by gravitation toward basin structures. This theory is supported by the fact that the two gas producing wells are located on structure lower than that at the "oil well" of the Brandon brick-yard. However, the wells drilled on lower structure to the south and west of the "oil well" produced neither gas nor oil. If further explorations are to be carried on, it would seem advisable to drill away from the indicated dome.

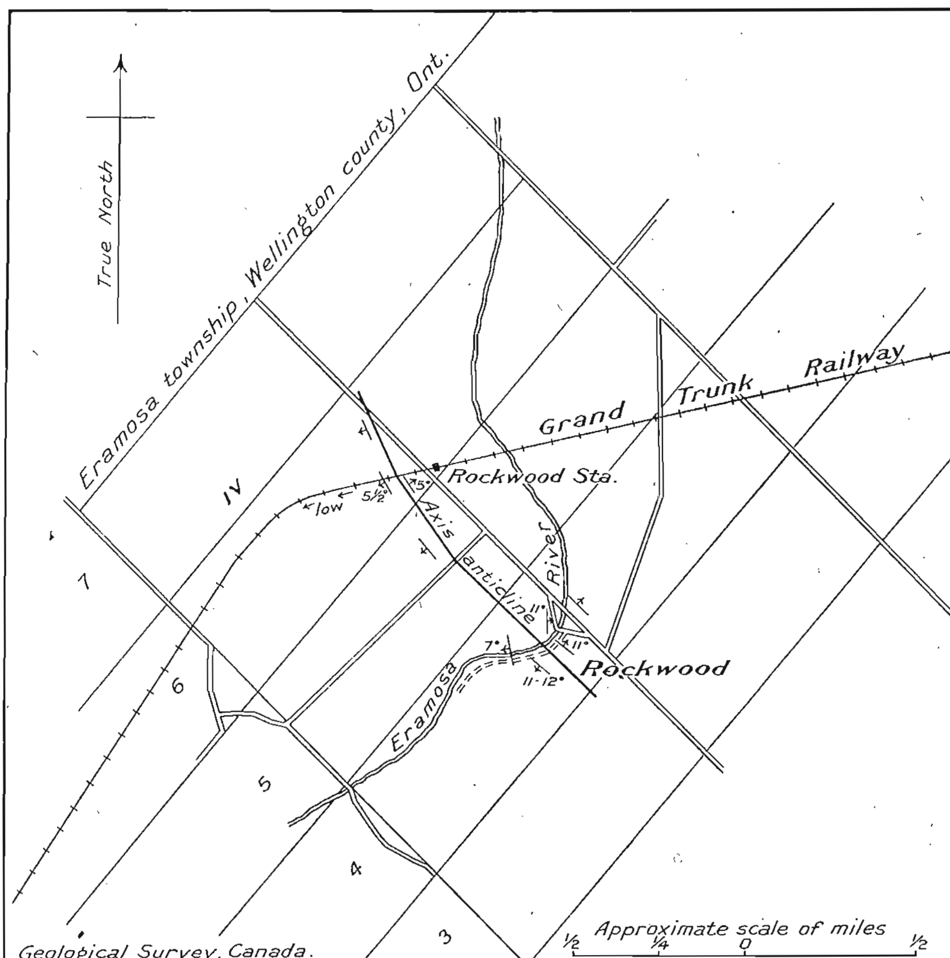

Figure 6. Sketch map of Rockwood and vicinity, showing anticline at top of Niagara.

Factors relating to the probable occurrence of a commercial oil pool near Milton should be carefully considered. Gas was obtained in the Greenles well north of Milton at 1,610 to 1,620 feet from the surface, or 510-520 feet in the Trenton, and actually at a lower elevation than the oil horizon of the Brandon brick-yard. This is an indication, either that there are different oil and gas horizons or that the porosity of the Trenton is variable, and that the formation is "pockety." As already stated, in most producing oil fields the oil is accumulated into pools by the difference of specific gravity between oil and salt water. No water of any kind is reported from the Trenton in the vicinity of Milton, and thus one condition contributing to oil accumulation is lacking.

Other indications of structure suitable for the accumulation of oil were sought in the attitude of the Whirlpool sandstone, as exposed along the Niagara escarpment for approximately 6 miles south and 4 miles north of Milton. The sandstone exposures were levelled and the elevations plotted. The outcrops vary from one-quarter of a mile to 2½ miles apart and indicate, in general, a gentle rise to the northward with no marked structure. Within the distance of three-quarters of a mile northward from the south end of the prominent bluff known as Rattlesnake point (lot 11, concession V, Trafalgar township), three outcrops of sandstone occur, the approximate elevations of the top of the beds from south to north being, 825 feet, 842 feet, and 825 feet A.M.T. Thus a slight doming or folding of the formation is indicated, but the direction of the axis of folding is unknown and the difference in elevation is too small to tempt a prospector to drill for oil under present conditions.

SUITABLE STRUCTURE FOR OIL OCCURRENCE AT ROCKWOOD AND VICINITY.

As already described in the Canadian Mining Journal,[1] a well-marked anticline occurs in the top of the Lockport dolomite (Niagara formation) in Rockwood village. "The crest of the anticline crosses the river about 200 yards southwest of the bridge on the road between concessions IV and V, west of the quarries, and extends through the Agricultural grounds, the west side of the schoolyard, through the middle of the rockcut on the railway about 235 yards west of the station, and crosses the concession road near the north side of lot 6. Immediately to the north and south of Rockwood a thick mantle of surface material covers the rock.

On the crest of the Rockwood anticline, for a width of about 100 yards, the dips are 5 degrees or less to the east and west. Farther away from the crest the dips are about 10 to 11 degrees on the east and somewhat lower on the west. To the east the dip of strata may be clearly seen 300 yards from the crest of the anticline in the exposures east of the bridge in Rockwood, and to the west the dip is clearly shown, although undulatory, as far as a Guelph outcrop about 400 yards west of Rockwood station. Allowing for the thickness of the Eramosa beds (about 40 to 50 feet) between the outcrop just west of the station and the remnant of the Guelph rocks, and for the difference in level of the outcrops, I have estimated that the westerly descent of the formation is about 70 feet in 1,200 feet, or about 300 feet in the mile. As the average dip of the formation to the west is about 20 to 30 feet per mile it is clear that the anticline is well marked.

This fold in the Niagara rocks was mentioned by Logan[2] and more recently by Malcolm. Its importance to the prospector for oil or gas does not, however, appear to have been appreciated.

The anticline at Rockwood (Figure 6) is the best defined of any known to the writer in southwestern Ontario, and affords a favourable location for prospecting for oil or gas.

Two other well marked anticlines separated by a syncline occur near the middle of the northeastern end of lot 12, concession III, Nassagaweya township, Halton county. The direction of these folds is about north 25 degrees west and the dips on the sides of the anticlines are from 12 to 14 degrees toward the syncline. The crests are about 220 yards apart. The sides of the anticlines away from the syncline are covered by drift."

Large areas of land have been leased by the Trenton Gas and Oil Company, Ltd., of Toronto, around Rockwood and the last-mentioned locality and drilling has started at the latter place.

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[1] Vol. XXXVIII, July 15, 1917, p. 290.

[2] Geol. Surv., Can., Geol. of Can., 1863, p. 330.

BOTHWELL-THAMESVILLE OIL FIELDS.

The oil fields south and west of Bothwell[1] have been producing oil from the Onondaga (Corniferous) limestone for twenty years, one well, known as the "Company well," having been pumped nearly continuously since 1864. No drilling has been done in this field this season, but many well records were available and it was hoped that a detailed study of the structure, based on the available information, might suggest promising fields for prospecting nearby.

The most important facts obtained relating to the Thamesville and Bothwell fields are shown on the accompanying structure contour map (No. 1710). A number of striking features merit attention, the primary one being the wonderful alignment of domes, including the abandoned oil fields north of Thamesville on the west, and the Bothwell oil fields on the east, with lesser domes between. Secondary structure of much importance consists of cross folds, terraces, and basins, the folding being at many places quite complex, as might be expected in gentle, open folds of this character. "Top show" or oil from the upper part of the "Corniferous" limestone has been obtained from lower domes, and also from terraces; but the important continuous production from the lower part of the formation has been obtained entirely from the higher domes, all of which are in the Bothwell field.

Except in one area, the probabilities of finding new pools of oil near Bothwell are poor. From 1½ to 4 miles east of Cashmere, however, there is an area that has not been disproved so far as obtainable information goes, and which, as indicated by the nearby structure, may contain a dome suitable for oil accumulation. This region seems worth testing.

The small oil field about 3 miles north of Thamesville, on lots 5 and 6, concession III, Zone township, Kent county, was redrilled this year by the Vacuum Oil Company. No. 1 well flowed oil at first and produced considerable oil for two or three months. Five other wells produced for a time, but the oil was from near the top of the "Corniferous" and was concentrated in a small pool at the top of a very small dome. The field is now reported to be closed down.

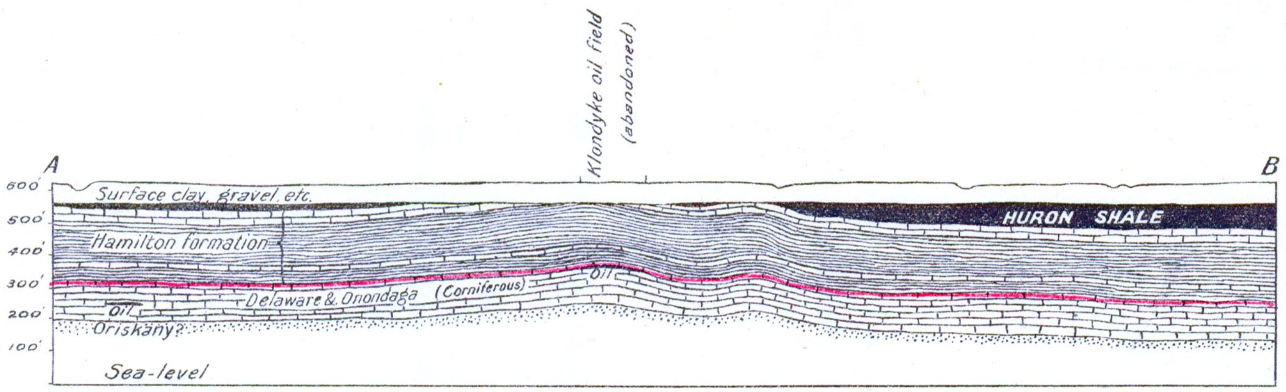
The Thamesville field is an example of the close relation between oil occurrence and structure. As may be seen from Map 1710, practically all the oil was contained in the upper 5 feet of the dome.

