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**TWENTY-FIFTH ANNUAL REPORT**  
**OF THE**  
**ONTARIO BUREAU OF MINES, 1916,**  
**BEING**  
**VOL. XXV., PART II.**

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**LEAD AND ZINC DEPOSITS IN ONTARIO**  
**AND IN**  
**EASTERN CANADA**

By  
**W. L. UGLOW**

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**PRINTED BY ORDER OF THE LEGISLATIVE ASSEMBLY OF ONTARIO**



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# LEAD AND ZINC DEPOSITS IN ONTARIO

## AND IN

### EASTERN CANADA

By W. L. UGLOW

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#### INTRODUCTION

During the period from October, 1914, to July, 1915, the writer was employed by private interests in making a study of the deposits of zinc and lead minerals, from the point of view of their economic value, that occur in the general region lying between Quebec city on the east and Sudbury on the west. On account of the nature of the work, the details and results of the exploration have been, until the time of publication of this report, private property. Recently, however, the unusual developments in the zinc and lead markets, due to military and other similar requirements, have caused at least a temporary abandonment of the work. Considerable information had been collected by the writer during that period, both as a result of field examinations and from an extended perusal of the literature; and acting upon the suggestion of the Provincial Geologist, the writer obtained permission to embody portions of the data in a report to the Bureau of Mines, for the benefit of the general and mining public. The report is prepared in the hope that it may stimulate prospecting and development, and that it may direct attention to those types of deposits which appear to give promise of developing into bodies of commercial importance.

#### AREA COVERED AND NATURE OF WORK

Field examination of mineral properties was limited to those that occur west of Quebec city and east of the western end of the Sudbury basin. Within this area, special attention was given to occurrences in the southeastern part of Ontario, that is, south of the Ottawa and French rivers. Geological literature was closely searched for descriptions of these and all other Ontario and Quebec deposits, and a great deal of valuable information was obtained from some of the earliest of the publications of the Geological Survey of Canada. As a general rule deposits located more than seven or eight miles from transportation were not examined by the writer, except in cases where descriptions and reported assays suggested that the deposits were of more than average value.

#### CLASSIFICATION AND DESCRIPTION OF DEPOSITS

Various well-marked types of zinc and lead deposits occur in eastern Canada. For the purpose of description and comparison, a classification of these deposits is here attempted, based on the same general principles as those adopted by Dr. Waldemar Lindgren in his work on "Mineral Deposits." In many cases, com-

plete descriptions of the deposits are lacking, and places have been assigned to them in the classification based entirely on inferences drawn from the nature of the associated ore and gangue minerals.

The chief divisions of the classification used in this report are as follows:

1. *Origin probably dependent on igneous after-action.*
  - A. High-temperature deposits.
  - B. Intermediate-temperature deposits.
2. *Origin probably independent of igneous after-action. Low-temperature deposits.*
  - A. Calcite-barite-fluorite-galena veins.
  - B. Origin of the calcite-barite-fluorite-galena veins.
  - C. Gash veins and impregnations in Paleozoic limestones.
3. *Anamorphosed low-temperature deposits.*

A simple genetic classification has been selected for the purposes of this report for three chief reasons; first, because the deposits seem to fall naturally into genetic groups; second, because a genetic classification has its basis in the conditions of origin of the deposits; and third, because in exploration and development work, the engineer can follow up the ore bodies to much better advantage if he can form an idea of their mode of origin.

Although a great many of the deposits are of very distinct types, and fall definitely into one or other of the chief divisions of the classification, there are other deposits which occupy intermediate or transitional positions. For the sake of convenience these are discussed under the heading of the division which they most closely resemble. Lead and zinc deposits are taken up together, that is to say, there is no grouping of deposits into those of lead and those of zinc. Minerals of both of these metals are found in all the deposits, and this is in accordance with the general situation in other parts of the world. Certain deposits of the area under discussion have zinc minerals in predominance, others have chiefly lead minerals, while a few occurrences have intimate mixtures of both. Consequently confusion would be the result of an attempt to make the metalliferous content of the ores anything but a very minor feature of the classification.

### **1.—Origin Probably Dependent on Igneous After-action**

In this major division are included those deposits whose mineralogical composition suggests that they have originated from hot ascending solutions which were charged to a greater or less degree with materials usually conceived to have been derived from igneous emanations. Where such deposits have been thoroughly studied in other districts, it has generally been found that they occur in or near igneous rock, which was probably the source of the emanations. In the Eastern Canada area, however, sufficient detailed geological work has not been done in connection with the various deposits to warrant the statement that the ore and associated minerals are definitely due to magmatic or meteoric causes. In most cases, the association of minerals, rather than the areal geology, is the criterion

used in establishing the place of a deposit in the genetic classification. Several of the deposits which are included under the heading (1B) are placed there, because the form of the deposit and its mineralogical composition are very similar to those of certain western deposits whose geology and genetic relations to intrusives have been very carefully worked out.

In this chief division there are two fairly well-defined groups of deposits.

#### A.—HIGH-TEMPERATURE DEPOSITS

This group includes deposits of deep-seated origin, both veins and replacements, the latter possibly of contact metasomatic nature. The temperature, at the time of their formation, was, according to Dr. Lindgren, probably between 300°C. and 800°C., but in most cases below 575°C.; the pressure was very high. These conditions are indicated by the presence of such minerals as pyrrhotite, garnets, pyroxenes, epidote, biotite, and lime-alumina silicates generally. According to E. T. Allen<sup>1</sup> pyrrhotite can be readily formed by the decomposition of pyrite in hydrogen sulphide at temperatures above 575°C. The higher the temperature is carried, the more sulphur is lost, and a product formed at high temperatures, say 800° to 1,100°C., takes up more sulphur when heated in hydrogen sulphide below that temperature. In the neighbourhood of contact intrusive masses, where the sulphides of iron occur, pyrrhotite is found close to the contact where the temperature was highest, and pyrite in the colder zones. It is commonly held by geologists that in nature pyrrhotite was formed from the same solution as silicates like olivine and augite. Garnets, diopside, and other lime-alumina silicates are high-temperature minerals<sup>2</sup> and are found in nature commonly around intrusive contacts or in vein deposits of high-temperature origin. A complexity of mineral composition frequently characterizes these deposits; and intimate mixtures of the ore and gangue minerals, and of sulphides with oxides, is considered a fairly safe criterion of high-temperature origin.

#### (1) *Notre-Dame-des-Anges, Portneuf county, Que.—(Zinc).*

(a) Location: The deposits, which are two in number, occur at distances of two and four miles south of Notre-Dame-des-Anges station on the Canadian Northern Quebec railway, in the township of Montauban, county of Portneuf, Quebec, and about forty-five miles west of Quebec city.

The more important deposit is at a distance of four miles from the village, and occurs in lots 37 to 46, range I of Montauban township. The other deposit is located about two miles from the village, and occurs in lots 6, 7, 8, of range IV of the same township.

(b) Ownership: The first-named deposit was opened up by Pierre Tetreault, of Montreal, who recently leased 1,000 feet along the outcrop of his vein to the Weedon Mining Co., of Sherbrooke, Quebec. North of the Tetreault line, the Laurentide Company had, at the time of the writer's examination in November, 1914, explored the continuation of the deposit for a distance of about 2,300 feet.

<sup>1</sup>E. T. Allen: "Studies in Ore Deposition, with Special Reference to the Sulphides of Iron," Wash. Acad. Sci., Jour., Vol. I, No. 6, pp. 170-177, Oct., 1911.

<sup>2</sup>A. Harker: "The Natural History of Igneous Rocks," p. 233.

The deposit located in range IV, lots 6, 7, 8 was also controlled by the Laurentide Company.

(c) **Geology:** The deposits occur within the area of the pre-Cambrian shield. The country rocks consist of a series of interbedded white quartzites, micaceous quartzites, gneisses of probable sedimentary origin, calcareous schists, with less extensive beds of white crystalline limestone. This series of thinly and thickly bedded sediments strikes from N. 20° E. to N. 30° E., magnetic, and dips from 15° to 40° S.E. In the immediate neighbourhood of the deposits, rock exposures are not abundant. Intrusive igneous rocks were not seen, although T. C. Denis, Superintendent of Mines for the Province of Quebec, states<sup>1</sup> that pyroxenite intrudes the gneisses and limestones. The sedimentary series is remarkably uniform in strike, but changes in dip are frequent, due to minor folding within the less competent layers.

(d) **Ore minerals:** The chief ore minerals are ferriferous zinc blende, of which a pure specimen might assay from 50 to 55 per cent. zinc. This mineral occurs sometimes in large cleavable grains, comparatively free from other minerals; but the usual occurrence is an association, often very intimate, of the ferriferous blende with smaller amounts of galena, pyrite, pyrrhotite and chalcopyrite. In the leaner portions of the ore body, pyrite and pyrrhotite are more conspicuous. The ore was said to show good values in gold and silver, although assays were unobtainable at the time.

(e) **Gangue minerals:** The chief gangue consists of the country rock, which is largely quartzite. Quite abundant, however, are garnets, biotite, diopside, amphibole and quartz. The presence of lime-alumina silicates in intimate association with the ore minerals is good evidence of high-temperature origin.

(f) **Occurrence of the ore:** In each of the two deposits mentioned, the ore occurs in two well-defined zones, each parallel to the strike of the sedimentary series. Within these series, the ore is found as fillings of gash veins and impregnations in a micaceous quartzite member, and to a less extent as impregnations in crystalline limestone.

The mineralized zones vary from a few inches to at least forty feet in thickness. They follow definite horizons in the sediments, both along the strike and down the dip. The typical occurrence seems to be as fillings of gash fissures, produced by the folding and shearing of the beds. The following sketch (Fig. 1) shows in plan and vertical cross-section the habit of the gash veins. As far as

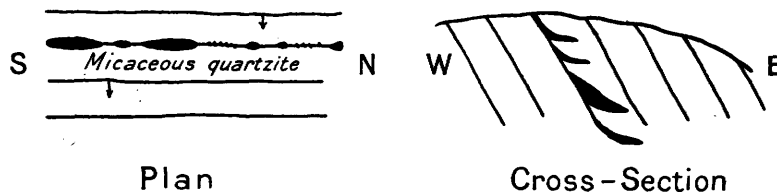


Fig 1—Sketch showing occurrence of ore (in solid black) at Notre-Dame-des-Anges.

<sup>1</sup> Report on the Mining Operations of the Province of Quebec, 1912, p. 29.

could be determined at the time of the writer's examination, these veins, especially the smaller ones, followed down the footwall of the micaceous quartzite for a certain distance, and then flattened off towards the hanging wall. By the continuation of a shaft down the footwall, other veins would be encountered, which would also flatten off towards the hanging wall. This occurrence was specially noticeable at one of the shafts of the Laurentide Company, where several of these small veins had been intersected in this manner.

The Tetreault Company had sunk inclined shafts on two very promising outcrops. In one of these the ore was thirty-six feet in width and was practically solid. The shafts were in the neighbourhood of 100 feet in depth, and were still in the same ore vein or lens. It is presumed that these bodies or lenses of ore were simply fillings of large gash fissures, similar to those found on the Laurentide property. A great many of these gash veins are bounded by a distinctly marked micaceous gouge, which varies in thickness with that of the vein. In other cases the ore is firmly "frozen" to the wall. This gouge does not necessarily mark the wall of the ore body, for impregnations of the ore minerals occur throughout the country rock, outside of the veins, but within the general ore horizon.

Along the strike of the mineralized zone, the ore is seen to occur intermittently. Bodies of high-grade ore were uncovered at the surface at two or three points, but these lensed out along the strike. This is good evidence that the same situation will occur as the ore is followed down the dip. Between the outcrops of high-grade ore, the ore horizon is usually quite lean, in places showing only a slight dissemination of the ore minerals, and in other places a few narrow gash veins.

The ore occurs throughout the mineralized zones in two types: first, a coarse-grained, cleavable type within the larger veins, which consists very largely of ferrous blende with only minor amounts of the other metallic minerals. This affords a very desirable product, and one that assays upwards of 50 per cent. in zinc. The second and more common type is known as the complex ore, and consists of a very intimate and somewhat fine-grained mixture of ferrous blende, galena and pyrite with minor amounts of chalcopyrite and pyrrhotite. With this type the gangue minerals are usually rather abundantly associated. Pink garnets, biotite and quartz may very commonly be seen embedded in a solid mixture of the metallic minerals.

(g) Genesis of the ore: From the presence of pyrrhotite, garnet and biotite, in intimate association with the ore minerals, from the gold and silver values in the ore, and from the nature of the intimate mixtures of metallic minerals, it is suggested that the deposit is of high-temperature origin, and was formed at great depths under conditions similar to those of contact metasomatism. There is nothing that would indicate a change of values with moderate depth.

## (2) *Calumet Island, Ottawa River, Que.—(Zinc-Lead)*

(a) Location: Calumet island is formed by two channels of the Ottawa river and is situated some fifty miles above the city of Ottawa. The chief deposits occur near the southern end of the island in lots 3 to 12, range IV. The nearest railway station is Campbell Bay on the Ottawa-Waltham line of the Canadian Pacific railway.

### (b) Ownership and history:

Some mining was carried on in the island in the early nineties, when several tons of ore were extracted on lots 10 and 11, range IV. . . . In 1897 and 1898, the Grand

Calumet Mining Company went on with the work, and several hundred tons of ore, mined from lots 9 and 10, range IV, were shipped to Belgium. In 1907 some exploratory work was carried on by a United States syndicate. The option, however, was not exercised.<sup>4</sup>

In 1910 the Calumet Metals Company was formed, and work since that time has been confined to surface development, prospecting, and to the extension of the old workings in the Bowie and Lawn shafts. In 1912, a concentrating mill to treat 150 tons per twenty-four hours had been installed, but was not operated steadily. The mill is equipped with jaw crushers, coarse rolls, screens, fine rolls, jigs, Huntingdon mill, Wilfley and Overstrom tables.<sup>5</sup>

At the time of the writer's examination of the property, it was closed down and the shafts were full of water. The chief owner at the time was Mrs. Reeder of New York, and there seemed to be but slight chance of the owners again opening it up, or of any other company gaining control either by purchase or lease.

(c) *Geology*: In the immediate vicinity of the deposits, the rocks consist of an interbedded series of sericitic quartzites, micaceous gneisses of probable sedimentary origin, and crystalline limestones, striking in a northwest-southeast direction, and dipping usually at various angles towards the northeast. The rocks resemble very closely those at Notre-Dame-des-Anges, Quebec, but they are considerably more deformed and schistose. Minor folding and faulting were frequently noticed. Within a few miles of the mine, large areas of crystalline limestone were seen, intruded by granite and gabbro.

(d) *Ore minerals*: These are also very similar to those found at Notre-Dame-des-Anges. In certain parts of the property, chiefly towards the southeast, the chief ore mineral is ferriferous blende. Towards the northwest end, argentiferous galena is reported to have been quite abundant. The typical ore, however, consists of a rather intimate mixture of these two minerals, and is usually considerably more fine-grained than the mixed ores at Notre-Dame-des-Anges. Native silver was occasionally found. Pyrite, chalcopyrite, magnetite and pyrrhotite, the pyrite sometimes in considerable amount, are associated with the ore minerals.

(e) *Gangue minerals*: The chief gangue consists of the country rock—quartzite, sericite schist, micaceous gneiss, with plentiful amounts of quartz, calcite and lime-alumina silicates.

(f) *Occurrence of the ore*: The ore occurs as a series of lenticular deposits of the gash-vein type within the quartzite and gneiss, and also less noticeably as impregnations in these rocks as well as in the crystalline limestones. Two zones of mineralization occur. Each is parallel to the strike of the rocks, and separated from the other by only a few hundred feet. The walls of the individual lenses do not seem to be very well defined, as in the case of the Notre-Dame-des-Anges deposits, and ore minerals are irregularly disseminated in small bunches here and there through the rocks in the general ore horizon. The mineralization along the strike appears to be decidedly intermittent, and mineralized portions are separated from each other by barren stretches. Underground development has shown that in vertical section the individual lenses come in and pinch out exactly as they do along the strike in a horizontal section.

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<sup>4</sup> Mining Operations in the Province of Quebec, 1911, pp. 27-28; *Idem*, 1912, p. 29.

<sup>5</sup> Geol. Sur. of Can., Ann. Rept., N.S., Vol. XV, 1902-3, p. 243 S.

Six shafts have been opened up on the property, and the greatest width of ore body discovered is said to be twenty feet. The greatest depth attained in the development is said to be 120 feet. All of the dumps show the presence of ore minerals, and an average assay of them from samples taken in 1911 by C. W. Willimott of the Geological Survey gave the following results:

Silver :	14.50 oz. per ton of 2,000 lb.
Zinc :	29.19 per cent.
Lead :	13.75 " "
Copper:	3.17 " "

(g) Genesis of the ore: The criteria of origin are much the same in this deposit as in the similar one at Notre-Dame-des-Anges. At the Grand Calumet property, the presence of lime-alumina silicates, pyrrhotite, and magnetite is significant of high-temperature origin, but the absence of garnets, so abundant at Notre-Dame-des-Anges, is here quite noticeable.

