

GEOLOGICAL SURVEY OF CANADA
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MINERAL RESOURCES OF CANADA

BULLETIN

ON

GRAPHITE

BY

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OTTAWA

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GRAPHITE IN CANADA

By R. W. ELLS.

Graphite or plumbago, as a mineral, is widely distributed both in Canada and the United States. It is found in rocks of widely different geological horizons in both countries, but, generally speaking, the largest and most valuable deposits from the economic standpoint, appear in all cases to belong to the older crystallines of pre-Cambrian age, which are referable to what has been usually regarded as the Laurentian system. Mode of occurrence in Canada and the United States similar.

In Canada, the largest deposits yet known clearly belong to the gneiss and crystalline limestones which mark the upper portion of the Grenville series, with which are associated numerous dykes or masses of eruptive rocks of various kinds. In the State of New York also, as at Ticonderoga, where the largest deposits at present worked in the United States are located, the mineral occurs in rocks similar to those in which it is found in Canada, the New York rocks being the extension southward of those which are so largely developed north of the Ottawa.

The celebrated deposits which have been mined for so many years in Ceylon, and the output from which forms the largest portion of the imports of this mineral into the United States, are apparently derived from crystalline rocks similar to those found in Canada. The mineral there occurs largely as the foliated and columnar varieties and is of great purity, and while the geological horizon of the containing rocks is not definitely stated they appear to represent some portion of the Archaean. Ceylon deposits.

The mineral graphite is composed largely of carbon with a certain variable percentage of iron. At a high temperature it burns without flame or smoke and leaves a red ash which is practically a red oxide of iron. It occurs principally in gneiss, mica-schist, crystalline limestone and in granite and diorite intrusions. Among the sedimentary series it also occurs with coal, forming a graphitic anthracite, in which form it is mined to some extent in Rhode Island. Similar graphitic

carbon is found in the coal basin of Massachusetts, and also in connection with a deposit of graphitic anthracite in southern New Brunswick. It is also associated with beds of somewhat altered clay shales and slates of more recent date than the crystalline rocks in a number of places.

Several varieties.

It is found in several forms, including the disseminated variety where it occurs as scattered scales or plates through certain portions of the gneiss, limestone or other sedimentary strata; and as veins of the columnar or foliated variety which sometimes intersect granite or other intrusive rocks at all angles.

The origin of the graphite has been a subject of controversy for many years. For a long time it was generally regarded as purely organic in character, and that its presence in the disseminated form was due entirely to the alteration of organic matter which formerly entered into the original composition of such strata where found. While this statement is probably true as regards much of the flake or disseminated graphite, there are certain occurrences of the mineral in this form which yet appear open to discussion. In regard to the vein graphite, its presence in granite, diorite or other intrusive rocks in the form of true veins, appears to be decidedly against this origin, and by many it is regarded as due to the action of certain vapours strongly charged with carbonic acid which have issued along with the eruptive rocks, and which have deposited the graphitic carbon in vein form after the manner of many of the other economic minerals.

Disseminated graphite.

The disseminated graphite often occurs in proximity to the veins, and in these cases it is supposed that the disseminated graphite has thence been distributed along the planes of the rock in contact from the vein matter itself. This is more especially the case where the rock in contact is a mica gneiss, but similar occurrences are found sometimes in the limestone also. In nearly all the localities where graphite has been mined its association with eruptive rocks is clearly seen, since, when not found in the eruptive rock itself, its presence in the stratified gneiss or limestone is generally in close proximity to the intrusions, and in many cases it has been noted that the richest portions of the disseminated mineral are those nearest the granite or other intrusive rock, indicating that these intrusions have exercised a beneficial action as regards the occurrence of the graphite in the adjacent sedimentary crystalline. This feature is well seen at the mine of the North American Graphite Company and at the other mines in this district, and will be referred to more particularly in the discussion of the rocks of this part of the province of Quebec.

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In considering the distribution of the graphite-bearing rocks of Canada, those which are found in the eastern portion of the Dominion will be first taken up.

GRAPHITE IN NOVA SCOTIA.

While the occurrence of graphite in certain rock-formations in Nova Scotia has been known for many years, up to the present time but little has been done in the way of economic production. Several attempts have however been made, more especially in the eastern portion of the province, to exploit deposits of this mineral, but so far these do not appear to have been attended with much success.

The principal occurrences of graphite in the province are described as belonging to the island of Cape Breton. Here the mineral is found chiefly in rocks which have been assigned to the pre-Cambrian age, consisting of crystalline limestones with slates and shales which are associated granitic intrusions. In places, as at Glenvale, River Inhabitants, Inverness county, it is found in a coarse red syenite full of graphite specks. At Dallas brook the rocks are felsites, limestones and slates with which the syenites are associated, and the limestones are graphitic, while beds of graphitic shale also occur. These black shaly beds were at one time mistaken for coal strata. The graphitic limestone is sometimes burned for lime; the horizon of these rocks is that known as the George River limestones, a portion of the Archaean.

One of the graphitic shale localities is found half a mile south of Guthro lake near the French Vale road. The band at this place is said to have a breadth of two to three feet, and can be traced for some distance on the strike. An analysis of this shale was made in the laboratory of the Geological Survey and gave graphite 38.387 per cent. Report of Progress Geol. Surv. Can., 1879-80 p. 1-2. The purified graphite from this place, when completely separated is of fair quality, and appears to be well adapted for lead pencils, electrotyping, and for most of the numerous uses for which graphite is available. Its value as an economic product would appear therefore, to depend largely upon the cost of its extraction and preparation for the market, necessary to ensure the requisite amount of purity.

The percentage of graphite in the Glendale shales appears to vary considerably in different parts. Thus, samples, collected in 1878 by Mr. Hugh Fletcher and assayed in the Geological Survey laboratory, gave of graphite only 13.965 per cent, but a more recent assay by Dr. Hoffmann, of

Graphite in
Nova Scotia.

Analysis
graphitic
shale.

material from the same deposit, made for Mr. James McIntosh, yielded graphite 31.8 per cent. A later assay is given in the Report of the Mines Department for Nova Scotia, of the shales from Christmas island which is practically the same deposit, in which the percentage of graphite is given as 50.23, with rock matter 43.37 and water 6.50. These shales apparently belong to the Cambrian rocks of Cape Breton.

On Cameron and Dundas brooks the gneiss, hornblende schists and dark slates of pre-Cambrian age are blackened with the contained graphite, but no definite information as to the actual graphite contents are available.

Occurrences
in Guysbo-
rough county.

In the county of Guysborough, near the Tor Bay road, several pits have been opened along the Salmon river in a black slate which is probably of Devonian age, and near the contact of the gold-bearing slates. These slates apparently contain a fair percentage of graphite.

The occurrence of graphite has also been reported from West bay, Grand Narrows, East bay and Hunters island, and in addition, Mr. Gilpin, in his Report of the Mines of Nova Scotia, 1880, mentions its presence, mostly in the form of plumbaginous shales, at Parrsborough, Salmon river, Musquodoboit, Hammonds plains, Fifteen-mile stream, Boularderie island, Gregwa brook, and Gillis brook, the last three being in Cape Breton. Concerning the extent of these deposits, no particulars are available, and but little attempt at mining has been done for some years; so that the actual economic value has apparently never been ascertained. The above mentioned localities appear to include the principal deposits as yet known to exist in this province.