This dome and that of the abandoned Klondyke on the northeast corner of lot 5, concession I, Zone township, are examples of small domes on the main anticline running through the Bothwell field, which have temporarily produced so-called "top show" oil from near the top of the "Corniferous" formation. As will be seen, these domes are considerably lower than the Bothwell domes, a fact which bears out F. J. Carman's theory that the oil has siphoned into the higher domes from the outlying lower ones. This involves the difficulty of explaining the methods of transportation of oil through miles of rock as close as the "oil sand" of the "Corniferous." Accumulation of oil, however, has taken place, and there has been adequate time since the solidification of the Onondaga formation for the slow migration of oil over considerable distances.

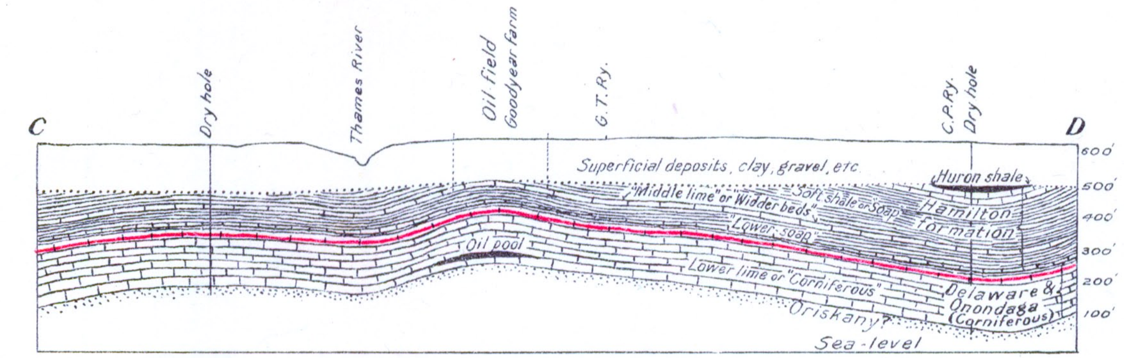
MOSA OIL FIELDS.

No account of the summer's work would be complete without an acknowledgment of the scientific enterprise of F. J. Carman and John McLeod of Bothwell, which has resulted in the opening up of a new oil field in Mosa township, Middlesex county, to the north of Appin junction. The Mosa field was drilled and abandoned some years ago, but Mr. Carman, believing that the real dome had been missed, gathered information from water wells, bored shallow test wells to explore the rock structure, and later bored to the oil horizon. The latest reports are that a considerable oil production is being obtained from this field.

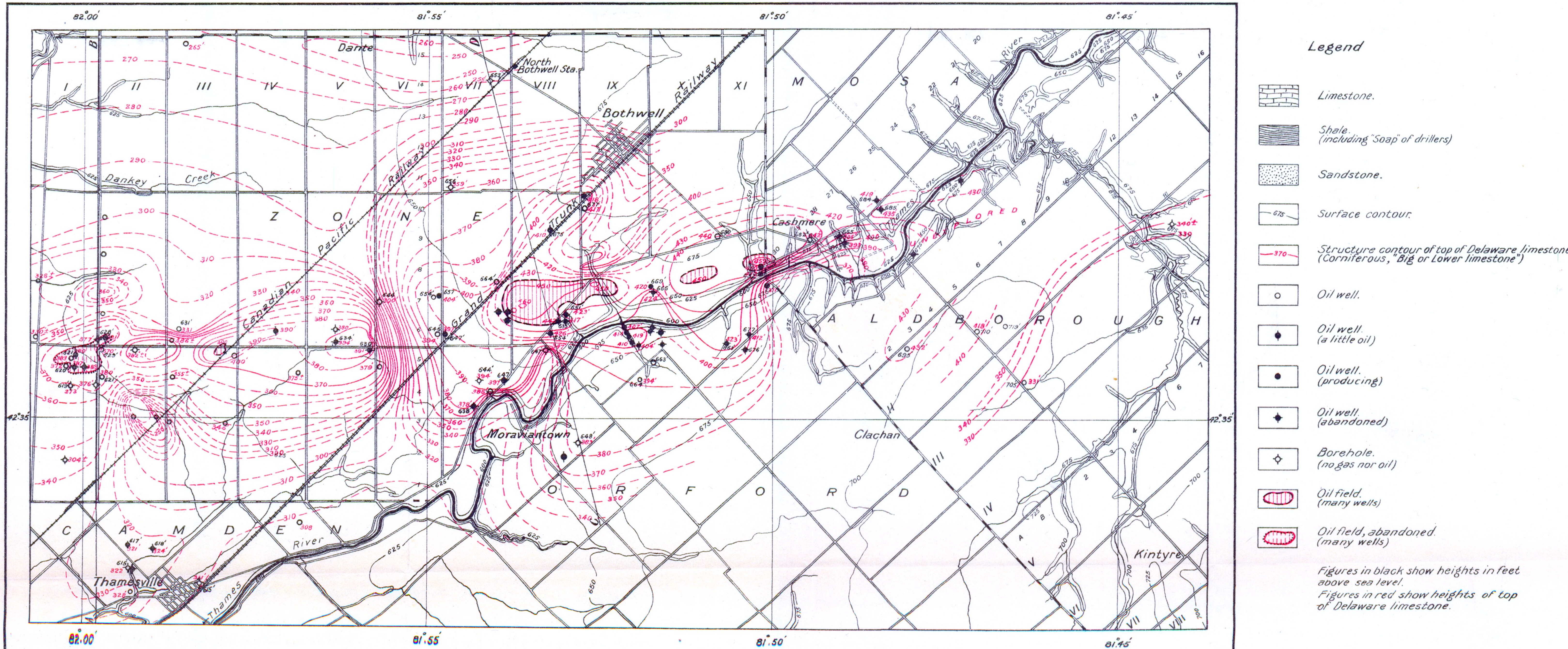
[1] For further particulars see Geol. Surv., Can., Mem. 81, pp. 70-71; Mines Branch, Dept. of Mines, Pub. No. 291, vol. II, p. 167.



Cross-section on line AB.



Cross-section on line CD.



Geological Survey, Canada.

Bothwell-Thamesville Oil Region, Kent County, Ontario.

Publication No 1710.

Miles

To accompany Summary Report by M.Y. Williams, 1917

Geology by M.Y. Williams, 1917.

The history of the development of the Mosa field is a repetition of that of the Bothwell field. At Bothwell, it was Mr. Carman's careful, scientific work that developed a fine oil field from an abandoned prospect. All this goes to show the importance of careful structural work followed by intelligent drilling, and quite disproves any idea that all our oil pools have been found.

Mr. Carman has promised that later on he will furnish the Survey with his information so that the Mosa field may be included in the structural map of the oil fields of southwestern Ontario, started this season.

EXPLORATIONS IN THE TRENTON FORMATION NEAR THE MOUTH OF THAMES RIVER.

In April, 1917, the Union Gas Company bored a well on lot 3, concession III, Dover West township, Kent county. At a depth of 3,165 feet or 282 feet in the Trenton formation a heavy flow of gas was struck and this, together with lighter flows from depths between 3,010 feet and 3,040 feet, gave an initial pressure of 1,250 pounds, and an estimated flow of 6,000,000 cubic feet per day.

Following this discovery, large areas of land were leased for gas and oil and the Union Gas Company and the United Development Company started drilling. To date, nine wells have been started within a radius of 2 miles of the "discovery" well and of these four have now gone deep into the Trenton. So far no oil and no appreciable quantity of gas has been struck.[1] Besides the companies named above, the Canadian Gas Company is drilling to the Trenton on lot 13, concession II, East Tilbury, and a Niagara Falls, Ontario, syndicate is drilling one of the wells included in those mentioned above. With one exception the wells are at least one-half mile apart and prospecting is being carried on carefully and systematically.

The gas from the "discovery" well was turned into the Sarnia pipe-line late in August. It is practically free from sulphur, but produced considerable quantities of light oil from the first. Late information indicates an increase in the oil production and a consequent decrease in the gas pressure.

Thanks to the co-operation of the interested companies and contractors, records have been obtained from the wells as they have advanced. Along with the accumulation of much information of general scientific value, two main problems are being solved: (1) the structure of the various formations and (2) the relation of the structure of the younger formations to that of the older formations.

Awaiting additional data, no map is published with this account, but enough is already known to indicate that No. 1 well lies in a northward plunging syncline, and is in the lowest part of the structure yet tested. In general there is a striking parallelism between the structure in the higher and lower formations. One exception to this rule occurs, however, in the case of a well drilled near the Thames river on lot 1, concession II, East Tilbury, by the Union Natural Gas Company. This well penetrates 125 feet of salt, the only salt known in the vicinity, and the Salina formation is somewhat thicker than in the other nearby wells. The lower formations are successively thicker, with the result that the dip of the Trenton between this and other nearby wells is the reverse of that of the higher formations.

The general conclusions for this field are: that the Trenton contains little water and varies greatly in porosity from place to place or is "pockety"; the finding of oil in the lowest structure prospected suggests that in the absence of saturation by water and consequent hydrostatic pressure, the oil and gas have gravitated to the rock basins and that consequently prospecting should be directed to them rather than to the anticlines and domes.

[1] Since this report was written a well drilled by the Union Gas Company, about 650 feet north of the producing gas well, struck oil under considerable pressure and is producing both gas and oil in commercial quantity. The Trenton formation is lower in this well than in any of the others and salt water occurs with the gas and oil.

THE OHIO SHALES OF SOUTHWESTERN ONTARIO.

By M. Y. Williams.

The writer, for the purpose of investigating the oil-bearing shales on the Indian Reserve at Kettle point, Lambton county, Ontario, visited the locality on February 13 and 14, 1917, and had about 700 pounds of shale blasted out to test the oil content and possible fuel value. During the summer the outcrops reported by C. R. Stauffer, near Kingscourt, at Alvinston, and at Shetland, were visited. The one reported in the bed of the Sydenham river northwest of Kingscourt proved to be boulders of shale, including portions of the characteristic "kettles," contained in boulder clay. The shale has been reported from excavations in the bed of the stream, however. At Alvinston and at Shetland the shale outcrops are as described by Stauffer.