(h) Treatment: The intimate association of the galena and zinc blende has made the concentration problem a rather difficult one, but modern methods of selective leaching and electrolytic precipitation of the zinc from such mixtures ought greatly to simplify the treatment.

Other deposits of a similar nature have been reported from this general locality, but they were not investigated by the writer.

### (3) *Zenith Zinc Mine, Rossport, Ont.*

(a) Location: The Zenith mine consists of location 30T., which has an area of 160 acres, and is situated 13 miles north of the transcontinental line of the Canadian Pacific railway, near Rossport on the north shore of lake Superior. The road to the mine leaves the railway five miles east of Rossport, at a point where a siding known as "Zinc Siding" has been constructed for the shipment of ore. Winston flag station  $1\frac{1}{2}$  miles east of the siding, is the nearest point where the regular train stops. The road to the mine is only a winter road as thirteen small lakes are crossed.\*

(b) Ownership: The mine is owned by the Grand Calumet Mining Company, Limited, of Ottawa: President, W. J. Poupore.†

(c) Geology: The deposits seem to consist of more or less irregular bodies of sphalerite in the hornblende and dioritic Huronian rocks of the vicinity.†

(d) Occurrence of the Ore: The ore exposures consist of one on the top of a hill on the one side, and another near the base on the other side, near the shore of a little lake. The hill is about seventy-five feet in height above the lake level. At neither point had the limit of the ore been shown in any direction, and therefore such features as the strike, dip and thickness could not definitely be determined. At the lower workings a surface of solid ore had been exposed, measuring about 20 feet x 15 feet, a smaller exposure about 90 feet to the southeast of this measuring 10 feet x 10 feet. Easterly from the main stripping about 30 feet, outcroppings seem to show the existence of a small vein about six inches thick striking about N.E., dipping 45° N.W., and a small parallel vein shows about 15 feet further west again. The upper workings are some 500 feet north of these. At the time of the visit above mentioned (1884) a surface of solid blende about 15 feet x 20 feet had been exposed by stripping. The formation strikes about W.N.W. and dips northerly about 50°. In an easterly direction from the exposure the ore if continuous must underlie a capping of country rock. Although no final opinion could be formed at that time and under

\*Ont. Bur. Mines, Vol. IX, 1900, p. 86. †Geol. Sur. Can., Ann. Rept., N.S., Vol. XV, 1902-3, pp. 244-247 S.

the conditions then existent, the impression was formed, from the features presented on the ground, and from the minute structure of some of the ore, that it probably exists as masses coinciding with the foliation of the country rock, and would thus follow it in all its flexures. If this be the case, one would expect in the sharper bends to find large irregular masses of ore connecting with thinner sheets in the less folded portions. This supposition would explain the peculiar features of the ore surfaces above mentioned, especially the upper ore, where it would appear as if the prospectors had uncovered one of these bends from above by stripping off the overlying rock representing the upper portion of a fold.<sup>7</sup>

In the open cut, a large body of zinc blende was struck and stoped up 15 feet to the surface, in places four and five feet wide, but of very irregular shape, and without any visible continuous walls. At 12 feet in the tunnel another band of solid blende a foot wide runs down into the floor, and at 30 feet beyond this is a third body, 15 inches wide at first but pinching out in ten feet at the base. Besides these three main strikes, many other intermediate stringers and veins from a fraction to ten inches wide were passed, all having approximately the same strike of north and south and dip of about 25° east, into the hill, which bearings coincide with those of the outcropping of the large vein at the surface above. The country rock, as seen in the tunnel, has been disturbed and broken up along two directions, giving it a "blocky" appearance, the main movement having been sufficient to produce schistose areas in widths from streaks up to several feet, striking north and south with dip 25° east, which directions are the same as those of the ore bodies. In fact it is in this schist, altered in places from the coarse green trap rock to a soft gouge, that most of the veins have been found.<sup>8</sup>

(e) Nature of the Ore: The blende is dark coloured and the associated minerals noticed were copper and iron pyrites and here and there a little dendritic native copper, also a white incrustation on the weathered surface, probably sulphate of zinc from oxidation of the ore.<sup>7</sup>

Grains of zinc blende occur imbedded in the massive trap, having no connection with the main deposits; frequently also masses of the sulphides, pyrites, pyrrhotite and chalcocopyrite are exposed in the seams, both separate from and contiguous to the blende. The massive zinc blende in the tunnel workings contains small grains of pyrites and pyrrhotite disseminated uniformly throughout it, forming but a small percentage of the whole yet in considerably greater quantity than is found in the very coarse blende at the old surface stope.<sup>8</sup>

A specimen of the ore from this place supplied to the chemical branch of the Survey by Dr. R. Bell gave 54.26 per cent. of metallic zinc. The average of the ore shipped, however, is said to have run about 45 per cent.<sup>7</sup>

(f) Development: Although the existence of ore at this place was known more than twenty years ago, owing to its inaccessibility it was not worked until the winter of 1898-99. Operations were then continued on and off for a year or two, but the mine is now idle. The total amount of ore shipped as per returns received at this office, was 1,065 short tons. The latest description of the progress made at the time is given in the report of the Ontario Government Inspector of Mines as follows:—To Feb. 21, 1900, three shafts had been sunk; No. 1, 35 feet deep; No. 2, 40 feet deep; No. 3, 12 feet deep. A small open cut had also been made, from which about 100 tons of ore had been taken. All the shipments were made in the winter by hauling the ore over the ice on the lakes and on the connecting stretches of road which had been cut out for the purpose. Freight from the mine to the railroad is said to have cost about \$2.00 per ton.<sup>7</sup>

Speaking of his visit to this place on Feb. 14, 1901, the Mining Inspector describes the condition of things as follows:—

Mining operations since a year ago have been confined to driving a tunnel into the hill in which the zinc blende deposits occur, starting on the level of the small lake at the foot at a point between the old shafts, about 100 feet north of No. 1 and 500 feet south of No. 2, and beneath the old open stope in the brow of the bluff. The length to date is 75 feet, including 18 feet of open cut at the mouth, and in its course of about northeast, the tunnel is intended to cross-cut to the main veins found on the surface as well as to explore the country rock.<sup>8</sup>

(g) Genesis of the ore: Although the above descriptions from the point of view of genesis are not very satisfactory, it seems reasonable to conclude that the deposit, from its occurrence in close association with igneous rocks, from the

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<sup>7</sup>Ont. Bur. Mines, Vol. IX, 1900, p. 86. <sup>8</sup>Geol. Sur. Can., Ann. Rept., N.S., Vol. XV, 1902-3, pp. 244-247 S. <sup>9</sup>Ont. Bur. Mines, Vol. X, 1901, p. 110.

association of pyrrhotite with the ore mineral, and from the dissemination of grains of sphalerite throughout the massive trap, belongs to this main division, and was formed under conditions of high temperature and pressure as a more or less direct result of igneous emanations.

(4) *Gesic Zinc Mine, Ont.*

Little information beyond what is contained in the following quotation could be found with regard to the property. It is placed in this division on account of its supposed similarity to the Zenith mine:—

The Gesic mine is about two miles south of the Zenith, on the same road. There are ten locations, aggregating 400 acres. The owners are W. A. Johnson, C. Palmer and J. Hare of Toronto, who are forming a stock company to take the property over. . . . I visited the property on Feb. 22, and found operations in progress on location ES 79. A test shaft with a dip of 50° or 60° north had been sunk 23 feet on the vein and was being continued. The formation is trap; the vein is said to be traceable over several locations, with a strike of east and west. At the surface of the pit there is very little mineralization; in fact the vein appears to consist of only a sheared zone of country rock. But at the bottom of the shaft zinc blende is making its appearance in promising quantities.\*

(5) *Faribault Brook Zinc Prospect, Inverness county, C.B.*

The following description is given by F. H. Mason, Analyst, of Halifax, N.S., and is quoted in the Annual Report of the Geological Survey of Canada, Volume XV, N.S., 1906, page 242 S:—

The only deposit of zinc blende that has any economic possibilities that I know of in Nova Scotia, is that owned by the Cheticamp Gold Mining Company situated at Faribault brook, a branch of the Cheticamp river, Inverness county, C.B. It occurs in a bed of sericite schist some 20 feet in thickness and is associated with pyrrhotite, mispickel and galena. The mineral occurs in bands through the schist, and is in places quite massive. I have seen lenses over two feet in thickness. A slope 45 feet deep has been sunk upon it. I have found that by crushing to about ¼-mesh and roasting prior to concentration a fairly clean galena and blende concentrate may be obtained.

Genesis of the ore: The association of the sphalerite with pyrrhotite and mispickel suggests a high-temperature origin for the deposit.

(6) *St. Francis, Beauce county, Que.—(Silver-lead-zinc)*

A vein which occurs at the rapids of the Chaudière in St. Francis, Beauce county, contains, in a gangue of quartz, argentiferous galena, blende, mispickel, besides cubic and magnetic pyrites, with minute grains of native gold. A portion of galena from the assorted and washed ore, which still retained an admixture of blende and pyrites, gave by assay sixty-nine per cent. of lead, and thirty-two ounces of silver to the ton of 2,240 pounds of ore.<sup>10</sup>

(7) *Ruel Zinc Prospect, Marshay township, near Ruel, Ont.*

(a) Location: This property is situated four miles southwest of Felix, on the Canadian Northern Ontario railway, about fifty-six miles by rail north of Sudbury, and about eight miles south of Ruel station. A bush trail from Felix leads to the property.

\* Ont. Bur. Mines, Vol. IX, 1900, p. 87.

<sup>10</sup> Geology of Canada, 1863, p. 517.

(b) Occurrence and nature of the ore: The country rock is a massive greenstone or altered gabbro, associated with a lean greenish carbonate phase of the iron formation. The latter strikes about east and west. The ore is a very fine-grained intimate mixture of galena and sphalerite, occurring in at least two zones parallel to the strike of the country rock. Pyrrhotite occurs in places, as well as pyrite and traces of chalcopyrite. The ore minerals seem to be of the nature of an impregnation in the greenstone and the iron formation. The galena occurs generally in very narrow vein-like stringers cutting through the blende. The ore is not usually clean, but contains bunches of barren rock scattered through it. It is reported that pyrrhotite was the original discovery, and that on sinking, zinc blende was encountered. The bottom of the shaft is reported to be in high-grade sphalerite.

(c) Extent and development: A shaft reported to be sixty feet deep, but full of water at the time of the writer's examination, and six surface trenches, constitute the total development on the property. Traces of the ore may be seen in a general east-west direction across three claims, but continuous development has not proved more than about 250 feet of ore deposit.

(8) *Sahkatawichtah \* Lake Deposit—(Lead)*

Fine-grained galena ore has been recently found in drilling operations in an iron formation belt south of lake Sahkatawichtah in the Sudbury district, Ontario. The location is about ten miles south of the Canadian Northern Ontario railway and about twenty-nine miles south of Flying Post. Details of the occurrence are lacking, but it is suggested that it may be of the same type as the Ruel deposit discussed above.

#### B.—INTERMEDIATE-TEMPERATURE DEPOSITS

This group is intended to include a variety of deposits which are believed to have originated at considerable depth below the surface. They occupy in some respects a transitional position between the deposits of high-temperature origin and those believed to have been formed rather near the surface. In their mineralogical composition the direct effect of igneous emanations is usually very inconspicuous, but a group of minerals is found in their make-up that is very suggestive of a derivation from hot ascending solutions, which may have obtained part of their load in some manner from contact with heated igneous rocks.

As mentioned on page 3, many of the deposits herewith described are placed in this group because of their resemblance in structure and composition to well-known deposits of western United States and Canada, whose genetic relations to igneous action have been quite thoroughly worked out.

The chief metallic minerals occurring in deposits of this nature are sphalerite, galena, pyrite, chalcopyrite and tetrahedrite. The ores usually carry recoverable values in silver and gold. The predominating gangue mineral is quartz, but carbonates are also common, such as calcite and dolomite. The deposits are marked by the absence of such minerals as pyrrhotite, magnetite, specularite, biotite, pyroxene, garnet and other lime-alumina silicates.

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\* Also known as Rush lake.

The deposits normally fill rather well-marked fractures, indicating that they were formed within the zone of fracture. According to Dr. Lindgren, the temperature of formation of this division of deposits ranged from 150° to 300°C.

Certain deposits are described under this heading which resemble in some respects the low-temperature deposits of the succeeding division, and in other respects those of the intermediate-temperature group. On account of the fact that the so-called low-temperature deposits discussed in this paper seem to form a well-marked lithological and morphological group, these deposits of transitional type are discussed at the present stage in the classification.

(1) *Barrie Township, Frontenac County, Ont.—(Argentiferous galena)*

(a) Location: Several openings have been made on both sides of the road from Myer Cave to Ardoch, and near the portage to Whitefish lake a short distance south of Perry. The chief deposits occur on lots 9 to 12 in concession VIII.

(b) Geology: The rocks consist of a steeply-dipping series of pre-Cambrian sediments striking about N. 50° E., magnetic, and consisting of finely-crystalline, bluish, slaty limestone, sheared pseudo-conglomerate, and mica schist. The series is intruded in several places by granite, and it is in the general vicinity of the intrusives that the ore minerals occur.

(c) Character of the ore and gangue minerals: The ore minerals consist of fine-grained argentiferous galena, pyrite, chalcopryrite and zinc blende. The gangue consists chiefly of a mixture of quartz and calcite.

Several assays of the ore from this place were made in the laboratory of the Geological Survey, the percentage [= quantity] of silver, in one case from a sample from lot 12 of rather coarsely crystalline galena, being 137.883 ounces to the ton of 2,000 pounds and a trace of gold, while a sample from lot 9 of the same range gave 119.583 ounces of silver to the ton, but no gold.<sup>11</sup>

(d) Occurrence of ore: The ore occurs both as stringers and lenses up to five feet thick, running parallel to the strike of the country rock, and also in a minor degree as an impregnation in the silicified limestones. As a general rule, both the galena and the quartz are very fine-grained.

(e) Genesis of the ore: The highly argentiferous nature of the ore, the presence of gold values, the fineness of the grain of the galena, and its association with quartz, suggest that the deposits were formed by heated solutions which had a genetic relation to the intrusive masses in the vicinity.

(f) Development: Four shallow shafts, full of water at the time of examination, are on the properties. Very little ore mineral of any commercial value was seen.

(2) *McKinnon Vein, Steeprock Lake, Atikokan, Ont.—(Lead-zinc)*

(a) Location: The deposit is located about ten miles northeast of Atikokan station on the Port Arthur-Winnipeg line of the Canadian Northern Ontario railway.

<sup>11</sup> Geol. Sur. Can., Ann. Rept., N.S., Vol. XIV, Part J, p. 67.

(b) *Geology*: The vein lies within the Archean complex, close to the contact of greenstone schists and intrusive granite. No sedimentary rocks are known in the immediate vicinity. A dike of diabase seems to form one wall of the deposit.

(c) *Nature of the ore minerals*: These consist chiefly of argentiferous galena and zinc blende, with pyrite and minor amounts of chalcopyrite.

(d) *Nature of the gangue*: The ore minerals are associated with a gangue of white sugary quartz.

(e) *Occurrence of the ore minerals*: The deposit is a quartz vein about ten to fifteen feet in width and stripped at the time of examination for a length of about 100 feet. The metallic minerals occur disseminated throughout the vein in rather fine grains and in places quite abundantly.

(3) *Black River Deposit, north shore of Lake Superior—(Lead)*

At a mining location at the mouth of the Black river, to the north of the Slate islands, the Laurentian rocks are seen near their contact with the Huronian schists. Here a vein of quartz occurs in the granitic gneiss. It runs nearly east and west, with a breadth of from one and a half to five feet, and holds galena and iron pyrites. The latter is more abundant near the shore; but about twenty rods beyond, in the hill, the galena predominates. According to Prof. Hadley, this ore is extremely rich in silver; the lead reduced from it containing from two to three per cent. of the precious metal. This galena, according to the same authority, contains a trace of selenium.<sup>12</sup>

(4) *Granite Islet, Black Bay, north shore of Lake Superior—(Lead)*

Veins holding lead ore are found in several localities on the north shore of lake Superior. Some of these traverse the granitic gneiss of the Laurentian series, as on Granite islet, in Black bay, where a vein of twelve inches in breadth carries a considerable quantity of galena in a breccia of fragments of the wall-rock, cemented by drusy crystalline quartz. This ore does not appear to contain much silver.<sup>12</sup>

(5) *Poirier Lake, Timiskaming County, Que.—(Lead-zinc)*

The following description is given by Dr. J. A. Bancroft in a report to the Superintendent of Mines, of the Province of Quebec. The locality mentioned is about 20 miles south of the National Transcontinental railway and about 50 miles east of the Ontario boundary.