GRAPHITE IN NEW BRUNSWICK.

Graphite in
Charlotte
county, N.B.

The presence of graphite in this province was early recognized, and in the first Report on the Geology of New Brunswick by Dr. Gesner, 1839, its occurrence in Charlotte county is mentioned. He there describes a deposit as occurring at a point about four miles and a half north of St. Stephen on land belonging to Mr. William Porter, where he says "there is a stratum of graphite (plumbago) or black lead situated between perpendicular strata of schistose rock. This stratum had been opened and was supposed to be coal."

Since that early date several attempts to work this property as a mine have been made. It lies a short distance to the west of the Basswood ridge road, and appears to be in a slaty schist which is broken by intrusions of gabbro and granite. No mining has been done on this area for some years.

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Other occurrences have been reported also from this county. Thus in the Report of the Geological Survey for 1876-77, Dr. G. F. Matthew describes certain graphitic slates at Dumbarton station on the Canadian Pacific Railway, which are associated with hard sandstones, possibly of upper Silurian age. Similar graphitic bands are found in the southern part of the township of St. Stephen, as also in the northern part of St. Patrick, but in so far as examined at the surface, the Dumbarton beds seem to be the most highly charged with graphite, and some portions of these appear to be sufficiently rich to warrant closer investigation.

Near the coast of the Bay of Fundy, on the shores of Belas basin, Lepreau Harbour, there is a deposit of graphitic anthracite which was mined for coal about twenty-five years ago. Several shafts were sunk, one of which reached a depth of 140 feet. The thickness of the band of black shale and coal was reported by the miners to be in places twenty feet, but this amount varies greatly along the outcrop. The amount of graphitic anthracite at the principal working shaft was said to be four feet in thickness. The deposit was highly inclined, the dip ranging from 80 to 90 degrees. The associated rocks are of Devonian age. While strongly graphitic the coal burned readily under a good draught until the carbonaceous matter was consumed, but left a large amount of reddish ash, reaching on analysis a percentage of 36.88. (Report of Progress, Geol. Surv., Can., 1878-79, p. 13d.)

In character of coal and associated rocks this deposit closely resembles similar deposits which occur in the states of Massachusetts and of Rhode island, which were described in a report by Dr. Edward Hitchcock in 1841. This coal has been mined there from time to time but its value as a fuel is not great. It has been used for some years as a source of supply for graphite and when crushed and properly separated it furnishes a mineral of considerable value. No attempt has ever been made to utilize the Charlotte county deposits in this way, but a careful examination of the material, as to its graphite contents would be desirable.

The principal deposits, from an economic standpoint, in this province are situated near the city of St. John on the St. John river near the Suspension Bridge which connects the city with the town of Fairville. The rocks at this place are for the most part crystalline limestones with slaty schists, which have been described as of pre-Cambrian and possibly of Laurentian age. They appear to correspond closely with the limestones of the Grenville series north of the Ottawa.

Graphitic
anthracite.

Deposits near
city of St.
John.

The presence of graphite at this place was mentioned by Gesner in his report for 1840, in which he says "the limestone of the hill contains several veins of graphite or plumbago, one of which is on the north side of the main street, and is upward of four feet in thickness. This graphite is too impure for the manufacture of lead-pencils. It is occasionally used for varnishing stoves and lessening friction, and may at some future period afford an article of limited export."

Mined for many years at intervals.

Mining has been carried on at intervals at this place for many years. In 1853, Mr. M. H. Perley reports that as much as 89,936 lbs. were exported, but the mine evidently closed down shortly after this date. It was reopened in November, 1868, by Mr. Garrett, and the returns of the output for 1869, taken from the statistics in the Geological Survey report for 1871-72, are 6,000 bbls., valued at \$12,000. No further returns were received from this property and mining seems to have been suspended for a time at least.

Later attempts at mining.

From Professor Bailey's report on the Mineral Resources of New Brunswick, 1897, it would appear that mining operations were again resumed for a short time. A little later, probably about 1872, work was again commenced on this property, by Mr. S. S. Mayer, of Carleton, at a point about 600 yards east of the river, on the land of Messrs. Hazen and Botsford, but after the extraction of a few tons the location was sold to parties in the United States. The works were closed down shortly after, but later another attempt was made by Mr. W. F. Best and others to revive the industry, at a point about 200 feet east of the Mayer location. At this place the graphite was concealed at the surface, but on sinking a shaft, it was struck in small quantity or showing at a depth of about fifteen feet. This area was regarded as a continuation of the deposit seen on the Mayer place, and the graphite is reported by Mr. Brumell, at that time on the Geological Survey staff, who examined the district in 1890, as occurring at the contact of crystalline limestone with a trap dyke. Where first struck, at eight feet from the surface, the ore-body had a thickness of only about two inches, but this rapidly increased and in the shaft it reached a volume of eight to ten feet at a depth of 50 feet. A mass of trap with a thickness of two feet, which extended for 50 feet along the deposit, was struck at a depth of 30 feet from the surface. The dip of the hanging wall is to the south at an angle of 55 degrees. The graphite is associated in places with pyrite which breaks away readily and leaves the graphite comparatively pure. The output is said to have found a ready market at \$7 per ton. Its occurrence is also recorded in the graphitic shales which are regarded as a part of the crystalline

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limestone series. 'See Annual Report Geol. Surv. Can., 1890-91, page 71 ss.'

All these openings near the St. John river appear to be practically on the same deposit or on deposits of similar character. In connection with the ore from what is known as the Split Rock mine, samples were obtained by Mr. Wallace Broad in 1877 for the Geological Survey, which were examined by Dr. Hoffmann. The material had a loose slaty structure, parting into somewhat irregular and lenticular fragments, with a grayish black colour, submetallic lustre and a black streak. A certain amount of pyrite was found in the specimens, and after separating the earthy portions with the pyrite analysis of the ore gave of graphitic carbon, 48.775, rock matter 50.058, and hygroscopic water 1.167 per cent.

Samples of the prepared carbon were sent to persons in England for a practical test of values, and as a result it is stated that, "in the one case the examination has shown the graphite to be of fair quality and adapted to the manufacture of the commoner kinds of lead-pencils; although its 'quality and nature' do not equal, as far as suitability for pencil-making is concerned, the graphite obtainable in Bohemia and some other places." "In the other case, and as regards its employment in electrotyping, the trial did not give a very good result; it was not considered so good as that which they were in the habit of using for that purpose." (Report of Progress, Geol. Surv. Can. 1878-79, pp. 3-4 n.)

Result of tests made in England.

Dr. Hoffmann further remarks on the mineral which was sent, that it was in the most favourable condition, containing only 0.16 per cent of a light coloured ash and therefore, as far as purity was concerned, left nothing to be desired. The failure to meet the higher requirements of the application of graphite, notwithstanding its purity, was thought by him to result from its state of physical aggregation, as implied in the terms "quality and nature" quoted above.

While the mineral at this locality is found in connection with the crystalline limestones at several points, the portion best adapted for mining appears to belong rather to certain bands of argillite or slaty schist through which the ore is disseminated. These bands vary from one to four feet in thickness. The graphite obtained from these places has been used quite extensively for foundry facings for which purpose it is well adapted, and in the manufacture of paint, but for the higher grades its value on the commercial scale has apparently never been demonstrated.