The Ohio shale has been described in previous reports by T. Sterry Hunt,[1] Alexander Murray,[2] Sir Wm. Logan,[3] E. M. Kindle,[4] M. Y. Williams,[5] and C. R. Stauffer[6] and to these reports the reader is referred for information regarding origin, fossil content, etc., of the beds in question.

The Ohio shale belongs to the Devonian system and occurs just above the Hamilton formation. The shales, which are dark grey, black, or brown in colour, and weather rusty red, are divided into the lower or Huron shale which outcrops at Kettle point and is characterized by large spherical concretions of calcite, popularly known as "kettles," and the upper or Cleveland[7] shale which does not contain "kettles." It is the Cleveland shale which outcrops at Alvinston and Shetland.

The Huron shale outcrops at the northwest extremity of Kettle point, and for a distance of about 1¼ miles to the south along the shore. Farther south no shale is present, the highest rocks being limestone. The shale beds, which lie nearly horizontal, have a maximum thickness, as obtained by drilling, of about 35 feet. An area at the point 60 yards east and west by 100 yards north and south, contains about 7 feet of shale above water-level. The overburden of broken shale and clay here is 2 to 3 feet thick. To the south and east, the surface slopes downward, the thickness of shale above the lake being between 3 and 5 feet, over an area 100 to 150 yards wide and 200 to 300 yards long. Eastward the land is swampy and to the south the surface declines as far as the extent of the shale outcrop, being for some distance less than 5 feet above the lake, the shale surface being proportionately lower. The higher area at the point contains about 50,000 cubic yards of shale above lake-level, and five or six times that amount is probably available from the lower area to the south and east. By working below water-level probably ten times the amount above the lake could be obtained. The quality of the shale is shown in the analyses, page 27.

The Cleveland or upper division of the Ohio shale outcrops in the Sydenham river for a distance of about 200 yards above the bridge east of Alvinston. The shale occurs in the sides and bottom of the valley, the total thickness represented being about 8 feet. The beds lie practically horizontal.

The Cleveland shale also outcrops in the north bank of Sydenham river from the steel road bridge northeast of Shetland for about 200 feet upstream. The outcrop extends from below low water-level to about 10 feet above, or perhaps 10 feet in all. The overburden of clay varies from about 10 feet in thickness at the top of the bank along the road allowance to 30 feet north of the road.

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1 Rept. of Prog., 1863-1866, p. 242.

2 Rept. of Prog., 1855, pp. 129, 130.

3 Geol. of Can., 1863, p. 387.

4 Geol. Surv., Can., Sum. Rept., 1912, pp. 287-290.

5 Geol. Surv., Can., Sum. Rept., 1912, p. 285.

6 Geol. Surv., Can., Mem. 34, 1915, pp. 182-189; 228.

7 Kindle, ibid, p. 287.

ANALYSIS OF OHIO SHALE.

The following report on shales collected by the writer is by Edgar Stansfield, Chief Engineering Chemist, Division of Fuels and Fuel Testing, Mines Branch, Department of Mines. No. 963 was blasted from the upper 3½ feet of Huron shale exposed at Kettle point. No. 964 was blasted from the 1½ feet just below 963. No. 965 was blasted from 3 feet of shale in a pit 150 yards away.

Analysis of Ohio Shale at Kettle Point, Ont.

—	No. 963	No. 964	No. 965
Proximate analysis:	Per cent	Per cent	Per cent
Moisture	2·3	2·1	1·8
Volatile matter	9·0	10·0	10·1
Ash	84·6	81·8	82·4
Fixed carbon (by difference)	4·1	6·1	5·7
	100·0	100·0	100·0
Nitrogen	0·13	0·14	–
Calorific value, calories per gramme	890	1180	1100
B. Th. U. per lb.	1600	2130	1980

The nitrogen content of No. 964 is equivalent to 15 pounds ammonium sulphate per long ton, or 13 pounds per short ton—corresponding to a commercial yield of about 10 pounds and 9 pounds respectively.

No distillation tests have yet been carried out, but by analogy with other shales the proximate analysis would indicate a yield of about 10 imperial gallons per long ton. Fifteen samples of New Brunswick oil-shales give an average yield of 68 pounds of ammonium sulphate and 48 gallons of oil per long ton.

The suggestion that this shale might be used as a boiler fuel is obviously impracticable, when it is mentioned that the refuse removed from grate and ash pit in commercial scale boiler trials gave for the last twelve trials average results of about 25 per cent combustible matter and about 3500 B. Th. U. per pound.

No. 1151 is from the Ohio (Cleveland) shale near Alvinston.

(*a*) *Proximate analysis:*

	Per cent
Moisture	1·3
Volatile matter	7·5
Ash	90·0
Fixed carbon (by difference)	1·2
	100·0

(*b*) Nitrogen . . . 0·32 per cent.
(*c*) Specific gravity of selected piece . . . 2·5 "
(*d*) *Distillation test:* 1,500 grammes of shale were distilled in a narrow, electrically-heated retort with a slowly increasing temperature until a maximum of 654°C. was reached. The temperature was then held at this point until there was very little further evolution of gas. The results of the distillation were as follows:

Volume of gas evolved—1·1 cubic feet, equivalent to about 660 cubic feet per short ton.
Weight of oil obtained—18·5 grammes equivalent to about 25 pounds per short ton.
Specific gravity of oil at 22°C.—0·868.
Imperial gallons of oil—equivalent to about 3 gallons per short ton.
Weight of ammonium sulphate obtained—4·6 grammes, equivalent to about 6 pounds per short ton.
Weight of residue—1,396 grammes, equivalent to about 1,860 pounds per short ton.

No. 1152 is from the Ohio (Cleveland) shale near Shetland.

(*a*) *Proximate analysis:*

	Per cent
Moisture	1·1
Volatile matter	8·1
Ash	90·0
Fixed carbon (by difference)	0·8
	100·0

(*b*) Nitrogen .... 0·28 per cent.
(*c*) Specific gravity of selected piece .... 2·6 "
(*d*) *Distillation test*: 1,500 grammes of shale were distilled in a narrow, electrically-heated retort, with a slowly increasing temperature until a maximum of 650°C. was reached. The temperature was then held at this point until there was very little further evolution of gas. The results of the distillation were as follows:
Volume of gas—1·0 cubic feet, equivalent to about 600 cubic feet per short ton.
Weight of oil obtained—24·6 grammes, equivalent to about 33 pounds per short ton.
Specific gravity of oil at 22°C.—0·887.
Imperial gallons of oil—equivalent to about 4 gallons per short ton.
Weight of ammonium sulphate obtained—4·2 grammes, equivalent to 6 pounds per short ton.
Weight of residue—1,404 grammes, equivalent to 1,872 pounds per short ton.

Besides the outcrops mentioned above, the Ohio shale is reported from numerous well borings, of which the following are examples:

Near Jericho, surface deposits 90 feet, shale 95 feet.
West side of Warwick township, surface deposits 14 feet, shale 50 feet.
Near Wyoming, surface deposits 104 feet, shale 4 feet.
Near Courtright, surface deposits 160 feet, shale 32 feet.
Near Oil Springs, surface deposits 50 feet, shale 70 feet.
Near the centre of Sombra township, surface deposits 120 feet, shale 20 feet.
The gore of Camden township, surface deposits 43 feet, shale 130 feet.
In northern Camden, three wells, surface deposits 50 feet, shale 146 feet; surface deposits 60 feet, shale 20 feet; surface deposits 63 feet, shale 200 feet.
Near Northwood, surface deposits 78 feet, shale 60 feet.
At Chatham, surface deposits 60 feet, shale 118 feet.
In Raleigh township, three wells: (1) surface deposits 60 feet, shale 40 feet; (2) surface deposits 140 feet, shale 45 feet; (3) surface deposits 140 feet, shale 45 feet.
Near Blenheim, surface deposits 160 feet, shale 40 feet.
South of Cedar Springs, surface deposits 163 feet, shale (grey) 17 feet, and black shale 58 feet.
Rondeau, surface deposits 104 feet, shale 60 feet.

From the above it may be inferred that the Ohio shale lies in a shallow irregular basin, the deepest part of which is near the northwestern extremity of Camden township, Kent county. An estimate of the total amount of shale in this area, allowing 40 feet as a conservative calculation of the average thickness, would be 60,000,000,000 cubic yards, or with specific gravity 2·3, 116,000,000,000 tons in round numbers. The average thickness of surface deposits over the region is probably about 95 feet.

GRAPHITE IN PORT ELMSLEY DISTRICT, LANARK COUNTY, ONTARIO.

By M. E. Wilson.

CONTENTS.

Illustrations.

INTRODUCTION.

An increased demand for the mineral graphite has been created in America, owing to the cutting off of importation from abroad since the outbreak of the world war, and as a consequence of this increased demand, a renewed interest in the Canadian graphite industry has arisen and mining operations have been revived on several properties that were formerly idle. To the properties of this class belongs that of the Globe Graphite Mining and Refining Company situated on lots 21 and 22, concession VI, North Elmsley township, Ontario.

Diamond drilling and other development work having been undertaken by this company during the past year, a few days at the close of the field season of 1917 were spent in making an examination of the property, this examination being part of an investigation of Canadian graphite deposits carried on by the writer in the course of areal field work in the Pre-Cambrian districts of eastern Ontario and southern Quebec during the past five years. The diamond drill records and other data in the possession of the company were placed at the disposal of the Geological Survey and every facility for the study of the deposits afforded the writer by Mr. C. A. Lux, president of the company, but owing to the almost entire absence of rock exposures in the vicinity of the deposits the examination was confined for the most part to the study of open-pits and underground workings, so that the information obtained with regard to the character, extent, and geological relationships of the deposits is incomplete.

LOCATION AND ACCESS.

The Port Elmsley graphite deposits are situated 3 miles to the southwest of the village of Port Elmsley and 7 miles southeast of the town of Perth, in Lanark county, Ontario. The distance to the nearest railway station, Elmsley, on the Toronto-Montreal branch of the Canadian Pacific railway, is 4 miles, but it is less than 1 mile to Rideau lake which forms a part of the Rideau canal connecting Kingston and Ottawa. The deposits are thus fairly well provided with transportation facilities, both for the receipt of fuel and the shipment of the graphite produced.