About two-thirds of a mile northward from Poirier lake, a rocky ridge, which in part is devoid of trees, rises to an altitude of approximately 100 feet. The ridge extends nearly east and west corresponding to the strike, S. 80° E., of the highly schistose rocks of which it is composed. The schists are traversed by a series of veins or stringers of quartz, frequently containing a little calcite and epidote, and occasionally bearing small amounts of galena, zinc blende, pyrite and a few specks of copper pyrites. Although these veins may seem to recur at widely separated intervals along a definite line, they can seldom be traced for more than a few feet before they become very narrow and finally disappear. They display a maximum width of four feet, but can be traced for only a few yards before they terminate.

A group of mineral claims are situated there, having for their chief centre of attraction a vein, four feet wide, containing a considerable percentage of galena, zinc blende and pyrite, with an occasional particle of copper pyrites in a gangue of calcite and quartz. At the time of our visit, Mr. George Richmond, who made the discovery, was engaged with a few men in sinking a shaft, which had reached a depth of ten feet. A few feet westward from the shaft, the vein pinches out, but stringers of barren quartz occasionally occur in line with its projection; several hundred feet westward one of these quartz veins, about eighteen inches

<sup>12</sup> *Geology of Canada, 1863, pp. 689-690.*

wide, contains a little galena and zinc blende. For a few yards eastward from the shaft, the bed-rock is covered, but upon reappearing at the surface there is no evidence of the presence of the vein.

Striking S. 80° E. and dipping 87° toward the south, this vein is situated between a small dike of fine-grained diorite on the north and actinolite schist on the south. Although in part distributed through the gangue of calcite and quartz, the galena, zinc blende and pyrite occur chiefly along or adjacent to fractures in the gangue. Of the economic minerals present, galena is the most abundant, zinc blende tends to occur near the walls of the vein, and the pyrite, which is present in very subordinate amount, is crystallized in beautiful, small pyritohedrons. At the bottom of the shaft the vein was seven inches narrower, pyrite was becoming slightly more abundant, and a dike of aplite, three to four inches wide, intersected the southern margin of the vein. In thin section under the microscope this aplite is found to be almost entirely composed of microcrystalline quartz with epidote of bright yellowish-green colour, which apparently has been derived from the alteration of a small amount of feldspar. So analogous is this aplite to similar dikes, which are associated with and genetically related to the "newer diabase" in other districts, that it lends emphasis to a belief that the vein owes its origin to the intrusions of quartz-dabase in the district.

I was informed that after our departure from the district, the shaft was sunk to a depth of forty feet, where there was about eight inches of vein matter in the form of stringers running in all directions.

The body of ore is by no means large enough to even suggest the possibility of its being developed into a mine for lead and zinc. An assay of an excellent sample taken from the shaft at a depth of eight feet, containing small galena, zinc blende and pyrite, shows the presence of 47 cents per ton in silver and not a trace of gold.<sup>23</sup>

(6) *Elmtree Prospect, Bathurst District, N.B.—(Zinc-lead)*

The following description is given by Dr. G. A. Young in a report to the Geological Survey of Canada.

A vein, principally of zinc blende, galena, chalcopyrite, pyrite and country rock, with a width of about 6 feet, is exposed in the bed of Elmtree river, about 5 miles from its mouth. The vein, with a general direction of about NNW, crosses the river at right angles to its course. It is nearly perpendicular, and cuts black slates of the Elmtree formation. On the upstream side it has a rather distinct wall, and there the enclosing slates are but little altered. On the downstream side the slates are considerably altered (silicified?), penetrated by calcite stringers, and partly mineralized, so that the boundary of the vein is not distinct.

As seen in the bed of the stream, the vein, or, since much altered country rock is present, more accurately speaking, the mineralized zone, contains much pyrite and chalcopyrite in narrow, discontinuous veins, some of which are 4 inches or more in width. The sulphides also occur in scattered grains and small aggregates.

On the eastern bank of the stream there is a small pit now filled with water. The dump is of altered wall rock and ore, and it is noticeable that pyrite is less abundantly developed than in the vein as seen in the river bed. The ore consists chiefly of coarsely crystalline, dark zinc blende, coarse galena, coarse pyrite in grains and aggregates, and a relatively small amount of calcite and quartz. The various constituents tend to occur in large and small aggregates, often vein-like, interbanded and intermixed with altered country rock. The relative amounts of zinc blende and galena vary widely, but, in general, the zinc blende predominates.

An assay of a sample collected a number of years ago gave a trace of gold, and 7.197 ounces of silver per ton.<sup>24</sup>

(7) *Victoria Mine, Garden River, Algoma District, Ont.—(Lead)*

This mine is situated near Garden river and about eight miles north of its mouth.

The galena occurs in stringers, grains and small bunches in a belt of green schists, glossy and cleaving in all directions.

<sup>23</sup> Mining Operations in the Province of Quebec, 1911, pp. 201-203.

<sup>24</sup> Geol. Sur. Can., Memoir No. 18, 1911, pp. 75-76.

The galena is argentiferous, and is often mixed with blende and iron and copper pyrites. Analyses made recently of samples . . . gave the following results:

	(1)	(2)
Silver .....	19.00 oz.	14.5 oz.
Gold.....	trace	\$6.00
Copper.....	5.62 per cent.	2.20 per cent.
Lead .....	53.2 “	5.72 “
Zinc.....	9.76 “	22.8 “

Work on this deposit was commenced in 1875. Shipments were made from 1878 to 1880. Two shafts were sunk, one 410 and the other 100 feet, and drifts and cross-cuts driven. No work is at present in progress.<sup>16</sup>

(8) *Cascade Mine, Garden River, Algoma District, Ont.* <sup>17 18</sup>—(Lead)

From the descriptions referred to in the footnotes, the Cascade mine seems to be on a continuation of the Victoria vein. One shaft was put down to a depth of about 200 feet; some cross-cuts were driven, two levels extended about 200 feet, and some stoping done. The general character of the vein was about the same as that of the neighbouring Victoria mine.

(9) *Wright Mine, Timiskaming County, Que.*—(Argentiferous galena)

(a) Location:

The most important and interesting ore deposit of the east side of lake Timiskaming is the property known as the Wright mine, which comprises the western parts of lots 61, 62 and 63, range I, Duhamel township, shown on the maps as Blocks A and B. The ore body, which is exposed on the water-worn rock surface of the lake shore, was observed by the early French explorers, since the location is marked *Ancé à la Mine* on a map of the lakes of Canada published in 1744, a print of which appears in Professor Miller's <sup>19</sup> report of 1905.<sup>20</sup>

(b) Geology:

In the vicinity of the mine, the rock is the breccia-conglomerate forming the basal member of the Huronian in this district, the pebbles or fragments of which are chiefly of granite, diabase or other eruptive rocks, embedded in a greenish, chloritic, slaty matrix, which owing to pressure appears to curve around or enfold the inclosed fragments.

The deposit occurs in a brecciated or shattered belt of the rock, composed of angular or subangular fragments, the interstices being filled by galena, with occasionally a small quantity of iron pyrites, together with more or less pink dolomite. Although this zone is about eighty feet in breadth and contains a varying quantity of galena throughout, only about six feet can be said to carry the mineral in workable quantity, and even this with considerable admixture of gangue and rocky matter. The rock immediately adjoining and inclosing the deposit has a decidedly porphyritic appearance, crystals and fragments of white feldspar and grains of transparent quartz being embedded in a fine-grained greenish matrix.<sup>21</sup>

(c) Character of the Ore:

A number of assays of the ore from this mine have been made, both in this department and by private assayers. The galena entirely free from gangue, is found to yield from 13 to 26 ounces of silver to the ton, with about 18 ounces as a mean value. It is also found to have a lead content of about 52 per cent., and usually yields traces of gold.<sup>20</sup>

Iron pyrites has been found intimately associated with the galena, and occasionally considerable quantities have been encountered in working the deposit. This is doubtless the source of the gold usually present in the ore.<sup>21</sup>

<sup>16</sup> Descriptive Catalogue of a Collection of the Economic Minerals of Canada: Paris International Exhibition, 1900, p. 104.

<sup>17</sup> Rep. Royal Com. Min. Res. Ont., 1890, p. 147.

<sup>18</sup> Geol. Sur. Can., Ann. Rep., Vol. X, N.S., 1897, p. 121 S.

<sup>19</sup> Ont. Bur. Mines, Vol. XIV, Pt. II, 1905; idem, Vol. XIX, Pt. II, 1913, p. 4.

<sup>20</sup> Geol. Sur. Can., No. 1064, 1910, pp. 38-40, M. E. Wilson.

<sup>21</sup> Geol. Sur. Can., Ann. Rep., Vol. X, N.S., 1897, pp. 147-149 i.

The values obtained in operation were greatly diminished, however, by the large amount of rock which had to be mined and the consequent crushing and concentrating which this involved. During the earlier part of its history the lack of transportation facilities was also a difficulty.<sup>20</sup>

(d) Origin of the Ore:

The origin of this irregular deposit is very obscure. The vein-matter has no doubt been deposited by replacement along a zone of fracture or brecciation in the Huronian, though the immediate cause of the brecciation in the conglomerate is not apparent. The occurrence of the ore in association with the porphyritic variation in the conglomerate is probably a mere coincidence, similar porphyritic rocks occurring quite frequently in the Huronian, as on Drunken island, and in the greywacké ridge which forms the southern boundary of the valley of the Little River.<sup>20</sup>

(e) Development:

Operations on this deposit were first begun in 1886, by Mr. C. V. Wright, of Ottawa, but no extensive work was carried on until 1890, when the property was acquired by the Mattawa Mining and Smelting Company. A very complete plant was installed and mining actively prosecuted until March, 1891, when work was suspended. From 1896 to 1902 the mine was operated in a small way, first by the Petroleum Oil Trust and later by the British Canadian Lead Company, both of these corporations representing English capital. Quite recently the property has changed hands, the present owners being the members of the La Rose Mining Company, of Cobalt. Active mining, however, has not been resumed. At the time of the suspension of work in 1902, a depth of 250 feet had been reached in the main shaft, while short drifts had been made at the 65, 100, 200 and 250 foot levels.<sup>20</sup>

(10) *Lead Hills Location, north shore of Lake Superior, Ont.—(Lead)*

(a) Location: The property is situated in the township of McTavish, at a distance of three or four miles west of the shore of Black bay.

(b) Ore Occurrence:

A rich vein of lead ore occurs in a pale red indurated marl. Prof. Chapman says of it: "The vein consists of a gangue of quartz, with enclosed portions of wall-rock, and some heavy spar, etc., carrying a very strong lode of intermixed copper pyrites and galena. The vein itself appears to average about ten feet in width; but at present it is to a great extent uncovered. The copper pyrites and galena, although scattered more or less throughout the vein, run principally in a solid lode, of at least four feet in width. The course of the vein is about N. 65° E.; and so far as this can be determined in the present undeveloped state of the vein, the dip, or underlie, is towards the southwest, at an angle of about 80°." In one sample he found 8.10, and in another 11.62 per cent. of copper. One of these samples also yielded 47.56 per cent. of lead. Another gave 38.35 per cent. of lead, nearly 1 ounce of silver and half an ounce of gold to the ton of lead.<sup>22</sup>

(11) *Lady Evelyn and Haycock Locations, Timiskaming District, Ont.—(Lead)*

(a) Location: The veins occur on the shores of the last stretch of Lady Evelyn lake, just before it empties into the Montreal river. The locality is about twenty-eight miles west-southwest of Haileybury.

(b) Description:

The western shore of this portion of the lake is composed of diabase that rises abruptly from the surface of the water and often forms steeply sloping or perpendicular cliffs. The contact between this rock and the slates is concealed for the most part by the lake, the eastern shore being altogether composed of a very distinctly banded greenish slate, which also rises into rather important elevations, having apparently been protected to a considerable extent from denudation by the proximity of the more unyielding diabase. The contact, for a short distance, runs inland along the western shore, leaving a comparatively narrow strip composed of the slates, which are seen to have been much shattered and broken up by the intrusion of the diabase. Some considerable masses of segregated quartz were here noticed filling irregular cavities and fissures produced during the eruption. Associated

<sup>20</sup> Geol. Sur. Can., No. 1064, 1910, pp. 38-40, M. E. Wilson.

<sup>22</sup> Geol. Sur. Can., Report of Progress, 1866-1869, pp. 358-359.

with the quartz is more or less calcite, and in this gangue were noticed galena, copper pyrites, iron pyrites and zinc blende. The banded slates on the eastern shore dip in an easterly direction at an angle of about 18°, and associated with and cutting these are similar segregated masses of "gash veins," in which galena is the prevailing constituent. The property on which these veins are situated is owned by Messrs. Klock and Haycock, and is locally known as the Haycock mine or location. A considerable amount of development work has been done, looking chiefly to testing the quality and extent of the ore bodies, but the inaccessibility of the locality would be a sufficient hindrance to any further operations, unless the deposit should prove of an exceptionally rich character. [Silver runs from 2 to 8.75 oz. per ton.]<sup>23</sup>

(12) *Bourke Deposits, Timiskaming District, Ont.—(Lead)*

(a) Location: Deposits of galena and zinc blende have been reported from the shores of Wolf and Twin lakes, in the vicinity of Bourke station on the Temiskaming and Northern Ontario railway.

(b) Description:

Narrow calcite veins, carrying small amounts of galena and zinc blende, have been found in the greenstone on the west shore of Wewegimok lake. To the south of Wolf lake there are several quartz-calcite veins carrying similar minerals. On claim H. R. 580, belonging to Mr. Dan Smith, of Sesekinika, one of these veins has been stripped or trenched for 200 feet. The vein, which is 14 inches wide at one place on the surface, carries a high proportion of galena and zinc blende. A shaft has been sunk 50 feet and several tons of lead-zinc ore have been piled up. The quartz has been deposited along the walls of the fissure, while the calcite, with most of the sulphides, has filled the centre.<sup>24</sup>

Samples of the ore were found to contain no silver.

(13) *Pie Island Deposits, Thunder Bay, Lake Superior, Ont.—(Zinc-lead)*

(a) Location: The veins occur on the western shore of this island, which lies across the mouth of Thunder bay.

(b) Geology:

The island consists of the usual argillaceous series of sedimentary beds traversed in a northeasterly and southwesterly direction by dikes of trap, the same rock capping the argillites in the table-topped hills. The developments were made on one of the northwest series of veins which occurs on the western shore of the island. The underground developments have been made in the vein where it cuts a trap dike, which intersects the argillites of the vicinity, or immediately adjacent to it.<sup>25</sup>

(c) Nature and Occurrence of the Ore Minerals:

The width of the vein is from three to four feet and is filled with a breccia of fragments of the country rock cemented together by crystallized quartz, which is mostly colourless but sometimes amethystine, and is accompanied by a little calcite which occurs mostly crystallized in scalenohedra in the vugs. The great feature of this vein, as shown by an inspection of the dumps, consists in the large amount of metallic minerals it carries. These are blende, galena and iron pyrites, mentioned here in the order of their preponderance, and all occurring for the most part well crystallized, especially in the case of the galena.

. . . This latter also occurs sometimes as thin seams in the joints of the argillite.

. . . An assay of such a piece showed it to carry neither gold nor silver.<sup>26</sup>

Some development work has also been done on a large vein on BB mining location, about a mile E.S.E. from the last-mentioned. It strikes in from the shore with a course N. 75° W. (magnetic) and dips to the north. It is about twelve feet thick, and is enclosed in the argillites of the district and intersects two trap dikes which cut through them. A shaft has been sunk on it. . . . In mineral contents it is very similar to the first mentioned, except that the quartz is accompanied by a good proportion of pink spar, probably dolomite. One assay made of some specimens selected as carrying some galena and a little blende, gave neither gold nor silver.<sup>26</sup>

<sup>23</sup> Geol. Sur. Can., Ann. Rep., Vol. X, N.S., 1897, pp. 141-142 i.

<sup>24</sup> Ont. Bur. Mines, Vol. XXIII, Pt. II, p. 34.

<sup>25</sup> Report on Mines and Mining on Lake Superior: E. D. Ingall; Geol. Sur. Can.; 1888, pp. 53-54 H.

(14) *Deposits of the Sudbury Basin, Ont.*

From many localities within the interior sedimentary basin of the Sudbury area, Ontario, occurrences of galena and sphalerite have from time to time been reported. Pits and small shafts have been sunk on several of these, but the developments were not such as to encourage thorough explorations. The origin of these deposits is believed to be related to the norite intrusive.

The chief localities are the following:

Bowell township, location W.D. 252, east of the south end of Trout lake.

Within the Onaping tuff at points north of Fairbank lake, Fairbank township.

Creighton township, lot 10, concession VI, at Stobie falls, on Vermilion river.

Rayside township, lot 2, concession III, in the Trout Lake conglomerate.

Balfour township, lot 9, concession V.

Balfour township, lots 6 and 7, concession I.