Importance of
preparation
for market.

For some years the ore was shipped in the rough after hand picking, but later a mill was erected and the graphite was for a time cleaned and prepared for the market on the spot. Unfortunately details of the milling plant are not available, and its fitness for the work can not therefore be judged; but as the proper milling and grading of the graphite is a very important feature as regards the market demand, it is possible that some of the failures which have attended this industry in the past may be due to a lack of the best methods for cleaning and separating the final product. That there is a large amount of the ore in this district has been quite clearly established, and in so far as the returns show there does not appear to be any marked reason why, with more suitable methods of mining and treatment, profitable returns should not be received from the capital invested.

Graphitic shales have been reported as occurring at various other points in the province. Thus Prof. H. Y. Hind, in his report on the geology of the province, 1865, mentions its presence at several places, including Portland, just described, Hammond river, the locality four miles north of St. Stephen, already alluded to, Dorchester, Mackerel cove, one mile east of Goose river on the shore of the Bay of Fundy, and at Goose creek itself. Most of these are in slaty bands of different geologic horizons, and appear to be of small, if any, economic importance.

Graphite in
Kings county.

In the extreme north-eastern corner of Kings county, on what is known as Thorns brook, there is a belt of dark graphitic shale or slate on the property owned by Charles McAlpine. The beds strike north-east, and for a breadth of some twenty feet show the presence of an earthy graphite which can be traced on the course of the outcrop for nearly a mile. The graphite is nowhere in the solid form and the slates are jointed and broken, being readily removed with pick and shovel. This property was opened up to some extent and a company was formed to carry on mining operations. The percentage of graphite, however, appears to be too low to warrant the investment of much capital in its development.

GRAPHITE IN THE PROVINCE OF QUEBEC.

The occurrence of graphite in the province of Quebec was noted by Sir W. E. Logan in the Geological Survey Report for 1846, at several places in the townships of Grenville and Chatham Gore. Mining, probably the first of the kind in Canada, was commenced on the Grenville deposits about that time or a little earlier, by the Hon. Mr. Harwood, of Vaudreuil, on a mineral-bearing vein which cut the

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crystalline limestone of the Grenville series. In the early reports of the survey, considerable attention was given to the subject of graphite by Dr. T. S. Hunt, and a large amount of interesting and valuable information, relating to modes of occurrence, treatment of ores and uses was published.

In the Geology of Canada, 1863, page 529, it is stated that 'plumbago occurs in the altered rocks of the base of the Palaeozoic series, in the Eastern townships, generally finely disseminated in calcareous or argillaceous shales, rendering them soft, unctuous, black and shining; but it has nowhere been found among them in sufficient quantity to be of economic value. Examples of these plumbaginous slates are to be seen, among other localities, in Granby, Melbourne, and St. Henry; in the latter place enclosing graptolites. The altered Devonian limestones of Owls Head (Memphremagog lake) are also plumbaginous. The plumbago which is found in Massachusetts, in the continuation of this metamorphic region, is well known to belong to more recent rocks, and to be, in fact, the coal of the Carboniferous system in an altered condition. The principal deposits of plumbago in Canada, however, belong to the Laurentian series, and by analogy suggest the existence of great accumulations of organic matter in the sediments of that remote period.'

Mode of occurrence in the Eastern Townships.

'The plumbago of the Laurentian rocks generally occurs in beds or seams of from a few inches to two or three feet in thickness. These are often interrupted, giving rise to lenticular masses, which are sometimes nearly pure, and at other times mingled with carbonate of lime, pyroxene and other foreign minerals. These deposits of plumbago generally occur in the limestones or in their immediate vicinity, and granular varieties of this rock often contain large crystalline plates of plumbago. At other times this mineral is so finely disseminated as to give a bluish-gray colour to the limestone, and the distribution of bands thus coloured serves to mark the stratification of the rock. Workable deposits of plumbago occur in the townships of Burgess, Lochaber, and Grenville. In one locality in the latter township, it is associated with sphene, zircon, pyroxene and tabular-spar,' (Wollastonite)

Mode of occurrence in Laurentian rocks; 11 M

'The plumbago of the Laurentian series is, however, not confined to the limestones. Large crystalline scales of it are occasionally disseminated in pyroxene rock, in pyrralolite, and sometimes in quartzite and in felspathic rocks, or even in magnetic oxyd of iron, as at the Hull ore-bed.'

Result of
recent investi-
gations.

The description of the mode of occurrence given above, is on the whole applicable to the deposits as known at the present day. The investigations of recent years have, however, brought to light certain points in this regard which will be described. It may be now stated that the valuable deposits of the mineral in this province are practically confined to the crystalline limestones and associated grayish and mica-gneiss which form the upper members of the Grenville series, formerly regarded as representing the middle or upper part of the Laurentian system.

In these rocks, which are cut by frequent masses of intrusives, including granite, diabase, pyroxene, &c., graphite occurs at many widely separated points. The occurrences noted as found in the slates of the Eastern Township have never been deemed of sufficient importance to warrant development in view of the great deposits seen in the crystalline rocks north of the Ottawa. Of these, the most important are found in the townships of Buckingham and Lochaber in the county of Ottawa, and in the township of Grenville, Argenteuil county. In this part of the province all the workable occurrences are at present located and some of them have been operated at intervals for many years. The graphite at these occurs both in the form of disseminated flakes, usually in the gneiss and limestone, and as true veins, both columnar and foliated, which are also found frequently cutting the granite and other igneous rocks, as well as the gneiss.

Mineral
widely
distributed.

A carefully prepared list of localities has been made showing the areas in which graphite has been found, and in some of which mining has been carried on with more or less success at intervals. From this list the wide distribution of the mineral will be readily seen.

Among the first localities where mining operations on graphite were conducted are those in the township of Grenville. Several occurrences of the mineral are known in this district, among the principal of which may be mentioned the following:

Lot 10, range V, the first recorded, afterward known as the Miller mine, worked at intervals by various companies for about 60 years; and recently by the Keystone Graphite Co. of Wilkesbarre, Pa.; lot 9, same range, adjacent on the east, opened in 1900 by the National Graphite Co. of Scranton, Pa.; The Calumet Graphite Co. on ranges II and III in rear of Calumet station on the Canadian Pacific railway, worked in 1899, 1900; and lot 2, range X.

In the Augmentation of Grenville, on lot 1, range VI; lot 3, range II; lots 13-14, range IV; lot 3 range VI; lot 8, range IV.

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Other localities doubtless will be found for the mineral in connection with the crystalline limestones where these are developed, but the above, apparently represent the principal deposits at present known to exist.

In the townships of Lochaber and Buckingham, graphite deposits have a very extensive development. The reason for this is not entirely clear, unless it may be due to some extent to the numerous areas and dyke masses of intrusive rocks, such as granite, pyroxenite, diabase, &c., which traverse the crystalline limestone and associated gneiss in all directions, and which have, as in the case of the micas and apatite, exercised a marked influence on the occurrence of the graphite at certain points.

Extensive deposits in Lochaber and Buckingham townships.