HISTORY.

The earliest published reference to the Port Elmsley graphite deposits is a description of the occurrence of graphite on lot 21, concession 6, North Elmsley township, by H. G. Vennor in the Report of Progress of the Geological Survey for 1872-73. Vennor states that the mine had then (1872) been in operation for some time and that the surface opening was 70 feet in length and 15 feet deep. The ore was carted to a mill at Olivers ferry on the Rideau canal where it was crushed in a stamp mill and concentrated first in buddles and finally in a settling tank. The concentrated graphite was then roasted in a reverberatory furnace and classified into four grades in revolving screens. The number one product, which included all the graphite failing to pass through a 60 mesh sieve, was further polished and purified by treatment in rumblers.[1] These operations were discontinued in 1875 and no further work on the property was attempted until 1893, when the Northern Graphite Company, under the direction of Mr. J. Fraser Torrance, began development operations. An option on an area of 1,200 acres was obtained by this company and drill holes were sunk to depths of 50 to 100 feet on lots 21, 22, and 23, concession VI, North Elmsley. The borings are said to have shown the existence of graphite to the full depth to which they were sunk[2], but the options were dropped and actual mining was not attempted.

In 1901, Dr. R. A. Pyne undertook development operations on the property and put down four diamond drill holes to depths ranging from 64 to 140 feet, on lot 21, concession VI, North Elmsley, but did not continue work after these operations. The following year Mr. Rinaldo McConnell purchased the mining rights to lots 21, 22, and 23, concession VI, North Elmsley, and until 1903 carried on development work and mining operations. Seven additional diamond drill holes were put down and a mill having a capacity of 20 tons of ore per day was constructed at the village of Port Elmsley on the river Tay, 3 miles east of the deposits. The principal features of the process used in the mill were crushing, screening, concentration in pneumatic jigs, polishing between millstones, and grinding in revolving screens.[3]

From the year 1903 to the year 1908 the mine remained idle, but was operated almost continuously between the years 1908 and 1911. During this period operations were carried on by the Globe Refining Company, of which Mr. Rinaldo McConnell was manager.

Towards the end of 1915, owing to the curtailment of shipments of graphite to America from foreign sources of supply, the price of the mineral in Canada and United States began to rise, and Mr. McConnell formed the Globe Graphite Refining and Milling Company to take over the property formerly owned by the Globe Refining Company and resumed operations on the Port Elmsley deposits. In 1916, Mr. McConnell sold his interest in the Globe Graphite Mining and Refining Company to an American syndicate and Mr. C. A. Lux of Syracuse, N.Y., became president and Mr. G. H. Brewer of Buckingham, Que., manager.

GEOLOGY.

General.

The Port Elmsley district lies on the border line between the Pre-Cambrian highlands of eastern Ontario and the Palæozoic lowlands which occupy all the lower portions of the St. Lawrence valley and thus belongs geologically to both of these provinces. The rocks of the region if classified according to their age and structural relationships fall into four principal groups: (1) an early Pre-Cambrian basal complex; (2) late Pre-Cambrian intrusions of diabase and related rocks; (3) Palæozoic sediments; and (4) unconsolidated Quaternary gravel, sand, and clay of glacial and post-glacial marine origin.

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[1] Ont. Bureau of Mines, Ann. Rept., vol. VI, 1896, p. 35.
[2] Ont. Bureau of Mines, Ann. Rept., vol. III, 1893, p. 196.
[3] Ont. Bureau of Mines, Ann. Rept., vol. XII, 1903, pp. 26, 50, 132.

It is the first of these groups—the Pre-Cambrian complex—that is of special interest in this connexion, since it is in this complex that the graphite deposits are found.

The detailed succession of formations within the Pre-Cambrian basal complex of eastern Ontario and the southern Laurentian of Quebec has not yet been completely worked out, but the results of investigations in scattered localities seem to indicate that four principal groups of rocks are represented.

Grenville Series. The oldest group of rocks yet observed to be present constitutes what is generally known as the Grenvile series. It is believed that this series was originally laid down as alternating beds of shale, sandstone, and limestone, but owing to the intense metamorphism to which they have been subjected the shale has been transformed to a garnet gneiss, the sandstone to vitreous quartz, and the limestone to crystalline limestone. Wherever the rocks of this series have been observed in contact with other rocks the latter are intrusive into them and the floor upon which they were originally laid down, if exposed, has not yet been discovered.

Pyroxene-gabbro—Pyroxene Syenite Group (Buckingham Series). Wherever the rocks of the Grenville series are represented, a group of rocks of which pyroxene is generally an abundant constituent is commonly associated with them. The dominant members of this group are pyroxene gabbro, pyroxene diorite, pyroxene syenite, and anorthosite, but peridotite, pyroxenite, pyroxene granite, granite pegmatite, syenite pegmatite, and diorite pegmatite are also represented. These rocks have been intruded into the Grenville series chiefly as thin lit par lit injections, sills, or small irregular bosses, but in places solid masses up to several miles in diameter are present. In the large masses the rocks of the group are commonly massive, but elsewhere they are generally highly foliated.

Hornblende-biotite Granite-syenite Group. In most localities the rocks of the Grenville series and the pyroxene gabbro-syenite group are intruded by dykes and batholithic masses of hornblende-biotite syenite and hornblende-biotite granite. These batholithic masses have made room for themselves partly by thrusting aside the overlying rocks and partly by lit par lit injection. The areal distribution of most of the batholithic masses has not yet been determined, but evidence is accumulating that they are distributed in northeasterly trending zones. The rocks of this group are not all contemporaneous in age since they intrude one another, but whether the separate intrusives belong to separate periods or to the same period of batholithic intrusion has not yet been determined.

Metamorphic Pyroxenite. Very commonly associated with the limestone member of the Grenville series are considerable masses of rock composed of diopside, scapolite, and other lime silicate minerals. These are generally known as pyroxenite. It is believed that they have been formed from the limestone member of the Grenville series through the agency of pegmatitic solutions emanating from the rocks of the pyroxene-gabbro—syenite and the hornblende-biotite, granite-syenite igneous groups. They are thus probably not all of the same age. To distinguish the rocks of this group from the igneous pyroxenite of the pyroxene-gabbro—syenite group the name metamorphic pyroxenite is used.

Local.

The Port Elmsley graphite deposits occur in the Pre-Cambrian basal complex, but in an area of these rocks lying several miles within the border of the Palæozoic lowland where the bedrock surface is largely hidden beneath a mantle of boulder clay. It has been ascertained, however, from an examination of the underground workings, the diamond drill cores, and the few scattered outcrops of rock occurring in the vicinity of the deposits, that the rock adjacent to the deposits is mainly a highly silicated Grenville limestone with which is associated a very small proportion of quartzite and considerable masses of monzonite and orthoclase pegmatite.

Grenville Series.

Crystalline Limestone. The crystalline limestone occurring in the Port Elmsley district is a medium to coarse-grained, grey to cream white coloured rock in which graphite, phlogopite, and light green pyroxene are abundantly disseminated. It is generally very definitely banded, the banded structure arising partly from variations in the abundance and proportions of impurities present in the different bands, partly from variations in the texture and colour of the bands, and partly from the alternation of bands of limestone with bands of the other members of the complex. In many localities the limestone is exceedingly cavernous, the walls of the caverns being lined with crystals of calcite, quartz, and chalcopyrite.

Quartzite. The quartzite member of the Grenville series is not abundantly represented in the area, but a few masses of the rock were seen on the dumps from No. 2 shaft and No. 2 pit. It consists of vitreous blue quartz in which aggregates of biotite, graphite, and pyrite are disseminated. The rock was not examined in thin section under the microscope, but the characteristic blue colour indicates that the fine, hair-like inclusions commonly disseminated in the Grenville quartzite are abundantly present.

Biotite-pyroxene Gabbro-syenite Group.

Pyroxene Monzonite. The most extensive masses of rock belonging to the biotite-pyroxene-gabbro—syenite group, observed in the area, occur in the rocky knobs which protrude through the drift at the south end of the property. At these points the rock is a dark, massive, medium to coarse-grained, granular type containing scattered, irregular aggregates of resinous, lilac-coloured feldspar. Examined under the microscope it was seen to consist of orthoclase, plagioclase, uralitic amphibole, biotite, apatite, pyrite, and calcite. The orthoclase is generally filled with perthitic inclusions of plagioclase having the optical properties of (Ab_7 An_3) oligoclase-andesine. The perthitic texture is exceedingly variable even in the same intergrowth, the plagioclase inclusions ranging from 0·2mm. in diameter to submicroscopic dimensions. The pyroxene originally present in the rock has been entirely transformed to olive-green-coloured, fibrous amphibole containing an abundance of disseminated grains of iron oxide. Biotite is not an abundant constituent of the rock, but a few scattered flakes of a reddish-brown to pale yellow variety occur in association with the amphibole grains. The remaining constituents of the rock—the apatite, pyrite, and calcite—are quantitatively unimportant, only a few disseminated grains being present. Since the essential constituents of this rock are orthoclase, plagioclase, biotite, and uralitic hornblende and the orthoclase and plagioclase are present in approximately equal proportions, it might be appropriately designated a biotite hornblende monzonite.

Biotite-quartz Monzonite. On the dumps from No. 2 shaft and in the diamond drill cores from the north end of the property a common rock represented is a variegated type consisting of reddish-brown mica and blue feldspar. When examined under the microscope the rock was seen to consist chiefly of orthoclase, andesine (Ab_{67} An_{33}), quartz, and pale brown biotite. The less abundant constituents present are apatite, titanite, pyrite, and graphite. The orthoclase contains an abundance of minute perthitic inclusions probably plagioclase. Both the quartz and the orthoclase contain numerous hair-like inclusions. In the quartz these are oriented parallel to the principal axes of symmetry, but are distributed irregularly in the feldspar. Since the orthoclase and plagioclase are present in this rock in approximately equal proportions it may be described as a biotite quartz monzonite.