Dr. A. P. Coleman makes the following notes on these deposits:

At several points the tuff has been found to contain small deposits of sulphides, especially zinc blende and galena, but never on such a scale as to be of economic importance. Such deposits are known at points to the north of Fairbank lake and along the same side of the basin towards the east, but the largest visited by us was a little east of the south end of Trout lake in Bowell township, where a location (W. D. 252, sometimes called Prue's mine) has been taken up, and a small shaft sunk showing quartz, with zinc blende, galena and a little copper pyrites. A dark grey, basic eruptive rock occurs beside the shaft and its eruption probably influenced the formation of the small ore body.<sup>28</sup>

At Stobie falls, on Vermilion river, in lot 10, concession VI of Creighton township, a considerable deposit of zinc blende with pyrite occurs in the Onwatin slate, and has been opened up on a small scale near the river bank.<sup>28a</sup>

Mr. R. R. Rose informs me that test pits have been sunk on a deposit of galena, sphalerite and pyrite with much quartz, on lot 9, concession V of Balfour township.<sup>28b</sup>

In the vicinity of Chelmsford, near Sudbury, are indications of zinc which may prove to be of some importance. These occurrences seem to have some connection with the graphitic slates, associated with which are also found the deposits of anthraxolite. . . . The location of this property is on lot 7, first concession of Balfour, four miles southwest of Chelmsford. . . . About 300 tons of ore had been extracted, said to show by assay 45 per cent. of zinc, 0.76 ounces of gold, and 9 ounces of silver per ton. The workings consisted of a development shaft. . . . 98 feet deep.<sup>27</sup>

The mineralized zone, which is parallel to the bedding of the greywacké and slate, contains some fine-grained galena, pyrite, chalcopryrite and some sphalerite, all in small amounts. The gangue is made up of calcium carbonate, quartz and fragments of the wall-rock.

## 2.—Origin Probably Independent of Igneous After-action

### LOW-TEMPERATURE DEPOSITS

The chief representatives of this group are a well-defined series of fissure veins, filled with a gangue of calcite, barite, fluorite and some quartz, and containing in several places considerable quantities of galena with some sphalerite, pyrite, chalcopryrite and marcasite. Some of the deposits resemble rather closely

<sup>28</sup> A. P. Coleman: The Sudbury Nickel Field: Ont. Bur. Mines, Vol. XIV, 1905, part III, p. 95.

<sup>28a</sup> A. P. Coleman: The Nickel Industry: Mines Branch, Dept. of Mines, Ottawa, 1913, p. 101.

<sup>28b</sup> Idem, pp. 101-102. <sup>27</sup> Ont. Bur. Mines, Vol. VIII, 1899, p. 33.

those of the previous group, especially where the quartz is plentiful, and where the silver values of the galena are above one ounce per ton. On the other hand, with the disappearance of the fluorite, quartz, barite and silver values in the veins, and a predominance of calcite with galena and sphalerite, the veins seem to resemble closely in composition the zinc and lead deposits of the Mississippi valley which are believed to have been formed by meteoric waters. All gradations exist between these two extremes.

The mineral composition of the veins is simple, and the constituents are generally coarse-grained. The veins are fillings in fault fissures, zones of brecciation, and joints. A full discussion of the origin and geological relations of this group will be taken up following the detailed descriptions of the chief deposits (Page 36).

A minor group of deposits, of little commercial value, also belongs to this division. In it occur deposits chiefly of zinc blende, which are both disseminated and in small gash veins in dolomites and limestones. They resemble closely certain phases of the Upper Mississippi Valley ore deposits. The mineral composition consists chiefly of calcite and dolomite, with varying quantities of sphalerite, marcasite and galena.

#### A.—Calcite-Barite-Fluorite-Galena Veins

##### (1) *Frontenac Lead Mine, Ont.*

(a) Location: This property, which comprises some 330 acres, is situated in Loughborough township, Frontenac county, Ontario, about 18 miles north of the city of Kingston. It consists of the south half of lot 16, part of lot 15 in the 9th concession, and the south half of lot 14 in the 10th concession. The arrangement of the lots is such that the property extends for a mile and a half along the course of the vein. The nearest station is Perth Road on the Canadian Northern railway about one mile from the mine.

(b) Railway facilities: The Toronto-Ottawa main line of the Canadian Northern railway crosses the south part of lot 16 within 200 feet of No. 1 shaft.

(c) Ownership: The property is owned by the North American Smelting Company, Limited, of Kingston, Ontario. The company also owns a lead smelter in the city of Kingston.

(d) History of operations: According to reports of the Geological Survey of Canada, a shaft was sunk on this deposit as early as 1866. Development work was continued in a desultory fashion until 1875, when the property was leased to an English company. About 2,000 tons of ore were mined at this period. In 1880 a lead smelter was constructed to treat the ores, but after two years of operation the mine and smelter were abandoned and remained so until 1911, when the property was taken over by the present owners. A new shaft was sunk to a depth of about 160 feet and a concentrator was built. About two years later, operations were discontinued, and at the time of writing the property is still inactive.

(e) Geology: The deposit occurs within the area of the pre-Cambrian shield and about two miles north of the overlapping edge of the Potsdam sandstone. The rocks occurring in the immediate neighbourhood of the mine are a series of interbedded siliceous and micaceous gneisses and crystalline limestones, striking

about N. 30° E. with a dip of 65° to 85° to the northwest. Pegmatite dikes intersect this series, probably originating from intrusive granite masses that occur a short distance to the north.

(f) Nature of the deposit: The deposit, which is a typical fissure filling, occurs as a calcite vein cutting almost at right angles across the rock formations. The course of the vein varies from N. 70° W. at the southeastern end of the property to about N. 30° W. at the northwestern end, with a rather uniform dip of about 75° to 80° to the northeast.

In all probability the vein is a filling of a fault fissure. Sufficient detailed work has not been done to determine accurately the displacement. Along the northeastern wall of the vein there occurs a well-marked clay gouge, which in places is about six feet thick. Horseshoes of country rock are frequently seen surrounded by vein material. The somewhat smooth and in places slickensided walls, and the width of the vein, which averages about ten feet, combined with the previously mentioned features indicate rather strongly a considerable differential displacement of the walls. The structure and composition of the vein resemble closely those of another vein of the same general type, which is known to occupy a fault fissure. (See Galetta Lead Mine, page 21 below.) The vein cuts all the other rocks and is consequently the youngest formation in the district.

(g) Character and occurrence of the ore and gangue: The vein varies in thickness from about nine inches to twenty-two feet, with an average of about ten feet, as judged from its present development. The gangue is almost entirely calcite, with well-developed crustified structure. Along the north wall, as mentioned in the preceding paragraph, there is a persistent selvage of apparently argillaceous matter, and several horseshoes of country rock. It is probable that the selvage consists of a very finely disintegrated portion of the country rock, rendered so at the time of the faulting. A similar situation seems to be developed at the Rossie lead mines in St. Lawrence county, New York, and it has been shown<sup>22</sup> that the selvage is merely finely ground country rock.

The metallic constituents of the vein are chiefly galena with smaller amounts of sphalerite and minor quantities of pyrite. It is interesting to note that the galena occurs in disseminated grains, and rather large crystals and clusters, arranged usually in certain horizons parallel to the crustification and close to the northeast wall. It is most abundant in the southeastern part of the vein where the latter intersects beds of crystalline limestone. Sphalerite is found chiefly in the northwestern part of the vein and occurs as fine-grained tabular masses, parallel to the crustification, and separated from each other by bands of calcite. The sphalerite is of the yellowish-brown variety not unlike that of the Upper Mississippi Valley deposits. Galena, also, is found in this part of the mine, but in its characteristic form of crystalline aggregates.

The galena is believed to occur in chutes, pitching northwesterly down the plane of the vein. In these chutes, the ore is in the form of disseminations of rather large crystals, and not massive, in accordance with the general significance of the word "chute." As the underground workings were full of water at the

<sup>22</sup> The Rossie Lead Veins: C. H. Smyth, Jr.: School of Mines Quarterly, Vol. XXIV, 1902-3, pp. 423 et seq.

time of the writer's examination, this occurrence could not be verified. However, certain parts of the vein are almost entirely barren of metallic minerals, while other portions show ten to fifteen per cent. of galena and sphalerite.

The older Geological Survey Reports on this property state that the ore assayed about five ounces of silver to the ton of galena. Recent silver determinations, however, have established beyond doubt the fact that the ore very seldom contains more than one and a quarter ounces of silver to the ton of galena. These averages accord more nearly with those of other ores of the same general type.

(h) Development: The extent and development of the vein are shown in the following sketch (Fig. 2). From the southeast to the northwest outcrops of the vein, the distance is about 5,000 feet.

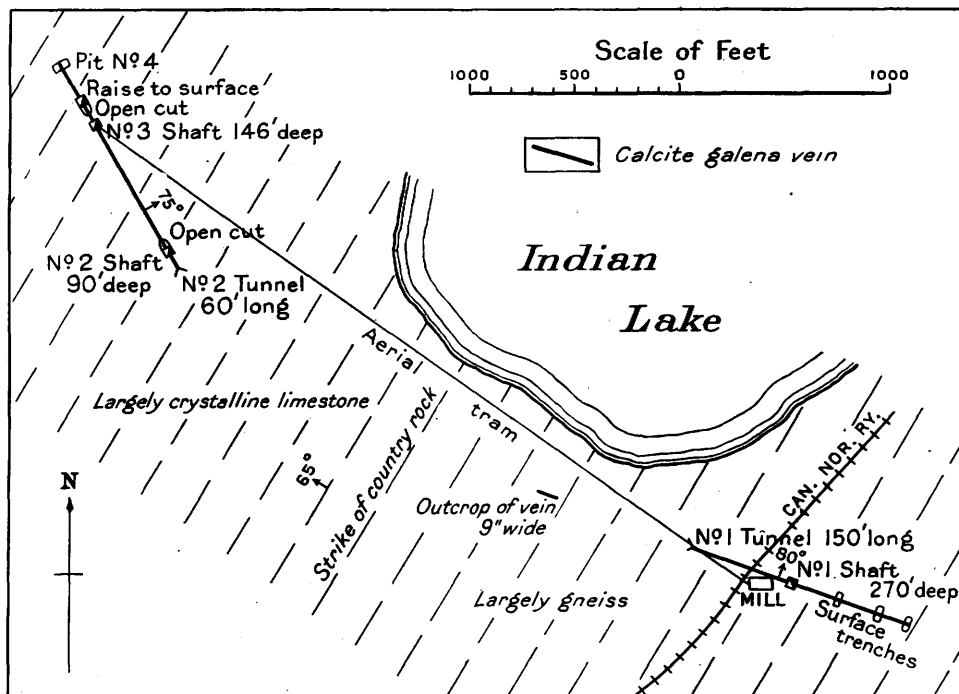


Fig. 2—Frontenac Lead Mine, Perth Road, Ont.

From the mouth of the tunnel at the eastern side of the swamp, the vein can be readily traced in a southeasterly direction by the tunnel itself, by shaft No. 1 with its drifts, and by surface trenches, for a distance of about 1,100 feet, as indicated on the sketch. A swamp covers the outcrop of the vein between tunnels No. 1 and No. 2, and the vein has not been located, except by a small outcrop of vein matter nine inches wide in a ridge of gneiss about a quarter of a mile northwest of No. 1 shaft. From No. 2 tunnel to No. 4 pit the vein can be followed at intervals by open cuts, shafts, drifts and trenches. Between No. 2 and No. 3 shafts a swamp intervenes, in which the vein has not been found.

Ore can be seen in place at the top of the shafts, in the open cuts, tunnels and trenches. The shafts vary in depth from 90 to 270 feet, and considerable drifting and stopping have been done at Nos. 1 and 3.

(i) Equipment: This consists of a recently-constructed concentrator, two power houses, compressors, and one well-constructed and equipped shaft at No. 3. Electric power may be brought to the property by the building of a short power line. There is an aerial tramway 3,900 feet long from No. 3 shaft to the mill, with a capacity of 20 tons per hour.

(j) Other Veins in the Neighbourhood:

On the eighteenth lot in the eighth concession a second vein runs parallel to the first, at a distance of about one hundred yards to the north of it. This second vein appears to be from three to six feet in width, and shows galena wherever it has been opened. It carries also a little barytes, which has not been found in the main vein. Smaller parallel lead-bearing veins have been discovered on the adjoining lots to the north.<sup>29</sup>

(2) *Chats Island Deposits, Ont.*

(A) Galetta or Kingdom Lead Mine:—

(a) Location: The chief deposit in this locality is the Galetta lead mine, owned by the James Robertson Company, Limited, of Montreal. It is located on Chats island in the Ottawa river, about five miles directly east of the town of Arnprior. The island is separated from the mainland by a narrow channel of the Ottawa river.

(b) Geology: The rocks in the vicinity of the mine consist of an interbedded series of crystalline limestones and biotite gneisses of pre-Cambrian age striking in a general northeast and southwest direction and dipping from 60° to 80° to the northwest. This series is intruded by igneous rocks of acidic and basic character. The lithological nature of the rocks was not accurately determined by the writer at the time of his visit. Unconformably overlying this complex, are the flat-lying limestones of early Paleozoic age.

The general area in this part of the Ottawa River basin is rather severely faulted<sup>30</sup> as shown on Map No. 25c. One of the faults occurs on this property, and Paleozoic limestones may be seen in normal fault contact with the pre-Cambrian complex.

(c) Character of the vein: The vein is a fissure-filling of the same type as the Frontenac lead mine vein. Its strike varies from N. 45° W. to due north (magnetic), and consequently it cuts nearly at right angles across the strike of the pre-Cambrian series. It usually has a steep dip towards the southwest.

The vein occupies a well-marked fault fissure. Near the northwest end, a small open cut shows on the northeast wall of the vein the steeply-dipping northeasterly striking gneisses of the pre-Cambrian and on the other the flat-lying Paleozoics, indicating a downthrow to the southwest. Horizons of country rock occur throughout the vein, suggesting a fault breccia, while drag-folding is very evident at some places along the fracture.

For a distance of about 800 to 1,000 feet between the workings at the east and west ends, the vein had not been uncovered. There is a marked difference in the course of the vein at the two ends, but the fact of considerable differential movement having taken place prior to the filling of the fracture argues for the con-

<sup>29</sup> Geol. Sur. Can., Report of Progress, 1866-1869, page 165.

<sup>30</sup> E. M. Kindle and L. D. Burling: Geol. Sur. Can., Museum Bulletin No. 18, 1915.

tinuity of the fracture throughout a considerable distance, and suggests that the two portions of the vein will be found to unite. Particular notice should be taken of the fact that this vein is a filling of a very well-marked fault fissure. The amount of displacement was not estimated by the writer. In many places the vein seemed to be a filling of a fracture zone rather than of one well-marked fault fissure.

(d) Nature of the ore and gangue: The gangue is very largely calcite showing the banded character of a crustified vein, similar in all respects to that of the Frontenac lead mine. In some places in the vein, barite seems to be rather abundant.

The chief ore mineral is galena, which occurs in grains, clusters of crystals, and thin sheets, usually parallel to the banding of the gangue. The silver content of the galena is rarely over one ounce per ton. Sphalerite and pyrite occur in minor quantities.

On account of the fact that it was through a special courtesy on the part of the President of the company that the writer was permitted to examine the mine, it is deemed inadvisable to describe fully the dimensions of the developed vein, and the grade of ore. At the stage of development existing at the mine in February, 1915, the property was without doubt the most promising lead prospect in Ontario.

(e) Operation: Development work, both underground and surface, has been carried on by the company for over a year, and at the time of writing a new concentrating mill had just been set in operation.

#### (B) Campbell's Prospect:—

(a) Location: The property is situated near the northwestern end of Chats island, and is apparently a continuation of the Galetta vein just described. The greater part of the deposit occurs in a shallow bay of the Ottawa river, between the high and low water marks. When the water is low, usually in August, a small island appears in the centre of the bay, and on this there is a shallow shaft and some pits located on the vein. During the larger part of the year, however, the river covers the outcrop to a depth of four to five feet. Pickets standing in the pits show the location and course of the vein at high water.

The property is owned by Mr. Jos. Campbell, of Arnprior.

(b) Geology: Both the lower Paleozoic sediments and the interbedded pre-Cambrian series of gneisses and crystalline limestones are found at this locality. There is considerable evidence of brecciation at the contact of the two series, suggesting fault relations.

(c) Character of the vein: The vein is of the crustification type and is composed of calcite with some barite. In width it varies from a few inches to three feet, and in this respect it is very similar to the pinch-and-swell character of most of the veins of this group. The vein has not been traced continuously at any one point for more than seventy-five feet, although the total length between the end pickets is about 500 feet.

(d) Nature of the ore: The ore mineral is galena, which is said to occur abundantly at certain places along the vein. It occurs in the disseminated form, but clusters of distorted cubes, commonly known as "cog lead", of considerable size have been taken out. Very little sphalerite and pyrite were seen in the vein material. The silver content of the ore is not known, but it is unlikely that it is more than about one ounce to the ton of galena.

(e) Operation: Very little work has been done on the property, on account of the fact that the vein is rather inaccessible throughout a large part of the year. No operations of any kind are being carried on at present.