In Lochaber township, deposits, some of which are of considerable extent, and have been mined at intervals for forty years, are found on lot 24, range VII; lot 10, same range; lot 23, range XII; lots 23, 24, 25, range VIII; lots 22, 23, 26 and 28, range X; lots 21, 23, 24, 25, 26, 27, range XI.

In the township of Buckingham, which adjoins Lochaber on the west, graphite is found on lots 22, 24 range IV; lots 19, 20, 21, 22, 23, 24, 26, 27, range V; lots 15, 16, 22, 23, 24, 25, 26, 27, 28, range VI; lots 4, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, range VII; lots 19, 20, 21, range VIII; lots 4, 5, 17, 19, 21, range IX; lots 3, 4, 12, 13, 14, 17, range X; lots 4, 5, range XI; lots 23, 24, range XII.

Among other widely separated areas in the province may be mentioned the following:—lots 25, 26, range, Litchfield; lot 47, XIV, Wright, lot 7, range I, Wakefield; lot 11, range II, Lathbury; lot 9, range XI, Hull; lots 1, 2, range III, Wentworth; Petite Nation, exact locality not mentioned; ranges IV, V, VI, St. Boniface de Shawinegan; on the St. Maurice river at Pointe à la Mine, two miles above the Piles; range II, S. E. Provost; Parish Ste. Ursule, range Fontarabia, Maskinongé county; lot 11, range III, Portland west; lots 23, 24, range VI, Cawood and at Babiche rapid, in the Lièvre river about 30 miles above High falls. Several of these are reported occurrences only, and on the greater number of them but little exploratory work appears to have been done.

List of occurrences in province of Quebec.

The above list of localities for the province of Quebec has been taken largely from the publications of the Geological Survey, supplemented in some cases by the lists contained in the reports by Mr. J. Obalski, Government Mining Engineer for the province. It includes practi-

cally all the deposits at present known to the Department, but as exploration and settlement progress, other occurrences will doubtless be found in either the crystalline limestones or gneisses which have a wide development throughout the country north of the Ottawa river. In many of these areas the amount of graphite will probably be found to be too small to be of much practical importance, but of others their value as a source of supply of this mineral has long been established. The failure of profitable returns from these mines when worked, as they have been in a desultory manner, is in many cases due, probably to imperfect appliances for the proper treatment of the ore, or to bad management or too great extravagance in the part of the companies engaged in the work of mining and manufacture. The history of some of these mining developments would doubtless form interesting matter for discussion, and if available would serve to point out the difficulties to be avoided in future operations, and what improvements might be made for the more successful exploitation of some of these valuable properties.

Mode of occurrence and associations similar.

The occurrence and associations of the mineral are to a large extent the same at most of the places indicated. Certain local conditions are found here and there which must be considered in any mining scheme proposed, but generally it may be said that the chief attention as regards future developments must be made in connection with large bodies of the disseminated flake graphite, as promising the most steady returns. Though the vein form frequently occurs at most of the points where attempts to work the graphite have been made, and has shown in such cases a mineral of great purity, the uncertainty of such deposits is such that, by itself, the employment of capital on a large scale would scarcely be warranted.

Study of deposits made by Prof. Osann.

In 1899 a careful study of the principal deposits in Quebec was made by Prof. A. Osann of Germany, in which he examined the Grenville and Buckingham areas. His report contains many points of interest as to the occurrence and origin of the mineral, some of which, condensed, may here be presented. (Vol. XII., 1899., pp. 73-78.)

History of Grenville deposit.

The history of the Grenville deposit on lot 10, range V., may be briefly stated. First described by Logan in 1845-46, and mined for a few years, the property was abandoned for more than a quarter of a century, when it was again worked for a short time as the Miller mine. It was acquired in 1898 by the Keystone Graphite Co. of Wilkesbarre, Pa., and a considerable amount of development work was done, apparently without fully understanding the actual conditions of the deposit. This work has also been suspended for several years.

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Work was also begun on lot No. 9, adjacent on the east in 1899, by the National Graphite Co. of Scranton, Pa., the rocks on both lots being practically similar in character. This work has also been discontinued.

The area was examined by the writer in 1899 and the following notes as to the occurrence of the mineral were taken.

The country rock is for the most part crystalline limestone which is cut by granites and other intrusives. The graphite usually occurs irregularly at, or near, the contact of the limestone with granite or diabase dykes, both rocks being present in the openings, also in irregular vein form which are massive rather than columnar in character, ranging in thickness from fifteen inches to two feet. These are not solid but apparently sometimes in dyke matter. Mode of occurrence.

Several openings have been made on the property. In the main pit the rocks are limestone with bands of rusty gneiss which are traversed by a white granite dyke and this in turn by a dyke of light green diabase. The graphite occurs principally in two irregular veins, and also in the granite mass, and there is a small vein on the edge of the diabase. The veins are shattered and mixed with the whitish, sometimes reddish granite.

This granitic-looking rock has somewhat the aspect of a vein in some respects rather than a true dyke. It carries several minerals, including scapolite, hornblende, graphite, pyroxene, pyrite, apatite and others. Other minerals included. South of the principal opening where mining has been carried on, the surface rocks for some distance appear to be all limestone, and in several small prospecting pits, sunk in this rock, a small percentage of disseminated flake graphite was observed.

Briefly summarizing the remarks of Prof. Osann on this area, it may be stated that, the mineral here occurs filling fissures as veins in the granular limestone, and is therefore younger than the containing rock. In some of the veins the graphite is the only mineral present; in others pyroxene, scapolite, titanite, wollastonite were also observed. From these graphite veins the country rock has been impregnated with the mineral, particularly in the case of the crystalline limestone, and where such impregnation is seen in the mica-gneiss it has been confined essentially to the layers richest in mica, along which the rock breaks easily. Along the contacts of the graphite veins, the neighbouring rocks have suffered alteration with scapolite, apatite, &c., and in places the granular limestone has been converted into a mixture of pyroxene, wollastonite and titanite. Sometimes the rock is so strongly impregnated with silica as to form a rock somewhat similar to quartzite.

Deposits of
Buckingham
district
studied by
Prof. Osann.

In connection with this subject Prof. Osann also made a study of the graphite deposits of the Buckingham district, more particularly those belonging to the Walker mine, or as it has been styled Graphite City, and recognized the fact that there were certain points of difference in the occurrence of the mineral at the two localities. Thus in the Buckingham district the mineral is frequently found in veins which cut the plutonic rocks, and he therefore concludes that in such cases the process of the vein formation has been by fumarole action after the cooling or solidifying of the eruptive rock. In this way the presence of the graphite is largely analogous to the occurrence of apatite in the pyroxenes of that district, and both minerals are often associated in the same vein.

In regard to much of the disseminated or flake graphite, found both in the limestone and in certain bands of the gray gneiss, he states that this graphite has been derived from carbon, originally present in the rock itself, and is probably of organic origin.

Foreign
materials
introduced by
contact meta-
morphism.

As the result of his study of several localities, Prof. Osann comes to the conclusion that minerals have been formed which are essentially the same as one is accustomed to observe in limestones which have undergone contact metamorphism. This portion of the limestone has been penetrated by gases and vapours from the neighbouring eruptive magmas, upon further cooling, perhaps also by solutions, and that in this way the materials foreign to the limestone, especially the silica, have been introduced. Further evidence in support of this theory will be found in his report, Vol. XII, 1899, p. 79.