Syenite Pegmatite. A third common rock type associated with the gabbro-syenite and the Grenville limestone consists of blue white to lilac-coloured orthoclase. In places, a small proportion of quartz is present in this rock, but more commonly it is composed of orthoclase entirely or of orthoclase and pyroxene. A few disseminated crystals of titanite were observed in some specimens of the rock collected on the dump from No. 2 shaft.

Metamorphic Pyroxenite.

The crystalline limestone occurring in association with the Port Emsley graphite deposits everywhere contains more or less disseminated diopside and all the intermediate rock types between this pyroxenic limestone and a rock composed entirely of pyroxene are represented in the area. In addition to the rocks composed entirely of diopside, or diopside and calcite, there are a great variety of rocks consisting of scapolite and pyroxene, orthoclase and pyroxene, or serpentine, which are all associated with the pyroxenite and are likewise believed to be of metamorphic origin.

Diopside Type. The most common type of pyroxenite is a fine, granular rock composed entirely of diopside or of diopside and calcite. This occurs very commonly as parallel bands alternating with beds of Grenville limestone and biotite monzonite.

Scapolite Type. A number of specimens of scapolitic pyroxenite were collected from the dump at the head of No. 2 shaft. One of these was found when examined under the microscope to consist of granular diopside and scapolite and a few disseminated flakes of pale brown mica. A second specimen belonging to this variety consisted of scapolite, pale pink pyroxene, brown amphibole, and pale brown mica.

Orthoclase Type. In the diamond drill cores examined considerable lengths of core, consisting of orthoclase pyroxenite, were present. This type passed by transition into orthoclase so that all the intermediate stages between a feldspathic pyroxenite and a pyroxene pegmatite could be observed.

Serpentine Type. On the dump from No. 2 shaft and in the diamond drill cores serpentine was a common constituent in association with the pyroxenite. This rock ranges in colour from dark green to pale yellow. The darker varieties generally contain considerable disseminated pyrite and mica.

Relationships.

Owing to the poorly exposed and highly deformed condition of the Pre-Cambrian rocks exposed in the Port Elmsley district, the relationship of the rocks of the gabbro-syenite group to the Grenville series is not directly evident. It is inferred, however, from the occurrence of parallel bands of monzonite, an igneous rock, in the limestone, and of large irregular inclusions of pegmatite in the limestone, that, as in other localities, these rocks have been intruded into the Grenville series as dykes or lit par lit injections. It is likewise inferred, from the high lime content of the metamorphic pyroxenite and the transitions which occur between the pyroxenite and the limestone and between the pegmatite and pyroxenite, that the pyroxenite has been formed by the silication of the Grenville limestone through the agency of pegmatitic solutions.

Graphite Deposits.

Distribution. Rock containing 5 per cent or more of graphite is known to occur on the property of the Globe Graphite Mining and Refining Company at a number of points. It occurs on the bottom and face of No. 3 pit, was intersected by a diamond drill hole in the underground workings at the north end of the property in 1917, and is reported to have been present in a number of diamond drill holes put down in 1901-02; but the deposit from which practically all the graphite produced on the property up to the present has been mined occurs at the east end of No. 1 pit, on lot 21, concession VI, North Elmsley.

Form and Structure. The outstanding structural feature which characterizes the graphite deposits occurring in the Pre-Cambrian complex of eastern Ontario and the southern Laurentians of Quebec, is the general occurrence of the richest graphite ore-bodies at the crests of folds or at other points where the structural relationships indicate that a relief of pressure has occurred, and this relationship is strikingly illustrated by the principal Port Elmsley deposit. The banded, silicated limestone occurring in the vicinity of the main pit trends in general in a northeasterly direction (north 60 degrees east) parallel the longer direction of the pit and dips steeply to the north, but at the eastern extremity of the pit the banding in the limestone turns abruptly to the south, forming an anticline pitching steeply northeastward. A graphite lead conforming to the strike and dip of the limestone is exposed almost continuously the whole length of the main pit—approximately 400 feet—but at the west end of the pit the lead is narrow and irregular, whereas at the east end an enormous, unsymmetrical, saddle-shaped mass 40 feet in thickness, developed on the crest of the pitching anticline, is present.

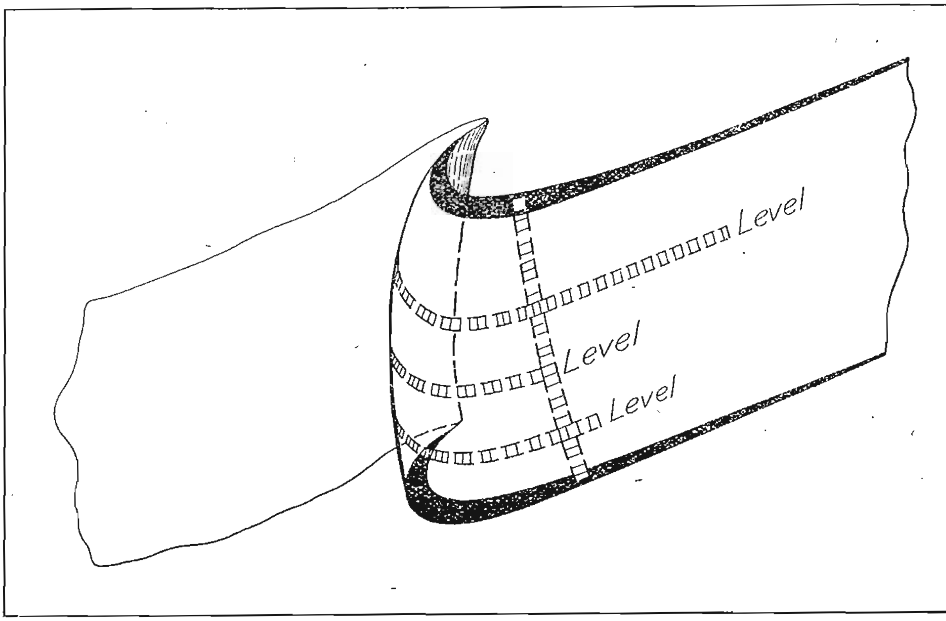

Figure 7. Diagram showing approximate form of graphite ore-body on crest of pitching anticline, lots 21 and 22, concession VI, North Elmsley township, Ontario.

It is possible that the main pit is situated close to the crest of the north limb of a major fold in the Grenville limestone and that the pitching anticline at the east end of the main pit is the continuation of this fold, but it seems more probable that the pitching anticline is a minor fold of the drag type developed on the north limb of a still larger anticline. The data from which this conclusion is inferred are the abundance of minor folds of the drag type in the limestone, as for example on the east face of the main pit directly above the southern termination of the graphite ore mass, the northeasterly strike of the limestone in the outcrops directly east of the main pit, and the unsymmetrical form of the main ore-body, the larger part of its mass forming the northwest limb of the saddle. This explanation of the structure of the limestone adjacent to the graphite ore-body has obviously a bearing on development operations, for if the pitching anticline in which the saddle-shaped mass occurs is a major fold the continuation of the graphite lead at the surface should be found to the south of the main pit; on the other hand if the pitching anticline is a fold of the drag type the continuation of the graphite lead should be found to the east of the main pit. In either case, however, it is probable that the continuation of the lead beyond the southeast limb of the anticline, like the continuation of the northwest limb, is not of workable dimensions.

Composition. The graphite ore in the Port Elmsley deposits, as in other districts in eastern Ontario and Quebec, is merely silicated Grenville limestone in which graphite is disseminated. The proportion of graphite present in the Port Elmsley deposits apparently increases at points where the silication is most complete, for the low grade ore in which the graphite present is only 4 to 6 per cent, consists mainly of calcite in which the silicate minerals are disseminated, whereas the high grade ore

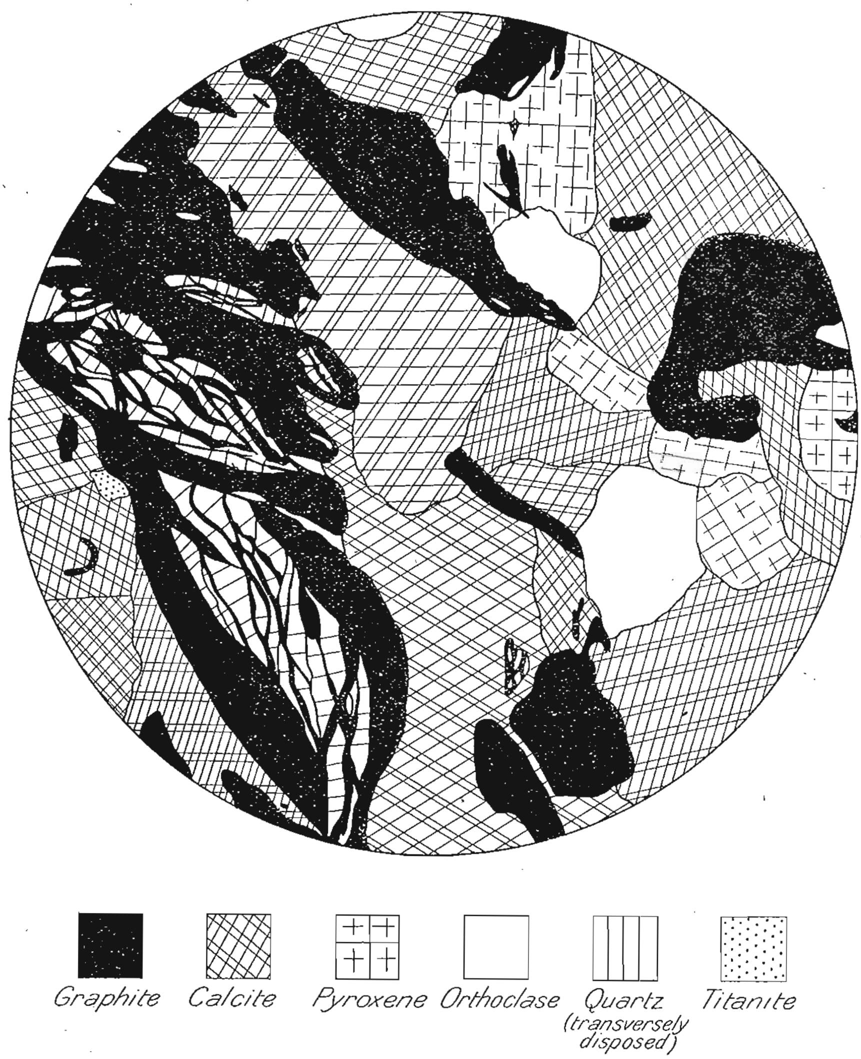

Figure 8. Camera lucida drawing of graphite ore, lot 21, concession VI, North Elmsley township, Ontario. Magnified 20 diameters.

containing 15 to 20 per cent of graphite consists almost entirely of silicates. The minerals commonly present in the graphite ore are diopside, orthoclase, titanite, calcite, graphite, and pyrite. In a thin section of the graphite ore from the bottom of No. 1 shaft the graphite was observed in places to exhibit an anastomosing structure, the interspaces between the graphite flakes being filled with quartz crystals transversely disposed (Figure 8). The graphite in the ore is generally associated with the pyrite and both of these minerals lie along the contacts of the mineral grains and most commonly adjacent to the pyroxene grains.