(3) *Hollandia Lead Mine, Ont.*

(a) Location: This property is located on lot A, concession VI, Madoc township, in the county of Hastings, Ontario. It is about two miles northeast of Bannockburn on the Central Ontario railway, which is the nearest railway station.

(b) Geology: The deposit occurs within the area of the pre-Cambrian shield of southeastern Ontario. The rocks consist of crystalline limestone, micaceous quartzite, and quartzose schists, in a highly-inclined interbedded series striking about N. 45° E.

(c) Character of the deposit: The ore occurs in a calcite vein which cuts almost at right angles across the rock formations and strikes about N. 54° W. Although outcrops have been found over a linear extent of about a mile, the vein does not appear to be continuous. It is rather a series of pinches and swells, and at certain points successive northwesterly outcrops seem to be slightly offset towards the southwest. In all probability the vein occupies a zone of dislocation very similar to that observed at the Galetta lead mine, for example. The walls of the vein are smooth and slickensided, and horses of country rock are not uncommon within the vein. The amount and direction of displacement were not determined at the time of examination, the workings being old and filled with water and surface debris. In certain places the vein attains a width of ten feet and usually exhibits well-marked crustification.

(d) Nature and occurrence of the ore: The ore consists chiefly of galena, with minor amounts of sphalerite. Silver values are very low, as would be expected. Pyrite occurs in the vein, but it is not abundant. The gangue minerals are calcite and barite, the latter being in small amount.

The galena occurs both as disseminated crystalline groups throughout the gangue, and as thin tabular masses parallel to the banding of the vein. Frequently it appears to be segregated towards the middle of the vein, which is usually very heavily mineralized. Sphalerite may be seen here and there in disseminated grains in a plaster of the gangue minerals still clinging to the walls.

The grade of the material as it was broken during previous operations must have exceeded ten per cent. in galena. A considerable dump of vein material now lies beside the mill shaft, and a conservative estimate would place its galena content at eight per cent. Very little of either barren rock or gangue occurs in the

dumps, and some small shipments of dressed galena have already been sent to the smelters. It was stated to the writer that the dump at the mill shaft represents what was left of the "mine run" after the coarse galena was cobbled and shipped.

(e) *Development*: The mine is an old one and has been worked intermittently for several years. At the time of writing it had been closed down for about eight years, and the workings were full of water. These consisted of three shafts, having respective depths of 150, 100 and 70 feet, with about 600 feet of drifting. A small power and concentrating plant had been built at the time of the last operations.

At the southeastern end of the property the vein has been opened up almost continuously by shafts, drifts and surface stripping for a length of 250 feet. Towards the northwest, trenches dug at intervals of several hundred yards along the same general strike, showed in places small amounts of vein material and some galena. It is not known whether these are extensions of the main vein or parts of parallel ones.

The property seemed to be well worthy of systematic exploration and development.

(4) *Katherine Lead and Zinc Mine, Ont.*

(a) *Location*: The Katherine mine is situated on lot 6, concession XI, Lake township, Hastings county, Ontario. It is about three miles west of Millbridge on the Central Ontario railway.

(b) *Geology and occurrence of the ore*: Owing to the fact that exposures in the vicinity of the mine are poor, and that the workings were full of water at the time of the writer's examination, the geology and character of the vein could not be studied. The following quotation is from a report on the district by Drs. Adams and Barlow.

The vein and associated rocks are very similar to the occurrence worked at the Hollandia mine, with the exception that a considerable proportion of zinc blende accompanies the galena. A shaft was sunk 125 feet deep, and at a depth of 100 feet a level was driven north 100 feet and some stoping done. Half a mile south of this shaft another was sunk to a depth of 18 feet. Some prospecting was done by means of a drill, and a hole 292 feet deep was made.<sup>21</sup>

The following note by the Ontario Mining Inspector, C. De Kalb, is interesting:

The vein carries argentiferous galena and zinc blende in calcite, the average of the ore showing ten ounces of silver. It lies wholly between walls of diorite, with a width varying from one to four feet, and a known longitudinal extension of half a mile. . . . Half a mile south of the main shaft is the south shaft. . . . The vein here is less highly mineralized, having, however, a width of nine feet, with six ore-bearing streaks, containing galena, but no zinc.<sup>22</sup>

The reported content of silver is noteworthy, especially if reliable, since it is so much higher than that of similar ores in the series of calcite veins now under discussion.

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<sup>21</sup> Adams and Barlow: "Geology of the Haliburton and Bancroft Areas, Ontario": Geol. Sur. Can., Memoir 6, 1910, p. 349.

<sup>22</sup> Ont. Bur. Mines, Vol. X, 1901, p. 130.

(5) *Bedford Lead Prospects, Ont.*

Several calcite-barite veins containing galena occur in the township of Bedford, county of Frontenac, Ontario. These all have a more or less northwest-southeast strike, and occur at intervals close to the road from Fermoy to Sangster. Only the best-developed vein was examined in any detail by the writer, and the following description of several of the occurrences is from reports of the Geological Survey of Canada:

Several veins containing galena are met with cutting the Laurentian limestone in the township of Bedford. One of them, on the twenty-first lot of the eighth range, has a direction about east and west, with an underlie to the north  $< 80^\circ$ . It is four feet wide, and consists chiefly of calcspar, through which galena is disseminated in crystals or in seams, sometimes an inch or two in thickness. A shaft was formerly sunk here to a depth of twenty-five feet. Two other veins similar in character are met with near the line between the eighteenth and nineteenth lots of the same range, the one running N.  $20^\circ$  W., and the other N.  $37^\circ$  W. A little to the west of these, and on the nineteenth lot of the seventh range, on the property of Mr. Weston Hunt of Quebec, are five nearly parallel lodes, running northwest, and included in a breadth of a quarter of a mile. They traverse crystalline limestone, and include galena in a mixture of calcspar and heavy spar. A specimen from one of them shows a breadth, across the vein, of five inches of solid galena. About a mile to the eastward of these lodes, there are others on land belonging to the proprietor of the last. Shallow trial shafts were, many years ago, sunk upon these, but the amount of lead ore obtained from them is not known. On lot thirteen of the fifth range of Bedford, Messrs. Foley & Co., of Montreal, have sunk a trial shaft to a depth of sixteen feet, on a lode of six inches, the gangue of which is heavy spar. The lode traverses the crystalline limestone, and enters the gneiss, in both of which rocks it holds good masses of galena.\*

The following description of the most important vein of the group is from the writer's notes, and is based on recent examinations.

(a) Location: This deposit is located on lots 16, 17 and 18 of the sixth concession of Bedford. The nearest railway facilities are at Westport, on the Brockville and Westport railway, a distance of about ten miles from the property.

(b) Geology: An interbedded series of white crystalline limestones, gneisses and schists, with intrusive granites, striking about N.  $60^\circ$  E., magnetic, and dipping about vertically, constitutes the chief country rocks of the district. The series is of pre-Cambrian age.

(c) Nature of the vein: Structurally the vein resembles that at the Hollandia, Frontenac and Galetta mines. It strikes N.  $75^\circ$  W., magnetic, cutting sharply across all the formations, and constitutes the youngest rock of the immediate area. It varies in width from a few inches to four feet, and is of the pinch-and-swell type. The walls of the vein are smooth and clean-cut, and horses of country rock are occasionally seen apparently surrounded by vein matter. In very many places the vein anastomoses, forming a series of small veins separated from each other by barren rock. The deposit appears to be a filling of a brecciated zone which was produced, probably, by faulting.

(d) Character and occurrence of the ore and gangue: The chief gangue minerals in the vein are barite and calcite. The vein material is distinctly banded, but ordinarily the calcite and barite occur together within the individual bands.

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\* Geology of Canada, 1863, pp. 687-688.

In certain parts of the vein, calcite is the predominant mineral, while in other portions barite is the more abundant.

The metallic mineral is almost entirely galena. No zinc blende nor pyrite was seen. The galena occurs disseminated through the gangue, but all parts of the vein are by no means equally rich. In places it seems to be entirely barren of the ore mineral. In other portions it is exceptionally rich. In the bottom of one pit the galena was stated to be so abundant that an examining engineer reported that it was equivalent in amount to a solid sheet 24 inches thick. In other pits, full of water at the time of the writer's examination, it was stated that there was sufficient galena to make solid sheets eight and ten inches thick. The galena occurs in crystal masses from the size of buckshot to bodies so large that they could not be lifted out of the pits without being broken. Wherever the galena occurs abundantly, the barite seems to be quite massive rather than banded.

(e) Development: The vein is opened up by nine pits along the same strike, extending over a distance of about 1,600 feet. They all show certain amounts of galena. Other pits are located about 800 feet further northwest, but these show only small stringers of barite with no galena.

The main pit, which is 26 feet deep, was full of water at the time of examination. The vein at the bottom of this pit was reported to be six feet wide, and to consist of rich galena ore in a gangue of calcite. At the top of this pit the vein branches into three or four narrow veins, all containing some galena. At no place on the surface was the vein observed to be more than twenty inches wide. For the amount of work already performed on the deposit, the results are encouraging, and further systematic exploration would in all probability prove an ore body of considerable extent and grade.

(6) *Union Creek Lead Mine, Ont.*

The following description is given in a report of the Geological Survey of Canada:

A deposit of lead ore has been opened on lot 20 range A, of Galway township, Peterborough county, Ontario. A shaft with lateral drifts has been sunk to a depth of about 100 feet, but this at the time of my visit was filled with water. Near it, however, a short tunnel is driven in the vein from a hill side. In this the vein is seen to vary somewhat in width, but to be fourteen inches wide at its widest part. The veinstone is barite with some calcite, carrying in the tunnel a few grains of iron pyrite, zinc blende and galena. A considerable amount of galena has been taken from the shaft where the vein is said to be somewhat wider and contains the galena in pockets. I am informed that about thirty kegs of galena have been shipped. A number of specimens of the galena and barite as well as a few of calcite and zinc blende now lie about the mouth of the shaft. . . . The galena was found to contain neither gold nor silver. The vein cuts gneiss which is interstratified with crystalline limestone.<sup>34</sup>

The deposit was worked in 1911, and some ore was concentrated in the mill.

(7) *Crown King Lead Prospect, Ont.*

(a) Location: This property is located on lot 1, concession VII of Somerville township, Victoria county, Ontario.

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<sup>34</sup> Geol. Sur. Can., Ann. Rep., N.S. Vol. VI, pp. 14-15 J.

(b) Geology: The rocks are similar to those described for the Union Creek area above. They consist of interstratified crystalline limestone and highly micaeous gneiss in vertical position, and striking northeast and southwest.

(c) Character of the veins: On the surface there seem to be three parallel veins, cutting across the rock formations and striking N. 50° W., magnetic. They vary in width up to four inches, and consist chiefly of barite banded parallel to the walls. They are probably the continuation of the mineralized zone of the neighbouring Union Creek property.

(d) Nature of the ore: The ore mineral is almost entirely galena, with which one of the veins is richly mineralized. The galena is more in the massive and less in the disseminated form than at the other properties previously described.

(e) Development: The veins are stripped at intervals for a distance of about 200 feet. There are three small pits within this distance, the main one being 17½ feet deep, but it was full of water at the time of examination.

#### (8) Ramsay Lead Mine, Ont.

On the third lot of the sixth range of Ramsay [township, county of Lanark, Ontario], a mine has been opened upon a vein holding galena, and cutting a grey dolomite which belongs to the Calciferous formation. The beds of this are nearly horizontal; and they repose conformably upon the sandstone of the Potsdam formation, the outcrop of which is seen at a distance of about a mile from the mine, where it reposes upon the upturned limestone and gneiss of the Laurentian series. The lode has a bearing of from N. 50° W. to N. 55° W., with an underlie to the northeast of about a foot in a fathom; and it has a breadth of from two and a half to five feet, the ore-bearing part varying from eight to twenty-four inches. The galena occurs in a gangue of calcspar, with small portions of iron pyrites, copper pyrites and blende. A shaft of thirty-seven feet was sunk upon this vein, and about seventy-five fathoms in the plane of it having been extracted, twenty-six tons of ore, yielding eighty per cent. of lead, were obtained. Some portions of the lode were nearly destitute of ore, while in other parts its amount was estimated at nearly two tons to the fathom.

This trial was made in 1858, when a smelting furnace was built, and a ten horse-power engine was erected for the purposes of a blast, and to remove the water from the mine. The influx of water was however, so considerable, that this was found insufficient, and the mine was for a time abandoned. More recently, however, a new engine of fifty horse power has been erected. About 105 fathoms southeastward from the main shaft, a counter-lode joins the main one, at an angle of about 20°; its course being nearly N. N. E. and S. S. W. At the junction of the two lodes, a shaft has been sunk in sandstone to a depth of twenty-one feet; and in the excavation, in which the united lodes attain a breadth of ten feet, there were obtained about ten tons of twenty-per-cent. ore. Other lodes holding lead ores, and nearly parallel with the ones described, have since been noticed in the vicinity.<sup>25</sup>

The lode is reported to outcrop to the southeast, on the shores of the Mississippi river at Carleton Place, one mile distant. An outcrop has also been reported several hundred feet to the northwest.

It is interesting to note that the veins in this area traverse the Ordovician limestone, and are known to be at least post-early-Ordovician in age. The resemblance of the other veins of this group, which are found entirely within the pre-Cambrian, to the Ramsay veins adds considerable interest to the question of their time relations.

<sup>25</sup> Geology of Canada, 1863, pages 688-689.

(9) *Lansdowne Lead Veins, Ont.*

Veins similar to those just described are found in Lansdowne township, county of Leeds, Ontario.

One of these, on the second lot of the eighth range, has been traced for a quarter of a mile, running nearly N.W. and S.E., and has an average breadth of two feet. Through the gangue, which is of calcspar and heavy spar, galena is irregularly distributed in crystals and small masses; and it is also found disseminated in the crystalline limestone which forms the walls of the veins. Trial shafts were at one time sunk here; but the mine was abandoned. Another lode running N. 65° W., was subsequently found on the third lot of the same range. It traverses crystalline limestone, and has a breadth of from six to twelve inches. Through the gangue, which is calcspar, galena is found in masses sometimes five or six inches in diameter. A trial shaft of fifty feet, which was sunk upon this lode in 1854, on the land of Mr. Buel, is said to have yielded sufficient ore to pay the expenses of sinking. A branch lode diverges from the main one near the shaft; and in the same neighbourhood there occur four other lead-bearing lodes parallel with the main, the whole being included in a breadth of about 1,000 feet. These run obliquely across the lots, and thus intersect the lands of several proprietors. On the fourth lot of the eighth range, Messrs. Foley & Co. have sunk a small shaft upon one of the lodes.<sup>38</sup>

(10) *Tudor Group of Lead Veins, Ont.*

This group of veins, although of minor importance commercially, is very interesting both on account of structural and lithological character and location with respect to previously discussed deposits. (See Map. No. 25c.) Since the deposits were not examined by the writer, the following descriptions from the literature are given in full. The veins occur in Tudor township, county of Hastings, Ontario.

Most of the localities known as affording galena have been noticed in Mr. Macfarlane's report for 1866, but during my explorations in Tudor, having visited all the lead-bearing lodes, openings were found to have been made in some, of which the localities only had been previously indicated, and one or two were in a better condition for inspection than at the time of Mr. Macfarlane's visit.

One of these on the twenty-eighth lot of range B, in Tudor, is a vertical vein running N. 70° W., the strata of calc-schist dipping 270° < 76°. At the time of Mr. Macfarlane's visit, a shaft which had been sunk on it to a depth of thirty-seven feet, was half full of water, preventing him from doing more than to state the information he had received from others. In 1867, I found that the lode, of which the veinstone is barytes and calcspar had yielded on the average three-quarters of an inch of galena; but the bottom of the shaft showed no more than half an inch of barytes, without galena. I was informed by Mr. W. Kesterman, of Belleville, then superintending the mine, that there had been extracted from the vein about six tons of galena, four and a quarter tons of which were sent to New York for sale, after being simply crushed and found to yield 66 per cent. of lead.

On thirty-first and thirty-second lots of the range east of the Hastings road, in Tudor, a lead-bearing vein runs in a vertical attitude N. 75° W., cutting the grey calc-schists with strike N.N.E.

In 1867 it had been traced in the direction given, across both the lots mentioned, with very good surface indications, and was known as the Murphy mine. The Hastings Lead Mining Company subsequently sunk a shaft on it, which, I understand, had been carried down to a depth of 125 feet, but the result being unsatisfactory, the work was abandoned.