The rocks of the Buckingham and Lochaber districts are largely gneiss, crystalline limestone and quartzite. These are cut by numerous masses of pyroxene, granite and occasionally by dykes of diabase. Similar rocks are found in the graphite areas of eastern Ontario which are undoubtedly the prolongation westward of the rocks north of the Ottawa, the overlying palaeozoic formations concealing them in the intervening Ottawa river basin.

These gneisses and associated altered sedimentary rocks have a general north-north-east strike, varying, however, very considerably at different points. As at other places in the area this divergence of strata appears to be often due to the presence of large masses of pyroxenic rocks, and the same features are seen along the Lièvre river in connection with the pyroxenes and gneiss of the apatite mines.

The gneissic bands are often largely composed of sillimanite and are frequently highly ferruginous owing to the weathering out of a certain

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amount of contained pyrite. The crystalline limestone occurs as interstratified beds in the gneiss, and forms the highest portion of the Grenville series proper.

The graphite here occurs in several ways :

1. As disseminated flake in the limestone and gneiss and sometimes in the quartzite, pyroxene and even in masses of iron ore as at the Hull iron mines ;

2. As lenticular or disconnected masses embedded in the limestone, or near the contact of this rock with eruptive masses, or partly in the limestone and associated gneiss. Sometimes the mineral is in the form of flake but is often associated with considerable deposits of the amorphous variety ;

3. In the form of true fissure veins which traverse the gneiss and sometimes the intrusive granite or other eruptive rocks. The mineral in these cases is of the columnar or foliated variety.

The beneficial effect upon the presence of graphite exerted by the agency of intrusive rocks was evident during the examination of many of these deposits by the writer in 1893, when it was seen that in all the mining areas this feature was conspicuous. In all cases where there were large bodies of disseminated ore in the gneiss or limestone such were usually closely associated with masses of granite or diorite. From notes furnished me by Mr. H. P. Brumell who was engaged in the graphite industry of the Buckingham district for some years it is evident the same conditions are seen on the property of the North American Graphite Co. He says of the rocks on lot 28, range VI, Buckingham, that 'a series of parallel bands of graphitic gneiss are cut without any throw by a diorite dyke about 50 feet wide which cuts the strata at right angles. To the north of this main dyke is a reticulating system of small diorite eruptions in the neighbourhood of which the beds of ore are materially enriched. Again about 40 chains to the north of the above and in the pits near the mill of the company there occurs an apparent overflow of diorite beneath which the richest ore was found. And it may be stated in a general way that where the graphite gneisses are cut by dykes the percentage of graphite is much higher than elsewhere.'

In regard to the economic production of graphite, while as already mentioned many of the fissure deposits are of great purity, the uncertainty of these occurrences is against their profitable exploitation on the large scale. Certain of the veins sometimes reach a thickness in places or between one and two feet, but these large veins are usually

short and soon split up into small ones or die out entirely. Among localities where this pure graphite appears to be most abundant, is the property of the Walker Co., where near the line between ranges VII and VIII on lots 21-22, Buckingham, in several of the pits there occur veins ranging in thickness from a few inches up to a foot and a half which have been worked to some extent. Vein graphite is also found on lot 27, range V, in three veins disclosed in a pit, having a thickness of from six inches to two feet. On lots 15-16, range VI, the vein variety also occurs, and on lot 23, range V.

Disseminated
flake of
greatest
economic
importance.

The most persistent of the graphite deposits however are those which are found as disseminated flake. In the Buckingham district this variety is found usually in the grey mica gneiss in bands or beds which sometimes have a thickness of from ten to fifteen feet, or in places even more as well as in limestone. In some of these beds the graphite is very thickly distributed and the rock is quite black from its presence, indicating a high percentage of the mineral. Several assays were made by Dr. Hoffmann in the Survey laboratory some years ago which were published in the report for 1876-77 and are as follows:—

A specimen of disseminated ore from lot 28, range VI, Buckingham, owned by the Montreal Plumbago Co., the sample being regarded as a fair average of one of the largest and most extensively worked beds in the area with a breadth of eight feet, gave by assay, graphite 27.518 rock matter, 72.438 per cent. A sample from lot 22, range VI, Buckingham Mining Co., gave graphite 22.385, rock matter, 75.875 per cent. Specimens from lot 20, range VIII, gave graphite 23.798, rock matter 75.026 per cent; and from lot 23, range VI, graphite 30.516, rock matter, 69.349 per cent. In all the above occurrences the amount of disseminated ore appears to be large, and in some the presence of the vein variety is also recognized.

It must not be supposed that all the disseminated ore occurs in beds equally as rich as those just mentioned, but at very many points deposits exist which give amounts of flake from large bodies of ore, which range from 10 to 15 per cent or even higher. These ore beds are quite the equal in richness of any of the deposits worked in New York state.

Other vein
deposits.

In addition to the vein deposits already mentioned as occurring in Buckingham, others are found in the Augmentation of Grenville, on lot 3, range II, where there is a reported vein 10 inches thick with disseminated ore, and on lot 1, range VI, as well as at other places in this area. The percentage of graphite from these deposits was found on assay to range from 97.626 to 99.815, thus shewing a

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degree of purity quite equal to that found in the best Ceylon or Ticonderoga ore. Concerning the value of the prepared graphite, Dr. Hoffmann states that "in respect to incombustibility the Canadian graphite may claim perfect equality with that of the Ceylon; and that, apart from any consideration of proportion and nature of the associated foreign matter, it is in no wise inferior to the latter as a material for the manufacture of crucibles." Regarding the disseminated variety he also says in discussing this subject, that "prepared according to the present process the dressed graphite obtained from beds of disseminated mineral, is apt to contain more or less carbonate of soda and oxide of iron." He however points out that these can be easily removed by a simple process and the graphite be left "with a very small amount of ash, and that of a nature in no wise prejudicial to its application for the purposes under consideration." Rep, 1876-77.

Discussing the nature of these deposits, Mr. J. Fraser Torrance, who spent some months in the graphite district in the study of apatite and other minerals, remarks that the bad reputation of the Canadian graphite on the market abroad is due to the uncertain quality of the article shipped, (Rep. 1882-83, p. 31 J.,) and to the fact that it contained certain impurities pointed out by Dr. Hoffmann as easily removable, but which had not apparently been done by the company that worked the mine; in other words that while certain portions of the mill product were of excellent quality, this excellence was not maintained throughout, so that the purchaser was uncertain as to the exact nature of the material purchased, and in consequence the market demand speedily ceased. In point of fact this statement appears to be clearly borne out in the history of all these mining operations which have been carried on at intervals for many years, since while all authorities are agreed as to the excellent quality of the ore, and to its abundance at many places, the loss of a permanent market has always been attributed to a lack of care in its preparation and proper purification.

Market affected by uncertain quality of product.