A number of average samples of the graphite ore taken from various points on the property in the course of the examination, were analysed by H. A. Leverin of the Mines Branch with the following results.

Analyses of Graphite Ore, Port Elmsley, Ontario.

Locality.	Per cent graphite content
Main pit 50 feet from west end..	10·80
Face main pit 80 feet from east end..	16·70
Bottom of shaft No. 1..	4·28
Feet 95–108, drill core No. 5..	7·38
Feet 108–111½, drill core No. 5..	6·67

Drilling. A sufficient number of drill holes have probably been put down on the Globe property to fully determine the extent of the principal deposits if the complete records of these operations had been kept, but the information now available is for the most part too indefinite to be of value. In the Annual Report of the Bureau of Mines of Ontario for 1893 it is stated that eight bore-holes were put down to depths[1] of 50 to 100 feet by J. Fraser Torrance, in 1893, and that these borings confirmed the existence of graphite to the full depth to which they were sunk. In 1901 four diamond drill holes, having depths of 130, 140, 64, and 100 feet respectively, were put down on lot 21, concession VII, North Elmsley, by Dr. R. A. Pyne. The results obtained, according to the manager's statement, were as follows.[2]

No.	Graphite. Feet.	Limestone. Feet.	Altered granite (pegmatite and monzonite?). Feet.	Depth. Feet.
1	32	...	98	130
2	...	140	...	140
3	...	62	2 (graphitic)	64
4	100 (30 feet high grade)	...	...	100

In March and April, 1902, seven diamond drill holes were drilled on the property to depths of 196, 160, 175, 68, 37, 35, and 40 feet respectively, by Mr. McConnell. It is stated "a number of graphite-bearing beds or zones were cut by the drill, varying in width along the course of the holes from 2 to 19 feet and in quality from lean to rich."[3] In 1917, eight diamond drill holes (numbered 1 to 8, Figure 13) and one churn drill hole were drilled by the Globe Graphite Mining and Refining Company, the present owners of the property. The various rocks intersected in holes No. 1 to No. 5 and those intersected in hole No. 7 are indicated in vertical section in Figures 9 and 10 respectively. The succession of rocks cut in holes 6 and 8 was as follows:

Hole No. 6.	Feet.
Soil and boulders..	0 to 18
Highly micaceous pyroxenite..	18 to 26
Feldspathic pyroxenite (including 3 inches graphite ore).	26 to 29
Graphite ore (6 per cent[4])..	29 to 32
Pyroxenite..	32 to 53

Hole No. 8.	Feet.
Soil..	0 to 8
Micaceous pyroxenite..	8 to 100

[1] Vol. III, p. 196.
[2] Ont. Bureau of Mines, Ann. Rept. vol. XI, 1902, p. 59.
[3] Ont. Bureau of Mines, Ann. Rept. vol. XII, 1903, p. 50.
[4] Estimated.

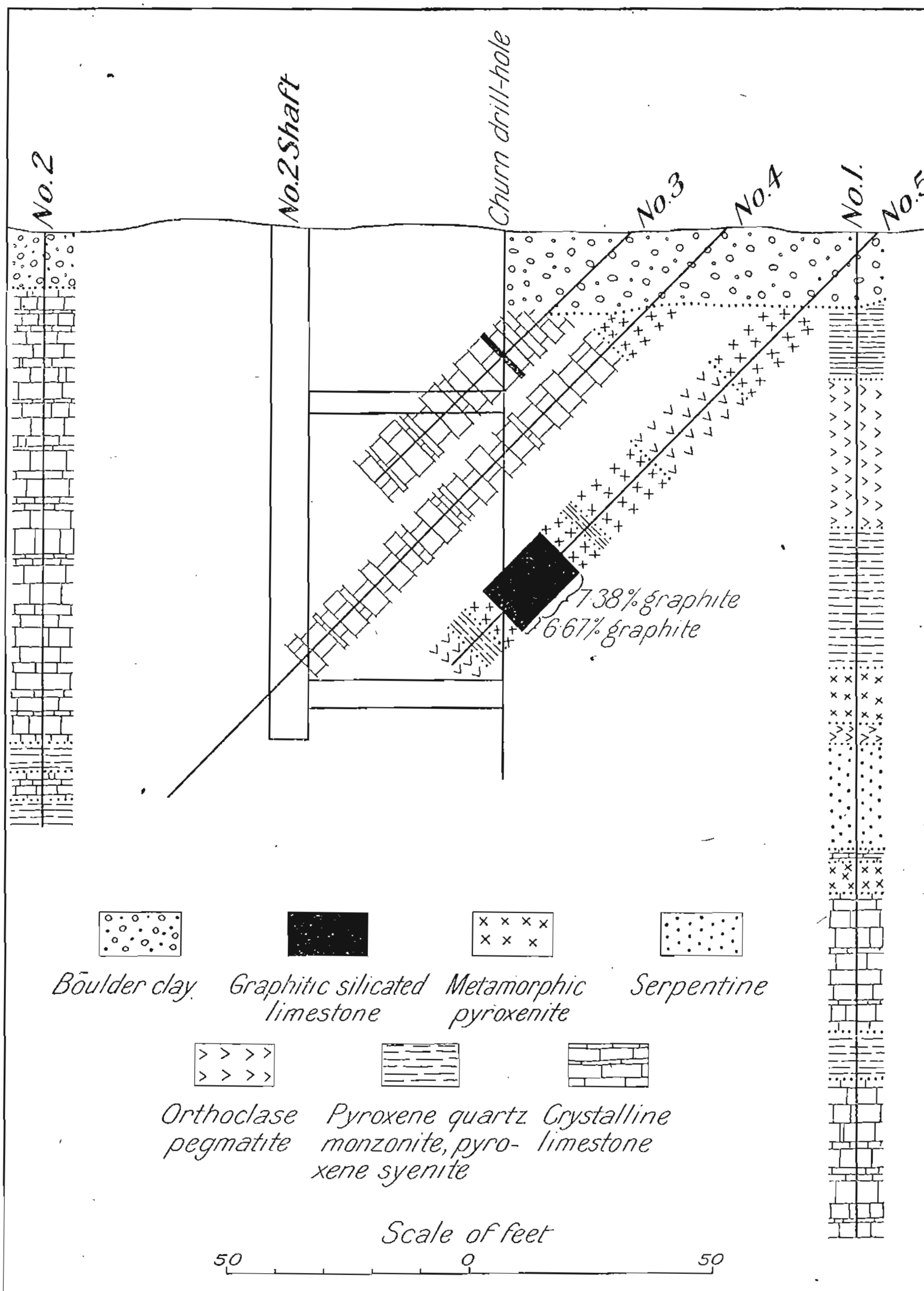

Figure 9. Transverse vertical section along line drawn from diamond drill-hole No. 2 to diamond drill-hole No. 5 (see Figure 13), lot 21, concession VI, North Elmsley township, Ontario.

The results obtained in the churn drill hole were reported to the writer to be as follows:

Soil		0 to 20
Graphite content	20 to 30 feet	nil.
	30 to 37 "	2·28 per cent.
	44 to 53 "	nil.
	53 to 57 "	1·98 per cent.
	57 to 62 "	nil.
	62 to 71 "	5·65 per cent.
	71 to 78 "	nil.
	78 to 84 "	6·50 per cent.
	84 to 114 "	nil.

Extent of Deposits. In the statement of the results of the diamond drilling operations carried on by Dr. Pyne, it is recorded that thicknesses of 32 and 100 feet of graphite ore, respectively, were encountered in two of the diamond drill holes, but it

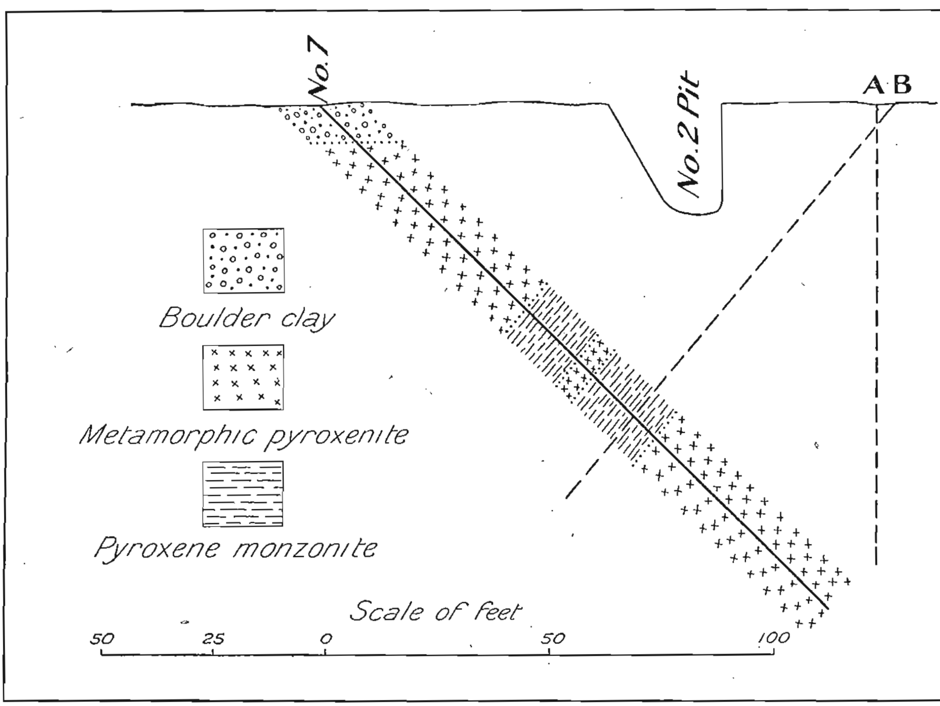

Figure 10. Transverse vertical section along line drawn from diamond drill-hole No. 7 through No. 2 pit (see Figure 13), lot 21, concession VI, North Elmsley township, Ontario.

is probable that these holes were drilled through the main ore mass, for all four of the Pyne holes were drilled on lot 21 on which the main ore-body is situated and diamond drill holes intersecting the ore are reported to have been encountered in the underground workings. In the diamond drilling performed by Mr. McConnell beds or zones of graphite ore, varying in width from 2 to 19 feet, and in quality from lean to rich, were cut. It is possible, however, that the width of 19 feet of graphite ore intersected in these operations was also a part of the main ore mass. In the drilling operations of 1917, 16½ feet of graphitic limestone, averaging approximately 7 per cent graphite, was cut in No. 5 drill hole, although in No. 4 hole, drilled 30 feet to the east of No. 5, graphite was not intersected. No. 2 shaft, from which a drift was projected to the point where graphite was encountered in No. 5 hole, was filled with water at the time the writer made his examination, so that these workings were not examined. The graphite ore masses found in the drift, however, were reported to be of small extent.