On lots 28 and 29, concession XIV of Tudor, there is a vein of red and white heavy spar holding galena, and cutting the grey calc-schists. Its bearing is N. 5° E., and it stands in a vertical attitude, while the enclosing rock, also vertical, strikes almost due north and south. It was discovered some eight years ago, and was first opened in 1859. In 1867 the mine was leased by Messrs. Lombard & Co., of Boston, who were working it at the time of my exploration in Tudor, and I had an opportunity of examining the shaft when free from water. The walls were regular and well defined, the width between them being in some parts from eighteen inches to two feet, and the ore appeared in scattered and irregular bunches in the gangue. When first opened, this vein yielded some large masses of ore, but,

<sup>38</sup> *Geology of Canada, 1863, p. 688.*

as in a previously mentioned instance, they greatly diminished, descending, and at the bottom of the shaft, which was twenty-five feet deep, there was scarcely any ore. In 1868, at the depth of forty-two feet, the mine was abandoned. It may be remarked that many of these veins in Tudor, yielding considerable bunches of ore near the surface, show little more than traces of galena at the depth of a few feet. Of twenty-five localities in Tudor, in which galena was discovered and partially worked, only one, the Murphy mine, continued to be worked in 1868.<sup>37</sup>

(11) *Lake Group of Lead Veins, Ont.*

This group is of the same general type as the Tudor group, and is of the same degree of importance. They are located in Lake township, county of Hastings Ontario.

Description:

The west half of lot 10, concession XI of Lake, is another of the localities mentioned by Mr. Macfarlane. On this lot, which was some time since bought by Messrs. Gillum and Kesterman, of Belleville, occurs the Donahue vein, striking N. 50° W., and standing in a vertical attitude. Little, however, has here been done, and although the lode has a width in some parts of from twenty to twenty-four inches, bounded by regular walls of grey calc-schist, the galena occurs only in scattered and irregular patches, and in considerable quantity.

On lot 8, concession XI of Lake (or possibly in concession X) a vertical vein, holding galena in a gangue of heavy spar, runs through a calc-schist in the direction of N. 45-50° W. The lode varies in thickness from ten to eighteen inches, and is bounded by well-defined walls. Little had been done on this lot up to 1867, but in the short distance then uncovered, I saw extracted some masses of ore, at a depth of three feet from the surface, which weighed from fifteen to forty pounds, and I was informed that when first discovered much larger masses had been taken from the vein. The lode is supposed to be on the property of Mr. Wm. Sweeny, of Tudor, but in consequence of the defective manner in which the township has been surveyed there at present exists a dispute as to the ownership of the lot.<sup>38</sup>

(12) *Methuen Lead Vein, Ont.*

(a) Location: Township of Methuen, Peterborough county, Ontario.

(b) Description:

There occurs a northwest and southeast lode near the southeast corner of Methuen, where, in 1868, a shaft was being sunk by Messrs. Parker and Baker. On this lode two or more shafts have been opened on the eastern edge of the second lot of the first range, close to the boundary line of Lake. The lode cuts grey vertical calc-schist, striking N. 20° E., and is composed of calcspar and heavy spar, the former being of a rose or flesh-red colour, in which there is a good show of galena. The average width of the lode is about eighteen inches, and it has been traced in a southeasterly direction for nearly three miles into Marmora.<sup>39</sup>

(13) *Storrington Lead Vein, Ont.*

In the township of Storrington [county of Frontenac, Ontario], near the shore of Dog lake, about two miles from the village of Battersea, another well-defined lead vein has been uncovered, and would appear to be in the strike of one of the lodes belonging to the Frontenac Company.<sup>40</sup>

<sup>37</sup> Geol. Sur. Can., Report of Progress, 1866-1869, pages 162-163.

<sup>38</sup> Geol. Sur. Can., Report of Progress, 1866-1869, p. 163. Note: These descriptions by Mr. Vennor are quoted in Museum Bulletin No. 6, Geol. Sur. Can., 1910, pp. 346-349.

<sup>39</sup> Geol. Sur. Can., Report of Progress, 1866-1869, pp. 163-164.

<sup>40</sup> Geol. Sur. Can., Report of Progress, 1870-71, p. 314.

- (14) Other localities in which similar calcite-barite-galena veins are found in Ontario<sup>41</sup> are:

Lake township, concession XI,	lot 11.
Limerick “ “	II, “ 27-29.
Tudor “ “	III, “ 32.
“ “	V, “ 12.
“ “	VI, “ 11.
“ “	VII, “ 10.
“ “	XIX, “ 26, 27, 28.
“ “	A, “ 21-28.
“ “	B, “ 5, 6.
“ “	B, “ 27, 28.

- (15) *Hull Lead Veins, Que.*

(a) General location: township of Hull, county of Ottawa, Quebec.

A beautiful vein of this mineral occurs on the west half of the seventh lot in the tenth concession of the township of Hull, four miles from the Gatineau river. It varies in width from two to three and a half feet, and was traced for upwards of 100 yards in a N.N.E. direction. The adjacent rock is a highly crystalline white limestone striking N. 22° 30' E., and dipping to the southeastward at a steep angle. The barytes is of an opaque white colour, and is associated with sea-green fluorspar, which occurs chiefly towards the edges of the vein.<sup>42</sup>

(b) Opaque white barytes was observed in the south half of the seventh lot of the tenth range of Hull, on the property of Mr. Morris Foley. It occurs in a vein from four to six inches wide running N. 48° W. . . . About eighty paces north of this position there are blocks of barytes, some of which appeared to be about a foot wide, associated with sea-green fluorspar, and very probably derived from some other vein near the spot. No galena was observed to be associated with the barytes in this lot.<sup>43</sup>

In these two deposits, special attention is called to the presence of fluorspar in association with galena, calcite and barite in veins otherwise almost identical in structure and composition with those previously discussed in this group. The significance of the fluorspar in these and other deposits is taken up at the end of this section, following the descriptions of the various prospects (page 39).

- (16) *Buckingham Lead Veins, Que.*

(a) General location: Buckingham township, Labelle county, Quebec.

(b) Description:

In some of the exposures of the limestone (crystalline) in Buckingham, it is intersected by veins of opaque white sulphate or barytes holding galena. One of these veins occurs on the 21st lot of the 4th range of the township, belonging to Mr. James B. Gorman. According to the report of Mr. J. Lowe, in the vein of barite, which is from six to fourteen inches wide, there are two strings or bands of galena. Of these, where exposed, one is an inch, and the other an inch and a half thick. . . . The course of the vein appears to be about N. 50° W., and its underlie N. 40° E., < 72°. Thirty paces to the westward from the opening on this lode there is another vein of the same character. It also is six inches wide, and consists of barytes, but the quantity of galena is less. The course of the vein, as indicated by an exposure of sixty feet is S. 53° E. On the line between the 20th and 21st lots of the same range, there is another vein of barytes, in which, however, no galena was visible at the spot where it was exposed.<sup>44</sup>

<sup>41</sup> Geol. Sur. Can., Memoir No. 6, 1910, p. 350.

<sup>42</sup> Descriptive Catalogue of a Collection of the Economic Minerals of Canada, and Notes on a Stratigraphical Collection of Rocks: Philadelphia International Exhibition, 1876.

<sup>43</sup> Geol. Sur. Can., Report of Progress, 1866-1869, p. 20.

<sup>44</sup> Geol. Sur. Can., Report of Progress, 1863-1866, p. 19.

(17) *Indian Cove Lead Veins, Que.*

(a) Location: east end of Gaspé peninsula, Quebec.

(b) Description:

The other locality of galena is in Indian Cove. Here is a downthrow to the southeastward, of at least thirty fathoms, by which the higher sandstone is brought opposite to the limestone. Between these walls, there is a lode about twelve feet wide, composed of the ruins of the two rocks cemented together by calcareous spar, and including numerous small veins of the same mineral, with crystals of galena. The principal one of these veins is about two inches wide in the thickest part; it has an underlie N. 74° W. < 55°; but the general course of the whole lode, in which the small veins occur, is about N. 18° E., and the underlie appears to be westward. The dislocation in this place points to a transverse valley or depression in the hills behind, which appears to run across to the opposite side of the promontory, in a course nearly N.E. In a dislocation on the northeast side of the promontory, which is supposed to correspond with the fault, and where a continuation of the lodes might be expected, no ore has yet been observed.

Transverse dislocations are of common occurrence in this vicinity. One of them, in a recess about a quarter of a mile above Indian Cove, is filled with white calcareous spar, which has a thickness of nine feet in one part, and one foot in another. The underlie of the vein is S. 65° E. < 76°, while the dip of the strata at the spot is S. 55° W. < 22°. On the north side of the promontory, seven dislocations, in the space of about a mile and a half, may be seen at one view, from a convenient distance out on the water. The displacements in six of these compensate one another; and the slope or underlie of the faults, in every instance, is in the direction of the downthrow.

Greenstone dikes, intersecting both the limestones and the sandstones, are seen in several places.<sup>45</sup>

It is interesting to note the presence of greenstone dikes cutting the formations in which the galena deposits occur. This situation resembles somewhat that in southern Illinois, where it is possible that a genetic relation exists between the fluorite-sphalerite veins and a series of basic dikes. (See page 40.)

(18) *Little Gaspé Cove Lead Veins, Que.*

(a) Location: east end of Gaspé peninsula, Quebec.

(b) Description:

One of these localities is in the bight of Little Gaspé cove, where the limestone is washed by the waters of the bay. Here are several fissures, holding these two minerals, and having a direction of N. 55° E., with an underlie to the northward. Near to these veins is a dislocation, with a downthrow on the northwest side, by which the limestone is brought against the higher sandstones. It is probable that the mineral veins have some connection with this dislocation.<sup>46</sup>

The lode occurs in a mass of stratified limestone, which dips about S.W. 24°; and rises northward into a hill 700 feet in height, which constitutes Gaspé promontory. It has a breadth of about eighteen inches, and is composed of calcspar holding masses of galena, together with small portions of blende and copper ore. A trial shaft was sunk here to the depth of twenty feet upon the main vein, from which, and from several smaller parallel veins in the vicinity, about twenty tons of sixty-per-cent. ore were recently obtained. Besides the two localities already mentioned, galena has been observed in veins in several other localities in the limestones on the south side of Gaspé promontory; and also on the north side, in a vein which may perhaps be a continuation of that of Little Gaspé cove.<sup>47</sup>

<sup>45</sup> Geology of Canada, 1863, pp. 400-401. <sup>46</sup> Idem, pp. 400-401. <sup>47</sup> Idem, p. 691.

(19) *Baie-St. Paul Lead Veins, Que.*

(a) Location: forty miles below Cap Tourmente, St. Lawrence river, Quebec.

(b) Description:

Here mineral veins occur, holding small quantities of galena. The gangue in which the ore is distributed is composed of calcspar, mingled with apple-green fluorspar. The veins on the south side of the limestone are smaller than those on the north, but they are all probably connected with one great line of disturbance. On the north side, there are two parallel veins in the space of six feet, one of them being three feet wide, including a fragment of gneiss which occupies half the breadth.<sup>48</sup>

(20) *Petite-Nation River Lead Veins, Que.*

(a) Location: north shore of the Ottawa river, a few miles east of Ottawa.

(b) Description:

Among others a vein of six or eight inches is said to exist upon the Petite-Nation river, on the seigniorship of the Hon. L. J. Papineau. Galena has also been brought from the Gatineau and the Black river; in the former case, associated with purple fluorspar.<sup>49</sup>

Note: The most interesting feature in connection with this and the Baie-St. Paul deposits is not the galena content of the veins, but the fact of the association of fluorspar with the calcite, in veins otherwise resembling the calcite-barite veins previously discussed.

(21) *Rossie Lead Veins, New York State.*

(a) Location: These are located in St. Lawrence county, New York state, near the town of Rossie. Descriptions of the deposits are given here; because in their general characters the veins closely resemble those of the Frontenac, Galetta, Hollandia and other properties in Ontario. Furthermore, their location and strike suggest that they may be the southeastward continuation of the Bedford and Lansdowne or Frontenac veins.

(b) Description: The country rocks are interbedded gneisses and crystalline limestones of pre-Cambrian age which strike northeast and southwest. Considerable mining had been done on these veins in the early days, but for the last forty years at least they have not been worked. Fluorspar had also been reported from these deposits, although it is not mentioned in the following description.

The veins cut across the foliation of the gneisses at a high angle, approach parallelism with one another, and have a strike of about N. 80° W. The Coal Hill vein is the largest of the group.

The vein varies from two to six feet in width, is nearly vertical, and sharply defined. As is well known, the gangue is coarsely crystalline calcite, carrying galena, with a little pyrite, and small amounts of sphalerite and chalcopryrite.

The galena, though quite lumpy and irregular, is on the whole more abundant towards the middle of the vein.

Some parts of the vein, particularly along the margins, contain abundant inclusions of the wall rock, forming a breccia cemented by the vein stuff. The fragments vary greatly in size, and are sometimes angular, while in other cases they are rounded and have clearly

<sup>48</sup> Geology of Canada, 1863, pp. 161-162. <sup>49</sup> Idem, p. 690.

suffered much loss by attrition or solution, or both. . . . To the unaided eye there is indication of much alteration, but closer examination, while showing alteration beyond doubt, tends toward the view that it has been very limited in amount. Under the microscope, fragments that, to the unaided eye, appear thoroughly altered, show a large amount of material which, beyond crushing, shows no change. Perfectly fresh, angular or rounded fragments of the various minerals lie in calcite and galena, with no trace of corrosion or alteration; and such fragments are decidedly in the majority.

Whether or no this fracturing was attended by any large vertical displacement is not shown, although the fissures are evidently due to faulting. The nature of the rocks is such that faults of some magnitude might give no measure of the amount of throw.

In view of the character of the minerals, both gangue and ores, their source is, perhaps, more apt to be found in the crystalline limestones which are frequent in the vicinity, and outcrop only a few rods east of the ridge in which the veins occur.<sup>50</sup>

(22) *Redwood Lead Vein, New York State.*

(a) Location: This vein is located in Jefferson county, New York state, near the town of Redwood. It is described here, because of its resemblance to the Ontario and Quebec deposits of this group, and because of its position with respect to the deposits in Lansdowne, Storrington, Bedford and Loughborough townships. In this connection, also, it is interesting to note that the Redwood vein cuts the Potsdam sandstone.

(b) Description:

About a mile north of Redwood, Jefferson county, the R. W. & O. railroad makes a deep cut through the Potsdam sandstone, affording a section some five or six hundred feet long. Throughout the section the sandstone is much crushed, but the strata remain nearly horizontal, and the faulting doubtless present is not sufficient to bring in any other horizon.

At one point in the section there is a fissure, from four to six feet wide, filled with calcite carrying galena, pyrite and sphalerite. Several smaller veins occur, there being, indeed, an irregular crushed zone about forty feet wide, within which the veinstuff and sandstone fragments form a breccia.<sup>51</sup>

(23) *Smithfield Mine, Nova Scotia—(Lead)*

A visit was made during the summer to this property, which is now held by Messrs. C. F. Fraser, Howard Clark, *et al.*, of Halifax. Although the shafts were full of water and the property idle for some time there was every evidence of considerable work having been done. I was informed that the underground work consisted of two shafts thirty and sixty feet deep. From the bottom of the thirty-foot shaft a cross-cut has been run from the foot-wall a distance of thirty-three feet to the south, traversing good ore throughout, but falling short of reaching the hanging wall. From the easterly or sixty-foot shaft two drifts had been run on the vein in either direction to a distance of thirty feet each.

The vein with an estimated thickness of thirty feet strikes approximately east and west and dips at an angle of 80° or 85° to the south, the country rock consisting of Carboniferous limestone striking N. 75° W. The ore consists of fine and coarse-grained argentiferous galena associated with iron pyrites, calcite, and small quantities of light-coloured zinc blende, and, it is said, can be dressed to 16 per cent. pure galena.<sup>52</sup>

(24) *Lake Superior Group of Deposits, Ont.*

Along the north shore of lake Superior there occur a number of lead, zinc and silver veins which resemble one another in many respects. They seem to be allied more closely to the deposits of this group than to those of any other group in this classification. Some of them seem to represent a transitional form between

<sup>50</sup> C. H. Smyth, Jr.: "The Rossie Lead Veins," *School of Mines Quarterly*, Vol. XXIV, 1902-3, pp. 423 et seq.

<sup>51</sup> C. H. Smyth, Jr.: "The Rossie Lead Veins," *School of Mines Quarterly*, Vol. XXIV, 1902-3, page 426.

<sup>52</sup> *Geol. Sur. Can., N.S., Ann. Rep., Vol. VI, p. 84 S.*

the types described under Intermediate and Low-Temperature deposits. Usually a certain amount of quartz occurs in the gangue; the galena is frequently argentiferous; argentite is not uncommon; and zinc blende is in places the chief ore mineral. These veins pass gradually, by the increase of the silver content, into silver deposits of the well-known Silver Islet type.<sup>53</sup>

Only the most important from the point of view of lead and zinc are described in this report. The so-called silver veins, however, also contain galena and sphalerite.