The early history of graphite mining in the Buckingham district dates back for about 40 years. The first mill of any importance appears to have been erected by the Lochaber Plumbago Co. on the Blanche river, lot 28, range X, Lochaber. The mill was run by water power, and was supplied with a battery of eight stamps and two circular buddles. The ore was stamped in water, and then passed over the buddles and afterwards through the stones and screens, but this part of the process was kept secret. The ore was obtained from several points in the vicinity and principally from lot 24, range VIII, and lots 23-24, range XI. The ore beds were apparently in crystalline

Early history of graphite mining.

limestone with bands of grey gneiss, through which were numerous veins irregularly distributed at or near the contact with a heavy dyke of granite, and the thickness of the ore bands was reported to range between 20 and 30 feet, while some of the veins had a breadth of 14 inches. A shaft was sunk on the ore body and several large trenches were made, so that a large amount of ore was raised and sent to the mill which from the first named lot is given as 620 tons (Rep. 1866, pp. 22-23.) On lots 22-23, the mineral occurred as the disseminated variety in a crystalline limestone which in places was black from the abundance of the graphite. The ore bed was reported as from 10 to 12 feet thick, and was worked by open cuts, the contained graphite being stated as about 20 per cent. This was mined to some extent and about 150 tons of the ore were sent to the mill for treatment. Operations have been suspended for many years, and when the locality was visited in 1893, the ruins only of the mill were to be seen.

Two other mills were erected in the early days of the industry, of which one was on the Garrett lot, (on McNaughton Creek), about two miles east of Buckingham, and the third on Fernie creek which is a discharge from the Twin lakes. This last was burned down but the other was abandoned and gradually fell to pieces by decay. No details as to the working capacity of these mills are available.

Walker
Mining Co's
mills.

These old mills have been supplanted by three new ones which have been in operation at intervals for some years. Of these the mill of the Walker Mining Co., on lot 19, range VIII, Buckingham, appears to have been the first erected about 20 years ago, but the original mill was abandoned and a new one put in operation in 1888 which worked at intervals to 1895, since which time it has practically been idle. The mill was well equipped with crushers, stamps, buddles, stones and screens, worked by a steam engine of 100 horse power, and with a reported capacity of 20 tons of raw material per day of 24 hours, or about three tons of the finished product.

The second mill is on the property of the Buckingham Mining Co. (Pugh & Weartz), lot 26, range VI, and has been in operation at intervals for some fifteen years. The mill of the North American Graphite Co., was erected in 1895, and though largely experimental is said to have a capacity of about two tons of the finished product per day.

The mills of the Walker Co., and of the last named, employ the wet method in the treatment and separation of the graphite, but in the other mill the dry process is employed. This has worked only fairly well, but the details of operation are not available. A modification of this plant is now in operation at the mills of the McConnell mine near

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Olivers Ferry, Ont., and the process there is stated to give satisfactory results.

In the wet process the raw material after passing through the crushers goes to the stamp battery where it is crushed in water. Thence it passes to the buddles, then to the millstones, and is finally separated in a series of screens by which the separated flake is graded for the market. In the mill of the North American Graphite Co., lot 28, range VI, an improvement was introduced in the buddling process by which it is claimed greater efficiency is attained by the use of the Brumell separator, whereby a very close separation is achieved at once by the flotation of the dried graphite ore upon the surface of a current of water. After concentration, the method employed is the same as that in use at most of the other mills on the continent, viz., by buhr stones and screens. The product is high grade flake and low grade ground stocks.

Details of wet process.

All these mills operate on the disseminated graphite, mostly from that contained in the greyish gneiss, and the columnar form is not considered as being in sufficient quantity to warrant the erection of commercial plants for its treatment owing to the uncertainty attending the deposits of this variety.

From the experience obtained from the running of these several plants it has been clearly established that for all purposes to which graphite is usually applied, with the exception of fine pencil making, the graphite so obtained has been proved eminently suitable. It has also been demonstrated that in properly constructed mills, and with proper care, a very high grade of graphite can be produced from the disseminated ores of the Ottawa district, as is evidenced from the analyses of the finished products made by different reliable assayers.

Much information relating to the extent and richness of the many graphite deposits in this province is given in the earlier reports of the Survey, more especially in the *Geology of Canada*, 1863, and in Vennor's report for 1873-74, pp. 139-143. In Vol. X, 1897, (pp. 66-73 S.) a very full description is given of the numerous deposits in the Buckingham district, prepared by Mr. A. A. Cole for the Geological Survey, shewing the extent of the ore bodies and the amount of development work done. This is accompanied by a reliable map of the area on which are placed all known outcrops, mill locations, and other points of general interest.

Information contained in earlier reports of Geological Survey.

GRAPHITE IN PROVINCE OF ONTARIO.

Graphite in Ontario.

The presence of graphite in certain rocks in Ontario was recorded as early as 1846 in Logan's report for the year. The locality first noted was in the township of Westmeath on lot 21, range A., front, near the Ottawa river, the mineral occurring in crystalline limestone, but no work has apparently ever been done here to determine the extent of the deposit which is probably not large.

In Murray's report on the district north of Kingston, 1852, the occurrence of a small vein of only one inch in thickness is reported on Mud lake, township of Loughborough, where it cuts the gneiss of that locality, but this may evidently be regarded as of no economic value.

Referred to in the Geology of Canada.

In the Geology of Canada, 1863, reference is made to its occurrence at several points, among which may be mentioned lot 6, range IX, Loughborough, where it is found in as a bed in limestone with a thickness of from three to eighteen inches, mingled with vitreous quartz, in which portions of pure graphite are imbedded; and on lot 18, range IX, Bedford, also in crystalline limestone, as well as at Bird lake, where it occurs in quartz with crystalline limestone. At neither of these places do the deposits appear to be extensive.

Important deposit near North Elmsley.

Since the date of these earlier reports deposits of graphite have been found at a number of places, some of which are large and of great commercial importance. In the Report by H. G. Vennor, 1872-73 mention is made of one of these in the township of North Elmsley, lot 21, range VI, about one mile north of Olivers Ferry on the Rideau canal. This was opened and has been worked at intervals by different people for more than thirty years, and at this place probably the first attempts at graphite mining in this province were made.

The mineral here occurs in crystalline rocks of the Grenville series, similar in character to those which have been already described in the province of Quebec. At the principal openings the old rocks are capped by horizontal beds of Potsdam sandstone. Where first opened up the graphite was found in a sandy greyish and somewhat decomposed gneiss, quite rusty in places, with beds of quartzite, underlying the crystalline limestone, and the graphite was well disseminated through a belt of considerable extent. The rocks here show the presence of a low anticlinal with low dips to the north-west and south-east.

The earlier mining at this place was carried on the gneissic portion of the formation, and the output was hauled to the shore of the canal,

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about one mile distant, where a mill for the separation of the mineral was erected in 1872. This was equipped with stamps, buddles, and sieves or screens, and several grades of the separated flake were produced, of which the finest was used for electrotyping, a second for lubricating purposes, a third for pencil stock, a fourth for stove polish, and a fifth for foundry facings. The amount of mineral in the rock at the mine was held to run from 10 to 20 per cent, and was taken from a pit 300 to 400 feet long by 200 feet wide with a depth of about 20 feet. After working for several years the mill was apparently closed down in 1875-76.

The property was later worked for a time in 1893 by Mr. J. Fraser Torrance, but this was apparently not attended with much success owing to reasons not stated. The details of the first company's operations are given at length in the Report of the Bureau of Mines, Ont. for 1896, (pp. 35-36).