As far as known at present, therefore, the only deposit on the property, of graphite ore of workable dimensions, is the original ore mass occurring in the main pit, and it has already been pointed out as regards the extent of this deposit that it occurs as an unsymmetrical, saddle-shaped mass (40 feet in thickness at its maximum point) developed on the west limb of an anticline pitching steeply towards the east. Since

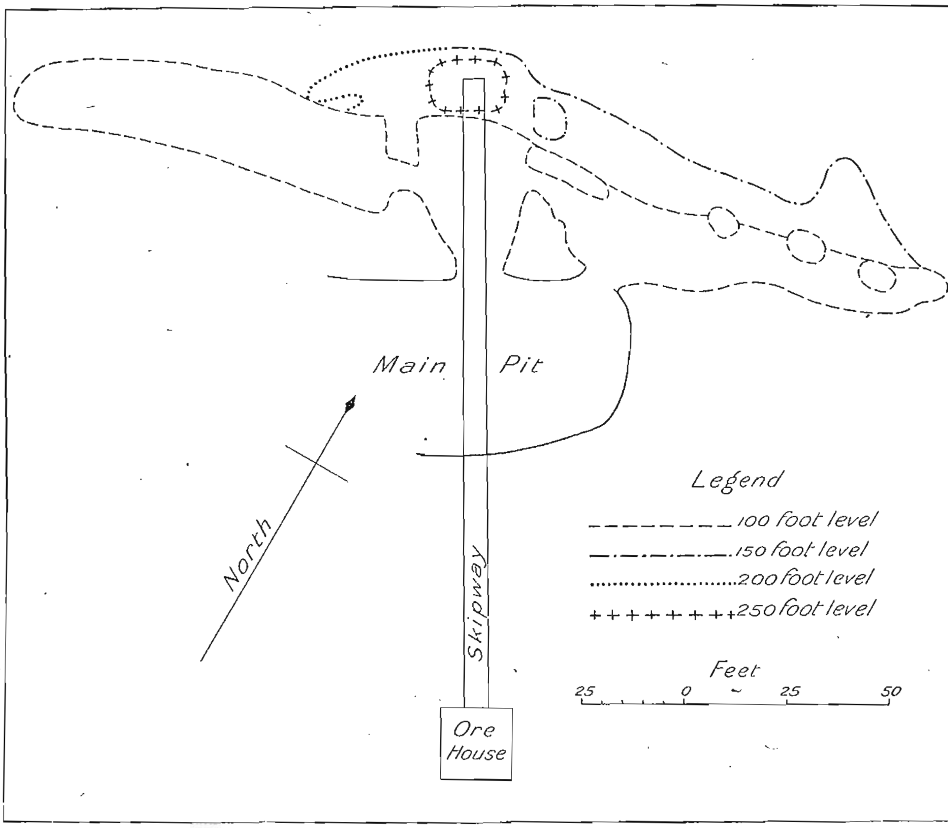

Figure 11. Plan of underground workings, Globe Graphite Mining and Refining Company, lot 21, concession VI, North Elmsley township, Ontario.

this anticline is probably a local fold of the drag type, and the fold structures in the intensely deformed rock of the Grenville series are generally irregular, it is impossible to indicate even approximately the depth to which the deposit extends. At the time the writer made his examination of the property, No. 1 shaft had been sunk to a depth of 250 feet, and at that point there were exposed two zones of high grade ore, 1 and 2 feet in width, respectively, separated by approximately 15 feet of limestone carrying 4½ per cent graphite. It is evident, therefore, that the graphite content of the deposit decreases at depth along the shaft. This change probably takes place, however, because the shaft descends diagonally across the direction of the dip of the west limb of the ore mass, and hence passes progressively farther away from the crest of the fold with depth. According to this hypothesis ore of higher grade should be found on the downward continuation of the main anticlinal mass—that is to the eastward of No. 1 shaft.

Origin. It is not the writer's purpose to discuss the origin of graphite in full in this connexion, but merely to indicate those relationships of the Port Elmsley deposits that seem to have a bearing on the problem. In a previous publication[1] it has been pointed out that three possible modes of origin for Canadian graphite deposits suggest themselves, namely, that they are of sedimentary origin, that they have been derived from igneous intrusions, and that they have been formed by the reduction of carbon dioxide derived from the Grenville limestone (reaction hypothesis).

The Port Elmsley graphite deposits, according to the sedimentary hypothesis, are presumably parts of highly carbonaceous beds in the Grenville limestone that have been broken up into detached masses by deformation. If a bed of this type were less competent than the associated limestone, it might be squeezed into a saddle-shaped mass similar in form to the main deposit.

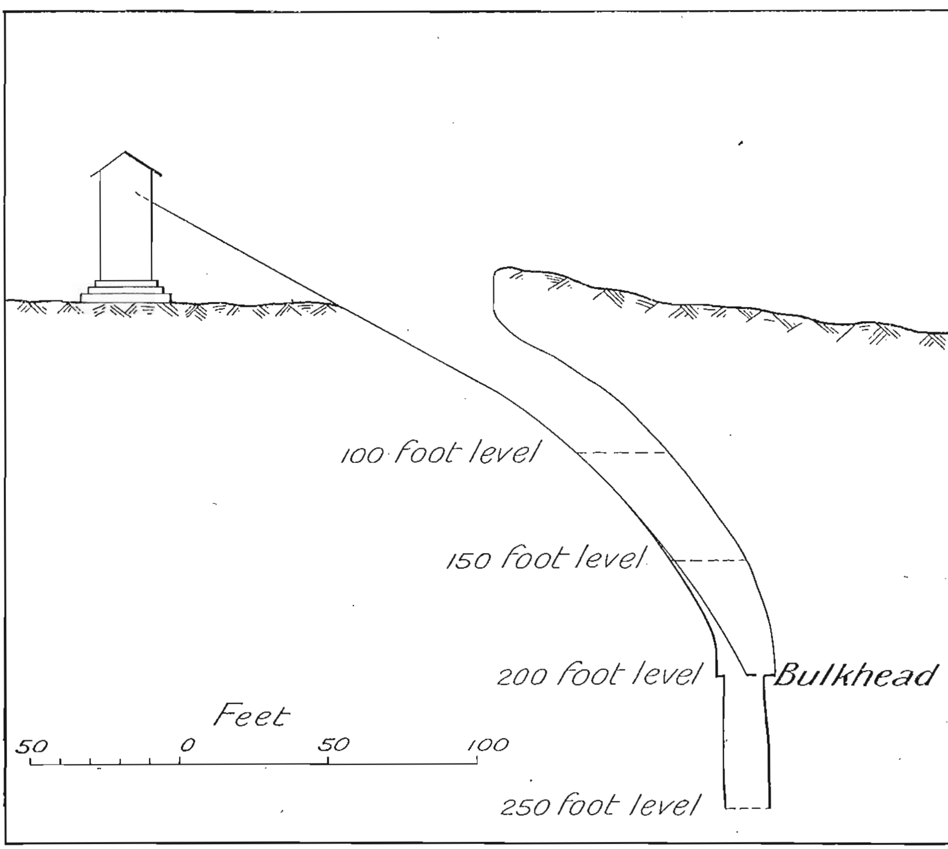

Figure 12. Southeast-northwest elevation, No. 1 shaft, Globe Graphite Mining and Refining Company, lot 21, concession VI, North Elmsley township, Ontario.

The association of the graphite with zones of silication in the limestone and the increase in the graphite content of the ore in proportion to the intensity of silication, would seem to indicate, however, that the graphite was in some way associated with the intrusions of the pegmatitic rocks by which the silication of the limestone was effected. Gaseous or aqueous emanations derived from an igneous intrusion would tend to accumulate at the crests of folds or other points where pressure was less

[1] Trans. Can. Min. Inst., vol. 19, 1916, pp. 349-370.