(a) Silver Lake Location, Thunder Bay—(Lead-zinc)

Silver lake lies at a distance of about six miles northward from the head of Thunder bay, and at an elevation of about 500 feet above lake Superior. A short distance to the west of it there is an enormous brecciated vein, some 250 feet in width, composed of masses of the country rocks cemented together with quartz and some barytes and calcspar, and holding small quantities of galena, copper and iron pyrites and blende. This has been traced for about three miles. In approaching Silver lake it contracts rather abruptly, but sends out several branches to the eastward, of which four or five have been followed for considerable distances and are found to be much richer in galena and blende than the great vein. The latter is on a line of dislocation which increases in going west and appears to die out to the eastward. The downthrow is on the north side, and brings the indurated calcareous marls of the Nipigon series on that side down to the level of the iron-ore beds (at the base of the series) on the south side, amounting to 400 feet, or upwards, on this location. The specimens are taken from a shaft sunk on a vein on the line of the eastward continuation of the dislocation, at a point from one to two hundred yards south of Silver lake, and about eighty feet above its level. Here the vein runs N. 80° E. and may be about six feet wide, but its north wall is not well defined. The gangue consists of calcspar, with some quartz and barytes, and holds a good proportion of galena and blende.<sup>54</sup>

(b) Island No. 2, Silver Lake—(Silver-lead-zinc)

Specimens of galena weighing about seventy-five pounds. The island known by the above description is traversed by one of the branch veins referred to under the last heading. The vein runs nearly east and west, and is described as being about six feet wide, with good walls. The gangue is chiefly calcspar, with some quartz, barytes, etc., carrying a fair proportion of galena, accompanied by blende. Two samples of dressed ore assayed by Prof. Chapman gave an average of 57.53 per cent. of lead and 202.6 dwt. of silver per ton of 2,000 pounds.<sup>55</sup>

(c) Paresseux Rapids, Kaministikwia River—(Lead)

Large vein varying from 10 to 25 feet in width which crosses the Kaministikwia in a W.S.W. course about the line between lots 20 and 21, Range 1, N. in the township of Paipouge. At this locality the blende may be in sufficient quantity to prove of economic value. Besides the blende the vein is composed of barytes, quartz, calcspar and fluorspar, with a little copper pyrites, iron pyrites and galena. It is supposed to be identical with the Shuniah vein, the large vein on location M. at the northwest corner of Neebing [township.]<sup>56</sup>

(d) Blende Lake, Thunder Bay—(Zinc)

Vein about eight feet wide on the shore of Blende lake, a small sheet of water about 1½ miles N.N.W. of the head of Thunder bay. The bay runs east and west. The north wall consists of ferruginous siliceous clay slates belonging to the Nipigon series, and the

<sup>53</sup> Geol. Sur. Can., Ann. Rept., 1887, Part H, Report on Mines and Mining on Lake Superior, by E. D. Ingall.

<sup>54</sup> Descriptive Catalogue of a Collection of the Economic Minerals of Canada, and Notes on a Stratigraphical Collection of Rocks: Philadelphia International Exhibition, 1876, p. 32.

<sup>55</sup> Idem, p. 32. <sup>56</sup> Idem, p. 30.

south wall of dioritic schist of Huronian age. The blende (which is of a dark colour), occurs in curving ribs two to four inches thick, transverse to the plane of the vein, in a gangue of white calcspar, with some galena and iron and copper pyrites. Silver is also said to have been detected in it. A shaft has been sunk upon it to a depth of twenty-five feet.<sup>57</sup>

(e) Location VI L, Black Bay—(Lead)

The above location touches the northwest corner of the township of Dorion. The vein is described by the owner as being about 12 feet wide, running northeastward and underlying to the southeastward. A parallel vein, underlying towards the first is said to occur at about twenty rods to the southward, and both are stated to have been traced for a considerable distance on the surface. The gangue is calcspar with quartz and barytes, and besides the galena it contains more or less copper pyrites.<sup>58</sup>

(f) St. Clair Location, Black Bay—(Lead)

This location comprises parts of lots 10 and 11 in the 6th and of 9 and 10 in the 7th concessions of the township of Dorion. As stated in a report by Captain John C. Harkness, the vein is twelve to twenty feet wide, composed of calcspar, quartz and gossan, and carries promising quantities of galena. It runs a little north of east, has been traced for thirty claims on the surface, and is situated on high ground favourable for mining, at about four miles from Black bay. The country rock is said to be red indurated marl, associated with reddish granite, with a high bluff of coarse grey trap a short distance to the northward.<sup>58</sup>

(g) Enterprise Mine, Black Bay—(Lead)

This mine is situated on mining lot C, in the township of McTavish, about three miles west of Black bay. The vein, which runs N. 60° E. and S. 60° W., cuts indurated red marl forty feet thick, underlain by grey quartzose sandstone, flanked by red granite at about 300 yards to the northward. At the surface there was a thickness of four feet of solid ore. . . . According to Professor Chapman of Toronto, this ore contains 47½ per cent. of lead and 10 per cent. of copper, together with an average of 17 dwt. 12 gr. of gold, and 2 oz. 2 dwt. of silver to the ton of 2,000 lbs. On entering the sandstone, the vein became smaller and poorer, but at 100 feet from the surface it had opened out to seven feet in width, and contained bunches of ore like specimen six. Several hundred barrels of ore were shipped from this mine in 1875, and work is still being carried on.<sup>59</sup>

(h) McKellar Island, Thunder Bay—(Zinc-silver)

. . . situated about one mile south of the southeast end of Pie island, Thunder bay . . . vein forty-five feet in width, consisting of alternating bands of white barytes and coarse calcspar, with blende, silver glance, and native silver in one of them. The wall-rock is massive dark crystalline diorite.<sup>60</sup>

(i) Dorion Township, Black Bay—(Zinc)

Three specimens of blende [from lot 10, concession VI, Dorion township]. The vein is reported to be about three or four feet wide, and to run NW., and SE. The locality is about four miles west of Black bay. It is not yet worked.<sup>60</sup>

(j) Dorion Zinc and Lead Mine, Dorion Township

The vein, which occurs at the contact of the granite and the Keweenawan marls, has a strike of N. 40° W. and a dip of about 70° to the west. It occupies a fracture zone due to a fault which occurred along this contact, the blende and galena impregnating the granite (the footwall) and the Keweenawan (the hanging-wall) in the form of veinlets which fill the fractures for about forty feet from the contact into the granite and fifteen feet into the Keweenawan. The main concentration, however, which is from three to three and a half

<sup>57</sup> Descriptive Catalogue of a Collection of the Economic Minerals of Canada, and Notes on a Stratigraphical Collection of Rocks: Philadelphia International Exhibition, 1876, p. 30.  
<sup>58</sup> Idem, p. 32. <sup>59</sup> Idem, p. 36. <sup>60</sup> Idem, p. 30.

feet wide, occurs along the contact, which is the fault plane proper. The galena and blende solutions which were accompanied by silica, calcite and barite, filled the little fissures and cracks formed by the fault, and enlarged them by replacement, the more soluble brecciated material being removed and the ores and gangue minerals deposited in its place. There was considerable development work done at this mine and the vein looked very promising.<sup>61</sup>

### B.—Origin of the Calcite-Barite-Fluorite-Galena Veins

In the descriptions of the deposits of this group, no mention has been made of the genesis of the veins. From the point of view of an examining geologist or engineer, the question of origin is very important in that the solution of it enables him to form reasonable conclusions as to the extent and possible change of mineralization in the veins at depth. Since the first twenty-three deposits described in this division form a well-marked structural and lithological group, it was deemed advisable to discuss their origin collectively, after all the field evidence had been presented.

The chief features characterizing these deposits that would require an explanation under any hypothesis of origin are the following:

(1) The veins, with perhaps one exception, strike in a northwesterly direction, cutting across the predominant strike of the country rocks.

(2) The deposits are fillings of fissures and are not replacements of country rocks. Usually they are bounded by very smooth walls, from which the vein material may be very readily broken.

(3) In several cases, these veins are seen to occur in fissures cutting Paleozoic rocks, of as late a date as the early Ordovician (e.g., Beekmantown).

(4) In a few instances the fissures are seen to be fault fissures, on account of the juxtaposition of rocks of different age, in the walls. In most of the other instances, such excellent evidence of faulting was not found, perhaps because it was difficult to detect a displacement in rocks of a somewhat uniform composition. However, a great many of the veins show smooth, slickensided walls, and include, in a matrix of the gangue, abundant horses of country rock. In one or two cases (especially at Rossie, N.Y.) these inclusions show considerable comminution due to grinding. The argillaceous gouge at the Frontenac lead mine is also suggestive of such comminution. These facts are good evidence of differential movement and brecciation.

(5) The vein at the Galetta lead mine occupies a fault fissure, and in one trench the flat-lying Paleozoics may be observed on one side of the vein, and the Archæan on the other. The amount of differential movement has not been worked out. However, it is very important to note that at certain points in this vicinity and in the neighbourhood of Ottawa several well-marked northwesterly-striking faults have been described by R. W. Ells,<sup>62</sup> E. M. Kindle and L. D. Burling.<sup>63</sup> (See Map No. 25c.) It is highly probable that small amounts of galena and fluorite, which have been reported from various points in these localities, have been derived from veins in these fault fissures.

<sup>61</sup> Ont. Bur. Mines, Vol. XV, Part II, 1906, p. 170.

<sup>62</sup> R. W. Ells: "The Physical Features and Geology of the Paleozoic Basin between the Lower Ottawa and the St. Lawrence Rivers;" Trans. Roy. Soc., Canada, Vol. 6, Sec. 4, 1900. pp. 99-120.

(6) It has been estimated<sup>68</sup> that some of these faults in the vicinity of Ottawa and Montreal show a differential vertical displacement of 1,800 to 2,000 feet. These figures afford a very interesting suggestion as regards the depth of the fault fissures, which are mineralized with lead and zinc ores.

(7) Many of the veins outcrop at intervals for long distances along the strike; those at the Frontenac, Hollandia and Galetta lead mines having each been traced, it is believed, for upwards of a mile. A straight line joining the Rossie and Lansdowne deposits and projected northwesterly will be seen (Map No. 25c) to pass very close to the Bedford veins. The strike of this line is not far different from that of the individual deposits. Similarly, a straight line joining the Redwood and Frontenac deposits, if projected northwestward, would pass very close to the Hollandia, Katherine and the Tudor Lake deposits generally. The strikes of the line and the individual deposits would not be very much at variance.

These facts suggest that there may be zones of dislocation extending for considerable distance northwest and southeast across this part of Ontario, and that the deposits may be fillings of parts of these zones.

(8) All of the veins that have been examined by the writer are of the pinch-and-swell type, and it is quite likely that the remaining ones show the same characteristics. Fractures of such a character are usually found in fault zones, where a relative displacement of the walls in any direction along a fracture would produce openings of a more or less lenticular shape.

(9) The chief gangue minerals in this group of veins are calcite and barite. Calcite seems to be more predominant in the wider veins as at the Frontenac, Hollandia and Galetta properties, while barite is more abundant in the narrower ones, as at the Bedford, Union Creek and Crown King prospects.

(10) The veins are of the crustification type, and sometimes this banding is accentuated by the presence of the ore minerals between successive bands of the gangue. The individual bands break very readily from each other.

(11) Fluorite is found occasionally as a gangue mineral. It is reported chiefly from the veins in the Gaspé peninsula and from those north of the Ottawa river in Hull and Buckingham townships. It is also described as occurring in a large vein at the Paresseux rapids, near Fort William, and in the Rossie lead veins.

(12) The chief ore mineral is galena. It usually occurs more or less richly disseminated in clusters and crystal aggregates throughout the gangue. These masses vary in size from small grains to some weighing several hundred pounds. At one or two localities the galena is seen to occur as coarse-grained tabular masses parallel to the crustification of the veins.

(13) Sphalerite usually occurs in more or less amount. In the veins of eastern Ontario and Quebec, it is usually quite subordinate, and is found in the veins chiefly where they cross crystalline limestone. It is almost entirely of a brownish colour, very similar to the ore of the Mississippi Valley region. In the Lake Superior group of deposits (No. 24 above), sphalerite becomes more abundant, and in a few of them it constitutes the chief economic mineral.

(14) Accessory minerals in the veins consist of pyrite (or marcasite?), chalcopyrite and quartz.

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<sup>68</sup> Geol. Sur. Can., Museum Bulletin No. 18, 1915.

(15) As a general rule, especially in the eastern group, the ore minerals may be described as non-argentiferous. Frequently, however, they contain as much as one ounce of silver to the ton of galena. This proportion is not very different from that prevailing in the sedimentary lead and zinc deposits of Missouri and the Upper Mississippi Valley region.

(16) In the Gaspé peninsula of eastern Quebec, dikes of greenstone are found cutting the limestones of the Ordovician, in which the mineral deposits occur. This areal association is exceedingly interesting, as it shows that in certain localities igneous rocks occur which might have afforded materials for the formation of the veins.

(17) In the vicinity of Madoc, Ontario, some veins, consisting very largely of fluorspar, are found cutting both the pre-Cambrian and the Ordovician. It is possible that these veins belong to the same group as the ones under discussion. Sufficient exploration has not been done on the deposits to show whether galena and sphalerite are present. Calcite occurs in the veins.

#### *The Hypothesis of Origin by Meteoric Waters*

The possibility of the extension of these veins to a considerable depth is a very important factor in estimating the value of the deposits from the point of view of development. In order to draw the most reasonable inferences as to such extension, it is necessary to formulate a hypothesis that will afford an explanation of the chief vein characteristics summarized above.

Primarily, it is important to know whether the deposits have been formed entirely by meteoric waters, or whether magmatic after-effects have had an important bearing on the origin of the veins. If the former be the true explanation, it is reasonable to suppose that the veins do not attain any considerable depth. On the other hand, if ascending hot waters have played an important part, it is quite probable that the mineralization may continue to great depths, and may vary considerably in character.

In the classification adopted for this report, these vein deposits have been classed as having an origin probably independent of igneous after-action. This seems to be the most natural conclusion, as to genesis, to be derived from a study of the individual deposits. For instance, the vein at the Frontenac, or Hollandia or Galetta lead mine, is of a very marked crustification type. No minerals are present in the veins that might not readily have been obtained by a leaching of the associated crystalline limestones. The veins themselves closely resemble in character the old lead veins of the upper parts of the Wisconsin-Illinois-Iowa deposits, which are recognized to be of meteoric origin. As a general rule, the galena and sphalerite of the Ontario-Quebec group are non-argentiferous. That is to say they contain silver only in minor quantities not of economic value. This is characteristic of galena and sphalerite veins of known meteoric origin. On the other hand, galena and sphalerite veins of igneous origin usually contain upwards of ten ounces of silver to the ton of sulphides. The veins have been found cutting lower Ordovician limestones. In the southeastern Ontario region, where these veins are specially abundant, there are no known evidences of igneous intrusion as late as the Ordovician, to whose influence the origin of the veins might be

ascribed. Usually the veins do not show the intimate mixture of minerals that very frequently is the case in deposits of igneous origin. The sphalerite is of the light to resin brown colour that usually characterizes the zinc blende of meteoric origin.

The above-mentioned characteristics obtained from the study of the chief individual deposits, suggest an origin for the vein material by waters of purely meteoric origin. The argument for this case seems to be a fairly strong one, and one that will probably meet with general approval. The analogy of the veins to deposits of meteoric origin in the United States that have been carefully studied is exceedingly suggestive.

#### *Probable Origin of the Fluorite*

After a study of the veins of this group, as a group rather than as individual occurrences, and after the correlation of the evidence as given in the tabulated summary above, a different mode of origin for these veins has suggested itself, one which appeals strongly to the writer. Consequently, the suggestion is made that the veins owe their origin to a combination of the influences of meteoric and magmatic waters. It is conceived that in all probability the vadose circulation leached much of the metallic and non-metallic constituents of the veins from the Paleozoic and pre-Cambrian rocks, chiefly the limestones, that occur in association with the veins. Calcite and barite might very readily be derived from this source. The limestones of the pre-Cambrian especially contain perceptible amounts of the sulphides of zinc, lead, iron and copper.

The presence of considerable fluorite in some of the veins, however, cannot readily be explained by a process of leaching of the limestones. Prof. Van Ingen pointed out in an address before the Geological Society of America at its Philadelphia meeting in 1914 that fluorine occurs in the teeth and bones of marine animals, and suggested that this source might afford a supply of fluorite for some deposits. It hardly seems reasonable that a selective leaching process in this limestone could have proceeded far enough to bring about the results observed in the veins. Igneous rocks also contain certain amounts of fluorine, especially in apatite. This might be a possible source of the fluorite in the veins which intersect igneous rocks. But it is important to note that some of the veins containing fluorite abundantly occur up in the Ordovician limestones, a considerable distance above the underlying pre-Cambrian. Meteoric waters could not very well have carried this fluorite upwards from the pre-Cambrian igneous series. The evidence, therefore, seems to favour some other origin for the fluorite.