Worked by
Mr. J. Fraser
Torrance.

The property apparently lay idle till 1901 when Dr. R. A. Pyne of Toronto secured the diamond drill of the Ontario Government and bored several holes to test the depth and extent of this deposit. In this work four holes were sunk to the depths respectively of 130, 140, 64, and 100 feet. The borings shewed the presence of graphite of good quality and in large quantity. In the first boring the log showed 32 feet of graphite, the remainder of the hole being in an altered granite and limestone to the full depth of the hole; No. 3 shewed two feet of altered granite mixed with graphite, the remainder of the hole being in limestone; and in No. 4, there was found 30 feet of rich ore, the rest being lean. The nature of the "altered granite" is not stated and it may include certain of the bands of gneiss usually associated with the limestones of the formation.

No attempt at mining is recorded by Dr. Pyne, but the property was secured shortly after by Mr. Rinaldo McConnell of Ottawa who also tested the property with the government drill preparatory to mining, which was commenced in the spring of 1902, the value of the property having been well ascertained, and the presence of large ore bodies determined, which in graphite contents compare very favourably with those which have been mined in the Buckingham district of Quebec. Surface showings were also found on lot 22, range VI, Burgess, but the actual value is not yet known.

Property
secured by
Mr. Rinaldo
McConnell.

The work of Mr. McConnell included the erection of a mill at the village of Port Emsley, or rather the alteration of an old grinding mill which had been built at that place on the River Tay, some years before. Here there is a water power with a seven foot head which furnishes, with a Dodge turbine, about 50 horse power.

Mining
operations.

Mining began at once, and when visited in Sept. 1903 there was an excavation of about 250 feet in length with a width varying from 8 to 14 feet and a depth from 10 to 15 feet. The old workings were abandoned and the new mine is several hundred yards to the south-west, situated on a bed of limestone which overlies the gneiss. This limestone contains thin rusty bands of sillimanite gneiss, and both are strongly charged with flake, some of the layers being quite black, so that the original composition of the rock is scarcely recognized. The dips are generally from 5 to 10 degrees, but at the north east end of the main trench the strata are inclined sharply to the north-west at an angle of 40 degrees. The openings are made along the low crown of the anticline, and no granite was seen on the surface at the mine itself, but there are small outcrops of a rather coarsely crystalline gabbro in the immediate vicinity. Granite ledges, however, show a short distance south-east of the pits and have been cut in the borings. The graphite appears to be all of the disseminated variety and no veins of the columnar were noticed. In the bottom of the trenches the ore seemed to be quite as rich as near the surface.

Treatment
of ore.

The ore which is at present mined in the limestone, after being hauled to the mill a distance of nearly three miles, is first roasted in an ordinary kiln, sufficiently to drive off the contained moisture, but not enough to calcine the rock itself. From the roaster it passes on a short track to the crusher, where it is broken to a uniform half inch-size, two sets of crushers being used. Thence it passes through a series of steel rolls which further reduce the ore to $\frac{1}{8}$ inch size. Then to the jigs which are of the pneumatic type, four in number and from the jigs the separated ore passes to the millstones where it is ground; and passing thence to the screens, it is there separated into four grades. The process of separation is apparently by the dry method throughout, and the whole routine from the preliminary roasting to the final bolting is automatic. The present capacity of the mill is about one ton and a half per hour, and the yield of graphite from the rock is placed at about 10 per cent. The dry process in this plant is claimed to work very satisfactorily. The mill is located a mile and half from Elmsley station on the Canadian Pacific railway.

Borings.

In the investigations on this area by Mr. Torrance, in 1893, borings were also made at a number of places on lots 21 and 22, range VI. and one on lot 23 of range VII. These borings reached depths of from 50 to 100 feet and the presence of the graphite bearing rock was reported as continuous to the bottom of the test holes while in some of the cores the mineral apatite was found.

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Deposits of graphite were observed in 1896 in the township of Blythfield on lots 13 and 14, range IV, near the bank of the Madawaska river, a short distance above the High Falls, on land owned by Mr. James Bailey. These were opened to a small extent, and the mineral occurs in a greyish rusty gneiss associated with granite and greenish-grey pyroxene. The disseminated ore is partly flake and partly amorphous. The gneiss is in places highly garnetiferous and no limestone was seen at the locality where the graphite is exposed. Other deposits.

Among other places where the presence of this mineral is recorded in Ontario may be mentioned lot 13, range VIII, township of Marmora, where it is said to occur in considerable abundance, though no record of development work is to hand. The graphite from this place was examined in the laboratory of the Geological Survey and is of the amorphous variety, containing a small amount of finely disseminated pyrite, and gave on analysis, graphite 72.13, foreign matter, 27.86 per cent. Annual Report, Geol. Surv. Can., Vol. VII (N.S.) 1894, p. II R.

It has also been reported as occurring in the township of Faraday, on lot 13, range I, and by Dr. Barlow in the townships of Dysart and Glamorgan, where it is somewhat widely distributed in the limestone and upper gneiss of the Grenville series, (Summary Report, 1896, p. 53) but apparently no development work has yet been attempted in this area.

In the township of Darling also a small deposit of the amorphous variety has been located near Tatlock, but the value has not been definitely determined, though from surface indications the amount of the mineral does not appear to be large.

In Addington county, township of Denbigh, on lot 34, range VIII, a deposit of graphite was located some years ago and samples were examined by this Department. The mineral occurred in layers and patches in a calcareo-siliceous gangue, and on assay was found to contain 51.67 per cent graphite. It appears to be of the amorphous variety. Deposit in Denbigh township.

Recently this property has been opened up by Mr. J. G. Allan of Hamilton, Ont., who has furnished me some notes as to the nature of the work lately done. Mr. Allan says operations were commenced about the beginning of December, 1902, and a number of tons were taken out that month. In 1903 the mine was worked for about five months and 150 tons mined. The shaft is about 45 feet deep and well timbered. The material is somewhat mixed with quartz, but runs Worked by Mr. J. G.

about 50 per cent graphite and is improving in quality at lower depths. There are two veins which are widening and look as if they would meet below.

The following is the result of assay of this ore by Thomas Heys and Son of Toronto.

Graphite.....	76·12
Silica.....	5·70
Ox.Iron.....	1·28
Carb.lime.....	16·20
Carb mag.....	0·70

A similar occurrence is found on lot 1, range VIII, of Ashby which is the lot adjoining on the west. At present shipping facilities are bad, as the distance to railway is between 30 and 40 miles, but there appears to be a considerable amount of good ore in this area.

Black Donald mine.

With the exception of the mine at Olivers Ferry and that just mentioned the only other property at present being operated is that known as the Black Donald mine in the township of Brougham on the west end of Whitefish lake the property of the Ontario Graphite Co. It is situated on lots 16, 17, 18 and 19, range III.

Nature of deposit.