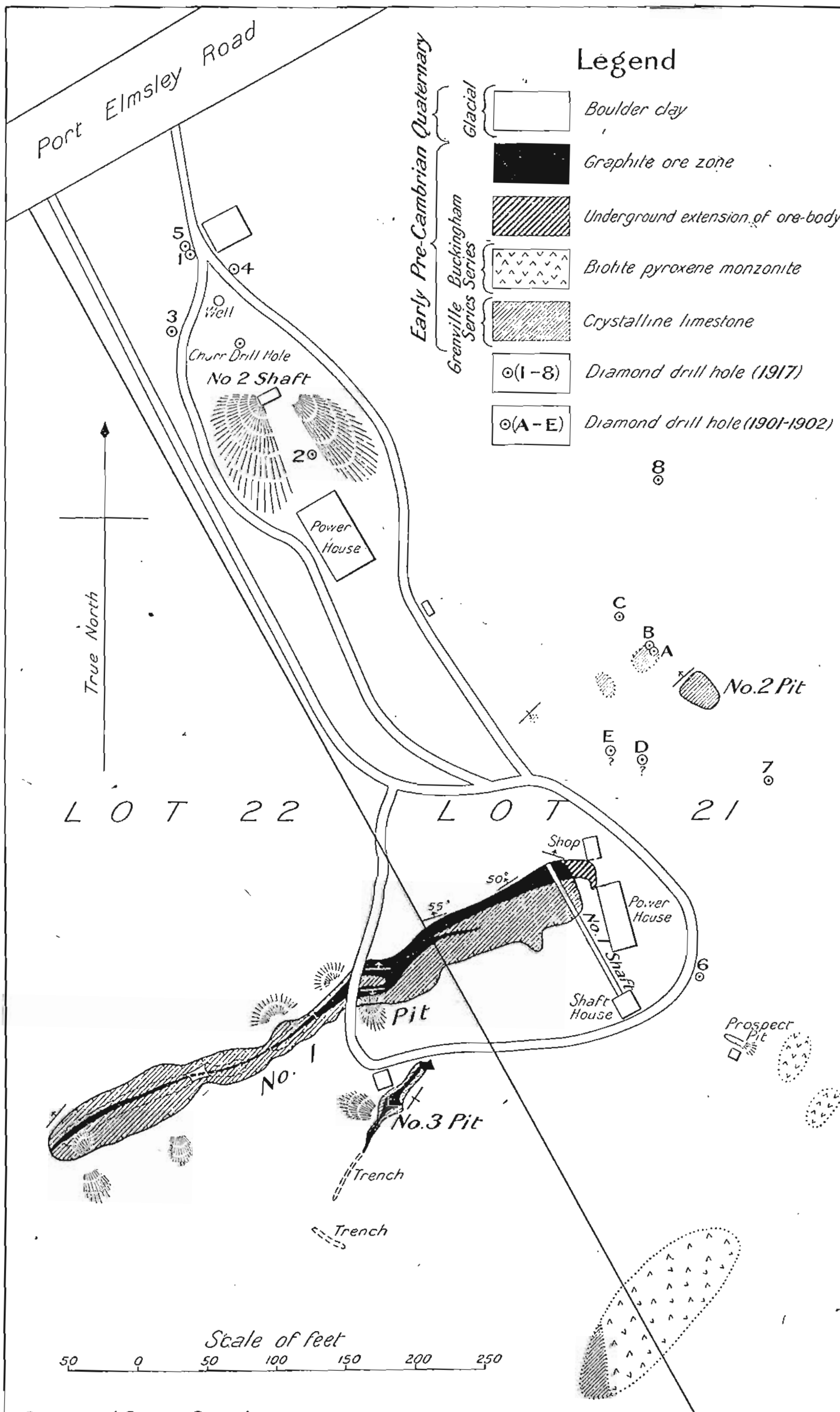

Figure 13. Diagram showing graphite deposits, lots 21 and 22, concession VI, North Elmsley township, Lanark county, Ontario.

intense, and in consequence silication might occur most completely at such points. There would likewise probably be a greater accumulation of graphite at such points whether it emanated from the igneous intrusive or was derived from the carbon dioxide set free by the silication of the limestone. On the whole, therefore, the relationships of the Port Elmsley deposits can be best explained on the assumption that they are either igneous emanations or a product derived from the carbon dioxide of the limestone, rather than by the sedimentary hypothesis.

Development. The development on the property, in addition to the diamond drilling performed, includes a number of open pits (see Figure 13), trenches, and underground workings prejected from No. 1 and No. 2 shafts. From No. 1 shaft, which has been sunk to a depth of aprpoximately 250 feet on the incline (Figure 12), levels have been projected on the southeast limb of the anticline, and most of the ore mined for a distance of 150 feet from the shaft to a depth of 200 feet. On the southwest limb of the deposit the ore has been largely excavated to a depth of 150 feet for a distance of 150 feet from the shaft (Figure 11). A drift is being excavated at present towards the crest of the anticline at a depth of 250 feet. From No. 2 shaft, which is 106 feet in depth, drifts have been excavated at depths of 50 and 100 feet, respectively, as indicated in Figure 9.

Equipment. The equipment in the property includes boilers, hoists, drills, compressors, and other machinery necessary for the mining of the ore, and a mill situated at the village of Port Elmsley to which the ore is hauled for concentration. The method of treatment used in the mill was formerly the usual dry process of crushing and screening, but recently an oil-flotation process has been installed.

THE ARNPRIOR-QUYON DISTRICT, ONTARIO AND QUEBEC.

By M. E. Wilson.

INTRODUCTION.

The greater part of the field season of 1917 was spent by the writer in making an investigation of the geology and mineral deposits of the Arnprior-Quyon district, situated in the Ottawa valley to the northwest of Ottawa. This district includes three important mines, two of which are in active operation at the present time, as well as other mineral occurrences to which the attention of prospectors has been directed at various times. It is, therefore, of considerable interest to those engaged in mining or related industries, especially since it includes important deposits of molybdenite—a mineral required for the manufacture of certain special types of steel now in much demand for military purposes.

The investigation included the necessary field-work for the preparation of a geological map of an area including the greater part of Onslow and Bristol townships in Quebec, and portions of Torbolton, Fitzroy, and McNab townships in Ontario, and for special detailed maps of areas adjacent to the principal mineral deposits occurring in the district.

After completing the investigations of the Arnprior-Quyon district, about three weeks in the latter part of September were spent in studying the geology and mineral deposits of the Mount St. Patrick district in Brougham township, Ontario, and following this a few days were spent in making an examination of the property of the Globe Graphite Mining and Refining Company at Port Elmsley, Ontario.

In making the geological traverses necessary for the preparation of the geological maps, I was assisted by Mr. H. V. Ellsworth, whose efficient service aided materially in the carrying on of the work.

The surveys necessary to supplement the existing maps of the various areas were performed by Mr. L. P. Gouin and Mr. A. Jutras.

MOLYBDENITE AND GALENA IN THE OTTAWA VALLEY.

Molybdenite.

The molybdenite deposits occurring in the Ottawa valley belong to the following classes:

(1) Segregation of pyrite, pyrrhotite, fluorite, quartz, and orthoclase in quartz syenite.
(2) Veins of pyrite, pyrrhotite, and quartz in granite gneiss.
(3) Pegmatite dykes and feldspathic quartz veins.
(4) Contact metamorphic deposits.

Deposits belonging to class 1 were observed in association with a syenite mass 2 miles in length and 1 mile in width, occurring in range VI, Onslow township, 3 miles north of the village of Quyon, Quebec. The Moss mine, belonging to the Dominion Molybdenite Company, includes most of these occurrences.

The deposits belonging to class 2 are very similar in composition to those of class 1, and differ from them chiefly in form. Typical examples of this type occur on the Ross and O'Brien properties, lots 16 and 17, concession X, Brougham township, Renfrew county, Ontario.

Deposits of the pegmatitic type, class 3, are exceedingly common, but are generally too irregular to be profitably mined. The pegmatite dykes occurring on lot 23, concession II, Ross township, Ontario, near Haleys Station, and on the Jamieson property, lots 5 and 6, concession VIII, Lyndoch township, Ontario, belong to this class.

The fourth class of deposits—the contact metamorphic—consists of molybdenite, pyrite, and pyrrhotite disseminated through green pyroxene (diopside), scapolite, and other lime silicate minerals. The most typical example of this class occurs on lots 8 and 9, concession XI, Brougham township, Ontario, the property of the Renfrew Molybdenum Mines, Ltd. Here the pyroxene ore rock occurs as a zone up to 20 feet in thickness, following the contact of irregular sills of pegmatite intruded into Grenville limestone. Other examples of this class of deposit are those occurring near Squaw lake, in Huddersfield township, and north of Duclos in Aldfield and Masham townships, Quebec.

Galena.

Veins of barite and fluorite, or calcite and galena, intersecting the Palæozoic and older rocks, are of common occurrence in the Ottawa valley, and mining operations either for barite or galena have been carried on at various times in these deposits, in a number of localities. Recently a calcite-galena vein belonging to this class, occurring on lot 22, concession VI, Fitzroy township, 2 miles to the northeast of the village of Galetta, Ontario, has been opened up and developed into a producing mine.

This deposit occurs as a northwest trending vein, averaging 5 feet in width, and has been proved by underground workings to be at least 500 feet in length, and to extend beyond a depth of 220 feet. The vein filling material is mainly cavernous calcite in which the galena is disseminated or distributed in vertical bands, forming approximately 10 per cent of the whole. The wall rock of the deposit is Grenville crystalline limestone in which masses of pegmatite and grey granite gneiss are included, but another vein in the northern part of the property occurs on a fault contact between Beekmantown dolomite and Grenville limestone, thus indicating that the veins are younger in age than the Palæozoic sediments.

The occurrence of a galena-bearing vein of this size in this locality is of considerable interest to the mining industry, since it indicates that other workable deposits of this type may be present in the Ottawa valley.

CHROMITE IN QUEBEC.

By Robert Harvie.

In view of the present importance of a supply of chromite, the field work of 1917 was devoted almost entirely to a study of the chromite deposits of the Thetford-Black Lake district. Special attention was given to meeting any requests for advice and in general the operators directly concerned were at once given the benefit of any results obtained from the study of their properties.

In the course of the summer all the working mines and almost all of the idle mines and prospects were visited. The conclusion of Mr. J. A. Dresser that the ore-bodies are results of differentiation from the magma of the original rock, appears to be justified. Since, however, the ore (specific gravity 4·5) has only a slightly greater specific gravity than the country rock (approximately 3·00), the differentiation has not been complete, neither has there been any well-defined tendency for the ore segregations to settle to the margin or other special point in the magma. It is, therefore, impossible to indicate any particular structural situation as being more worthy of attention from the prospector. It is recommended, rather, that wherever any definite, even though small, body or stringer of ore is found, careful attention be given to proving it. The experience of the district tends to show that ore-bodies occur in groups, although no reason has been ascertained for this grouping.

In certain pits it has been found that the ore was associated with light-coloured granitic dykes, this leading to the belief by the operators that these dykes were favourable to the formation of the ore. Such is not the case, since the ore-bodies were formed previous to the dykes. In this connexion it may be pointed out that mill operators should be careful to remove any portions of the granitic rock from the mill feed, as the garnet, to which the dykes have in most cases altered, tends to concentrate with the chromite and hence reduce the value of the product.

INDEX.