Work was done on this area in 1895-96, and when examined in August of the latter year had been suspended. The ore-body was apparently large and was uncovered along its course about south-west from the shore of the lake for about 150 feet, with an exposed surface breadth of about 10 feet. The rocks around the lake are largely crystalline limestone associated with rusty gneiss and masses of granite. The strike of the former is N. 55° to 60° E. with a south-east dip of 60 degrees. The graphite where exposed appeared to be in bed form, underlaid by a hard whitish granite or pegmatite composed of quartz and felspar, and the ore body occurred on both sides of the granite dyke, continuing out under the waters of the lake. Graphite scales were also observed in certain portions of the granite, but it did not seem to be largely disseminated in the gneissic portion. A certain amount of pyrite was seen along the contact of the granite in the altered portion of the gneiss.

The general impression as to the graphite at that time was that it formed a large body of fairly pure mineral well worth development.

This property was shortly after opened up extensively. A mill was erected in Ottawa to treat the ore chemically, owing apparently to the somewhat large amount of calcite which it contained, and the ore was

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brought in from the mine for treatment. This mill was operated for some months and then closed down.

As to the mine development, the Ontario Graphite Co. began operations on a somewhat large scale, the details of which can be given from the reports of The Bureau of Mines of Ontario.

Thus in the report for 1895, it is stated that the deposit has a length of 300 feet, and four cross cuts made at intervals of 50 feet shew widths of the vein or bed as respectively 12, 17, 18 and 24 feet. The place was bored with a diamond drill with the following result. One bore on the shore of the lake passed through 39 feet of graphite, succeeded downward by six and a half feet of mixed limestone and graphite; this again by 10 feet of graphite; then seven feet of mixed limestone and graphite, one foot and a half graphite and two feet feldspar and quartz. In another hole further removed from the shore there was graphite 15 feet, graphite and limestone seven feet and graphite six feet.

The deposit is not homogeneous throughout. The calcite occurs in nests and irregular pockets or masses, but containing also irregularly disseminated graphite and minute scales of mica. The quality of the mineral is somewhat lowered by the presence of the calcite in such a degree as to render portion of the deposit useless. An assay by Dr. J. T. Donald of Montreal, gave graphite 84.12, but the percentage varies in different specimens from 49 to 85. The graphite has a greyish aspect, is very hard, and occurs both as flake and amorphous. It is partly embedded, in gneiss in the manner of a vein with a strike north-east and south-west.

In the report for 1901, (Mining Bureau of Ont.) it is stated that the company known as the Ontario Graphite Co. was organized in 1896. The workings consisted of open cuts and a shaft 80 feet deep, with a drift to the north-east from the bottom of 150 feet which extended under the lake. The vein is vertical, and at the bottom has a width of 22 feet with enclosing walls of crystalline limestone. An analysis by the Crescent Steel Co. gave graphitic carbon, 84.06, silica, 3.90, lime 10.05.

In the report for 1902, (Bureau of Mines), further details are given. The steam plant was replaced by an electric plant, operated by power generated at the Mountain Chute on the Madawaska river, two miles and a half south-east of the mine. This plant furnishes sufficient power for working the mine including lighting and heating, and for the graphite refinery which is erected close to the mine on the shore of the

lake. The main shaft is 10 x 12 feet, vertical, and 80 feet deep. The main level northeast was extended to 200 feet out under the lake and to the south-west for 24 feet. The former was stoped out 50 feet high for 120 feet, and 30 feet for the remaining 80 feet. The latter was stoped out 16 feet high for the full length, the stopes being from 8 to 22 feet wide or averaging 13 feet. A 20 foot collar extends down the shaft with a 50 foot open head frame.

Development. South-west from the shaft the vein was located by an open cut for 135 feet, 12 feet wide and 39 feet deep. Fifty-four feet south of this is another open cut, 10 feet wide and 50 feet long; and 50 feet beyond this a vertical shaft was sunk to a depth of 49 feet. Beyond this cross cuts uncovered the vein for several hundred feet. In 1901 three diamond drill holes were sunk from the bottom of the 80 foot shaft, finding graphite at a depth of 122 feet from the surface, where a hard flinty rock stopped the further progress of the drilling.

The surface exposures shew the rock to be a white limestone in which the graphite vein or bed is located, with a thickness varying from seven to twenty-two feet, averaging about 14 feet of clean ore or graphite with 15 to 20 per cent of rock matter. For two to three feet back the walls are of schistose limestone, carrying thickly disseminated graphite flake. Beyond this the graphite is regarded as sufficiently abundant to make a milling ore over a width of 40 feet where worked. In the central portion the mineral occurs both as flake and in the crystalline form.

Development seriously affected by break in roof of mine.

In the autumn of 1902 a break occurred in the roof of the drift which extended under the lake so that the water with the marl which formed the lake-bed was admitted and flooded all the workings connected with the main shaft. This accident has, for a time seriously affected further development, but work has since been carried on the western portion of the deposit, the results of which have not yet appeared.

This place is distant from the Kingston and Pembroke railway at Calabogie by winter road about 12 miles, but the regular road is fully twice as long. About 2,200 tons ore were extracted in 1901, most of which was shipped.

Extent of ore body.

The amount of ore in the extension of the deposit west of the main shaft appears to be quite as large as in the eastern or lake portion of the ore body, and in its extension from the west shaft is reported as having at one place a thickness of 46 feet, which however may be only a local development. The mine is well equipped with appliances

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for raising and separating the ore and the output from the refinery is produced in nine grades, of which the first four are composed of flake or crystalline graphite of different sizes and with a purity of from 93 to 96 per cent carbon; the next is a mixture of flake and amorphous running about 78 per cent carbon; and the last four are amorphous powders of varying degrees of purity from 54 to 62 per cent. For details of mill, &c., see Bureau of Mines report, Ont., 1903, pp. 132-34.

Other occurrences of graphite are recorded, as in South Canonto on the second range, lot not mentioned, where a small amount of work has been done. Also on lot 2, range VI, Bedford; Dunganon, lot 28, XIII; Loughborough, lot 6, range IX; North Burgess, lot 10, range I; North Elmsley, lot 7, range IX; and at Parry Sound; see Minerals of Ontario, Bureau of Mines, 1900, page 199.

In regard to the western portions of the Dominion including the Rocky mountain area and Pacific coast slopes no records of graphite deposits of economic importance have yet been recorded.

STATISTICS.

The first records of production given in the Geological Survey Production. Reports of the Section of Mines, are for the year 1886, the output for that year being stated as 500 tons with a value of \$4,000. Since that date for about ten years the figures fluctuate and in 1893-4 the output was practically nil. There was a marked revival of the industry in 1895, and since that time the output has increased regularly to 1901, when it reached 2210 tons valued at \$37,780. Owing to the closing of one of the principal mines for a time the output for 1902 declined to 1095 tons valued at \$28,300.

The principal producers during the last year mentioned were the Canada Paint Co. of Fairville, N. B., the North American Graphite Co. of Buckingham, Que.; and the Ontario Graphite Co. of Ontario, operating at Whitefish lake, Brougham township.

The value of graphite in the crude and as manufactured imported in the year 1901 into Canada, was \$77,893 as under.

Plumbago, not ground	\$ 2,357
Black lead	25,346
Plumbago, ground and manufactured, crucibles, &c.	49,890
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	\$77,893

In 1902 this amount slightly declined, the figures being for

Plumbago, not ground	\$ 3,649
Black lead	20,467
Plumbago, ground and manufactured, crucibles, &c..	43,656
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	\$67,772