An interesting suggestion concerning the origin of the fluorine is afforded by its occurrence in the calcite-barite-galena veins of eastern Quebec where the Ordovician is cut by intrusives chronologically related to the Taconic revolution. It is possible that the presence of the fluorine in the vein minerals has a genetic relation to the igneous activity of post-Ordovician age, which produced important results in the Province of Quebec, but which, as far as known, did not affect Ontario. In this connection it is interesting to refer to the occurrence of the

fluorite veins in southern Illinois<sup>64</sup> and western Kentucky.<sup>65</sup> In these districts also the ores occur largely as fillings of fault fissures or as cements for breccias in zones of dislocations. Galena, sphalerite, pyrite, marcasite, chalcopyrite, calcite, barite and some quartz occur associated with the ore material, which is chiefly fluorite. Dikes of peridotite cut the formations containing the veins and it has been suggested by H. F. Bain<sup>64</sup> that possibly the fluorine may have been introduced into the veins by waters that derived it from the cooling igneous rocks. It is well known that the important fluorspar deposits of England and Saxony also occur in limestones, gneisses, schists and slates, which in both cases are intersected by basic dikes.

#### *Vein Fillings of Fault Fissures*

It is probable that the veins of the group under discussion occur as fillings of fault fissures and zones of dislocation. Very frequently these veins have been found to be at least half a mile in length. The location and strike of the individual deposits as shown on Map No. 25c indicates that perhaps the displacement zones are much more extensive than are indicated by the known continuance of each individual deposit. They may even extend for several miles in a northwest direction across southeastern Ontario. If so, the natural conclusion is that they must extend to very considerable depths since it is generally accepted that the lateral extent of a fissure is to some degree a measure of its depth. Again, the data obtained by E. M. Kindle and L. D. Burling<sup>66</sup> in their work on the fault zones of southeastern Ontario, show that several of the faults in the vicinity of Montreal and Ottawa show a relative vertical displacement of upwards of 2,000 feet. It is believed by the writer that the calcite-barite-galena veins occupy fault fissures of this type and age. If this is the case, therefore, it is probable that many of these fissures extend to depths where they might tap the circulation of hot solutions carrying materials obtained ultimately from magmatic waters.

#### *Suggested Hypothesis for Origin of these Veins*

From a consideration of the evidence given above, therefore, the following working hypothesis is suggested as to the genesis of this type of veins:

The vein material represents a combination of substances obtained from meteoric and magmatic waters. Meteoric solutions possibly leached calcium, barium, lead, zinc and iron compounds from sedimentary and igneous rocks and constituted the chief ground water circulation. At some time later than the Ordovician there was a period of moderate to severe earth stresses which resulted in the crumpling and folding of the strata in Quebec, and considerable normal faulting in regions farther distant from the centre. Igneous activity probably was an accompaniment of this period of readjustment. The deep fractures that were formed at this time allowed a somewhat deep circulation of the ground waters, and an easy egress for hot ascending solutions. These hot solutions possibly contained some fluorine, which is common as an igneous after-effect. A union of

<sup>64</sup> The Fluorspar Deposits of Southern Illinois; by H. F. Bain, U.S.G.S., Bull. 255, 1905. Fluorspar Deposits of Southern Illinois; by S. F. Emmons: Trans. Am. Inst. Min. Eng., Vol. 21, 1893, p. 52.

<sup>65</sup> The Lead, Zinc and Fluorspar Deposits of Western Kentucky; by E. O. Ulrich and W. S. T. Smith, U.S.G.S., Prof. Paper 36, 1905.

<sup>66</sup> Geol. Sur. Can., Museum Bulletin No. 18, 1915.

these solutions in the fault fissures which would constitute main channels of circulation would, therefore, provide the material necessary for the formation of veins of the calcite-barite-galena-fluorite type. The actual deposition was no doubt controlled by the conditions of temperature and pressure, and by the varying composition of the solutions.

If this hypothesis be correct, it is probable that the veins will show considerable vertical extent. Of course it is not suggested that the mineralization would extend to the bottom limits of the fracture zones, nor that it would be constant. On the other hand, there is every reason to believe that the mineral composition of the veins would vary considerably in depth.

In connection with the above discussion it is interesting to recall a short paper in "Economic Geology" by L. V. Pirsson,<sup>67</sup> and another a short time later by J. E. Spurr<sup>68</sup> on the "Origin of Certain Ore Deposits." Dr. Pirsson suggests that possibly igneous emanations from deeply concealed magmas may have been responsible for the peculiar composition of certain ore deposits which occur in districts where igneous rocks are not known to come to the surface. He even intimates that the mid-Mississippian deposits of zinc and lead may have derived some of their constituents from this source. On account of the similarity of the views expressed therein to the suggestion made above with reference to the origin of the calcite-barite-galena veins of Ontario and Quebec, a few paragraphs from the paper are here included. The suggestions made by Dr. Pirsson seem to accord much more closely with the conditions in Ontario and Quebec than, for example, with those in Missouri.

Moreover, the dissimilar properties of the ores in different districts, the variable relations between lead, zinc and copper in closely related ones, the occurrence of nickel and cobalt, and in places of fluorite, which latter when occurring in large masses could scarcely represent an extract from the teeth and bones of animals, etc., still remain unexplained.

As there is every degree between eruption with catastrophic violence to quiet outwelling of magma of mixed volatile and non-volatile substances under proper conditions, so there should be all gradations in the mode of rising of the gaseous portion through the shattered lithosphere and its escape at the surface.

Furthermore, as it is natural to believe that magma, perhaps in the pseudo-rigid but potentially liquid form conceived by Iddings<sup>69</sup> must everywhere underlie the outer rock zone, so everywhere there will be a tendency for it to rise upward when opportunity permits. One of the first effects of relief of pressure on its upper surfaces would be the liberation of the volatile constituents. It may well be that in many places no further action than this happens. All the shiftings and movements of the lithosphere would then tend in variable degree, to be attended by upward movement of gaseous constituents, and in the same measure the passage of magma upward would be heralded by the development of increase of solfataric or fumarolic activity at the surface; a fact well known in volcanic regions. This quiet working upward of volatile matters may then be considered as the mildest phase of volcanic action with which we are acquainted and one which has happened, is happening, or will happen, practically everywhere over the world. To it we may ascribe in large measure peculiarities seen in the composition of many mineral springs and waters in otherwise apparently non-volcanic regions.

The application of this principle, the quiet upward movement of volatile magmatic material, if it be admitted, in explaining the origin of the ore deposits previously mentioned, is evident. If sulphide ores have been deposited from acid emanations in those cases where the connection with intruded bodies of magma is clear and unmistakable from the visible presence of the latter, it seems a natural and inevitable step to ascribe those instances

<sup>67</sup>L. V. Pirsson: "Origin of Certain Ore Deposits." *Econ. Geol.*, Vol. 10, No. 2, 1915, p. 182.

<sup>68</sup>J. E. Spurr: "Origin of Certain Ore Deposits." *Econ. Geol.*, Vol. 10, No. 5, p. 472.

<sup>69</sup>"The Problem of Volcanism," p. 164, 1914.

where no igneous rocks are seen or known in connection with them to such emanations working upward from magma in the depths below. It does not appear necessary to establish the connection that magma should have ever reached the surface or, perhaps, even the upper zone of intrusion in the lithosphere, though naturally where this has happened the chances for ore deposition would be greatly increased.

As to the mid-Mississippi area which has served as a basis for this suggestion, it can be said that evidences of the milder modes of igneous activity, in addition to the occurrence of the ores themselves, are not wanting in many places, while in some it has assumed a more active and evident form. Thus in central Arkansas are many intrusions of syenites and related alkalic rocks of late Cretaceous age; there are also the occurrences of diabase, porphyrites, etc., in the eastern Ozarkian uplift of Missouri; of peridotite dikes in Kentucky and Illinois, with which are associated ores and fluorspar, the latter in huge masses, and indicative of fumarolic action from magma below. The great volumes of "sulphurous" gases, which issued from the ground and whose presence is mentioned by so many observers at the time of the New Madrid earthquakes in 1811-12, may possibly have had such an origin, and afford an example of the outbreak of magmatic vapours from below. It is not suggested that they were the cause of the seismic phenomena, but merely attendant upon it; the disturbance and displacements of the rock masses giving them an opportunity to escape. All of these instances and others that might be cited appear to point in the same general direction.

### C.—Gash Veins and Impregnations in Paleozoic Limestones

#### (1) *Albemarle Zinc Mine, Ont.*<sup>10</sup>

(a) Location: This property is located on lot 30, concession II, of the township of Albemarle, Bruce county, Ont., about eight miles from Warton.

(b) Ownership: The mining rights to 100 acres are owned by the Albemarle Zinc Company, of which George Bourne, of Warton, is Manager.

(c) Operation: Small amounts of development work have been done at intervals since the summer of 1910, consisting of surface trenching and the sinking of a shaft to a depth of thirty feet. There are several open pits.

#### (d) Occurrence of the ore:

Zinc blende occurs filling pore spaces and cavities, and partially replacing fossils and the country rock. The greatest accumulation of ore was found in cavities open to the surface and evidently dissolved out by meteoric water. Loose ore was mixed with pebbles and earthy materials, and in one place as much as 110 pounds of ore were obtained from a single pocket.<sup>11</sup>

#### (2) *Lake Mistassini, Que.—(Lead-zinc)*

(a) Location: At the northeastern corner of the Chibougamou region of Quebec, between lakes Wakonichi and Mistassini, two miles north of the Hudson's Bay Post.

#### (b) Description:

The Mistassini galena and blende occur in a rather flat-lying limestone, which has received some flexures and shearing; the galena and blende are found in small spots and splashes in these flexures. The existence of these minerals, associated with limestone, indicates a possibility of larger deposits elsewhere in the Mistassini basin.<sup>12</sup>

<sup>10</sup> Ont. Bur. Mines, Vol., XXIV, Part I, 1915, p. 151.

<sup>11</sup> Geol. Sur. Can., Summ. Rept., 1912, p. 281.

<sup>12</sup> Report on the Geology and Mineral Resources of the Chibougamou region, Quebec, Dept. of Colonization, Mines and Fisheries, Prov. of Quebec, 1911, p. 185.

### 3. Anamorphosed Low-Temperature Deposits

At several localities within the pre-Cambrian shield in southeastern Ontario deposits of lead and zinc sulphides occur disseminated through crystalline limestones. In a few of the localities these disseminations are sufficiently segregated to constitute sulphide deposits of probable economic value. In other places the ore minerals are merely richly disseminated, and not in bodies that give promise of developing into deposits of commercial importance. Two examples of this group are discussed in detail in the following section.

All limestones are believed to contain zinc and lead in at least very small amounts. Traces of these metals have been found in most limestone analyses. The crystalline limestones of the pre-Cambrian of southeastern Ontario and western Quebec, many of which belong to the Hastings or Grenville groups, very commonly contain the sulphides of these metals disseminated through them in grains of recognizable proportions. It is believed by the writer that compounds of zinc and lead were deposited in these limestones syngenetically with the calcium carbonate in minute quantities in a manner similar to the occurrence of zinc and lead in unmetamorphosed Paleozoic limestones. The great regional metamorphism which these early pre-Cambrian limestones have at various periods undergone, is believed to have afforded conditions favourable for the segregation of the minute quantities of the zinc and lead minerals present into disseminated grains of distinguishable size. That is to say, limestone recrystallizes so readily under conditions of differential stress, that each period of regional deformation was accompanied by the development of flowage conditions in the limestone. These flowage conditions, therefore, afforded an opportunity for the like particles of lead and zinc minerals to segregate into larger grains.

Although crystalline limestones are abundant throughout the area covered by this Report, the presence of galena or sphalerite in commercial quantities within their masses is known in only a very few cases. Two of these examples have come to the attention of the writer, and careful field investigations have led to the belief, that in these cases the segregation process has been enabled to attain such large proportions that the final result is not a disseminated deposit of ore grains of recognizable size, but a deposit in which the grains have been so closely segregated as to constitute a series of lenticular masses of almost solid ore minerals. Extraordinary conditions seem to have accounted for the opportunity of increased segregation, and these conditions are believed to have been the greatly increased heat and pressure induced in the crystalline limestones by the intrusion into them of large masses of granite and gabbro which occur in the immediate vicinity of the zinc and lead deposits. The limestone near the granite and gabbro contacts is usually very coarse grained, and the ore minerals are chiefly developed in these coarse-grained phases. For reasons explained in the discussion of the individual deposits, the granites and gabbros are not believed to have contributed anything in the way of ore minerals to the limestone.

On the other hand, there are large areas in southeastern Ontario and western Quebec where apparently the same limestones are intruded by granite without the known presence of zinc and lead sulphide deposits.

The deposits described below are conceived by the writer, therefore, to be merely anamorphosed representatives of limestones which contained within themselves the elements that finally were segregated into the sulphide bodies.

(1) *Long Lake Zinc Mine, Frontenac County, Ont.*

(a) Location: This property has formerly been known as the Olden or Richardson zinc mine and is located in lot 3, concession V, and lot 3, concession VI of the township of Olden, Frontenac county, Ontario. The nearest railroad stations are Tichborne Junction, eight miles distant, on the Montreal-Chicago and Kingston and Pembroke lines of the C.P.R., and Mountain Grove, about seven miles distant on the Toronto-Peterborough-Montreal line of the C.P.R. A siding on the latter line has been constructed at a point four miles north of the mine. The property is about thirty-six miles north-northwest of the city of Kingston.

(b) Ownership and operation: The mineral rights of 196½ acres underlying the locations mentioned above are owned by James Richardson & Sons, Limited, grain merchants, Kingston, Ontario. The property has been operated in a desultory fashion by the owners since about 1897, but no systematic exploration has yet been carried out to determine the extent of the mineralization. During the winter of 1914-1915 the property was under option to a group of United States zinc interests known as the Long Lake Zinc Company, and the underground workings were unwatered and a thorough examination was made by the writer. In May, 1915, the property was returned to the owners, and is still idle at the time of writing.

(c) Geology: The mine lies within the area of the pre-Cambrian shield of southeastern Ontario, about sixteen miles north of the overlapping edge of the Paleozoic. The rocks are well exposed, and the succession in its broad features appears to be as follows:

	Sandstone: Upper Cambrian
	<i>Unconformity</i>
	{ Granite: Moira (?)
	<i>Intrusive contact</i>
	{ Gabbro and diorite gneisses
	<i>Intrusive contact</i>
PRE-CAMBRIAN	{ Crystalline limestones
	{ Quartzites
	{ Acidic gneisses
	{ Green schists

Of the last four members of the succession, only the crystalline limestone occurs in the immediate neighbourhood of the mine. It is the oldest rock in the mine area. It is usually coarsely crystalline, and occurs in elongated strips, striking about N. 20° E., magnetic, seldom more than a few hundred feet in width. The limestone has been intruded by a gabbro, which shows a slightly gneissic structure.

The banding of this gneissic gabbro is parallel to the northeasterly trend of the limestone, and in no place is the gabbro seen to cut across the limestone, except in dikes. Slight irregularities along the contacts, however, give evidence of the intrusive nature of the contact. Both the limestone and the gabbro, as well as the associated quartzites, gneisses and green schists, have been intruded by a massive, coarse-grained granite, which underlies great stretches of country to the north and south. Dikes of aplite and pegmatite from this parent source traverse both the limestone and the deposits of zinc ore.

(d) Development: The property has been explored throughout a length of 3,500 feet by surface stripping and underground workings. Practically all of the development has been done at points where the ore came to the surface, and is of the following character:

- (1) Five shafts on the ore body varying from 60 to 125 feet in depth.
- (2) About 350 feet of drifting, mainly in ore.
- (3) Three open cuts up to 60 feet long and 40 feet deep.
- (4) Twenty-five pits and trenches varying in depth from 3 to 30 feet. (See Fig. 3.)

In addition to this, about one thousand feet of diamond drilling, distributed in shallow holes mainly between the east and mill shafts, was accomplished during the winter of 1914-1915.

(e) Nature of the ore and gangue: The ore is chiefly zinc blende of a dark chocolate-brown colour, with small amounts of galena. In places, pyrite is a common associate of the ore, while pyrrhotite and chalcopyrite are present to a slight extent. Where the sphalerite is coarse grained, it is almost entirely free from the other sulphides, but wherever the fine-grained phase of the ore predominates, it is usually rather intimately mixed with the sulphides of lead, iron and copper, as well as with the gangue minerals. An assay of a sample of the ore, taken at random from the various dumps and outcrops, gave a silver content of 1.05 oz. per ton of 35.4 per cent. zinc concentrates. The ore, therefore, is from a commercial point of view non-argentiferous.

The chief gangue mineral is the calcite of the country rock. Greenish diopside and quartz are also of common occurrence in association with the fine-grained variety of the ore.

The records of shipments made from the property show that hand-jigged concentrates have been made that assayed 50 per cent. zinc and 8 to 9 per cent. lead. Ore was also hand-picked that assayed 40 to 44 per cent. zinc.

(f) Occurrence of the ore: The ore occurs entirely within the crystalline limestone in horizons parallel to its banding. Thickened and flattened "lenses" of the sulphides are the characteristic feature of the deposit, but ore grains are usually disseminated more or less thinly through the limestone, in these same general horizons. On careful inspection it is seen that all gradations exist between the thinly disseminated ore and the apparently massive "lenses." Even these so-called "lenses" contain disseminated grains of the gangue minerals throughout their mass. Their boundaries are not sharply defined, but exhibit a gradation

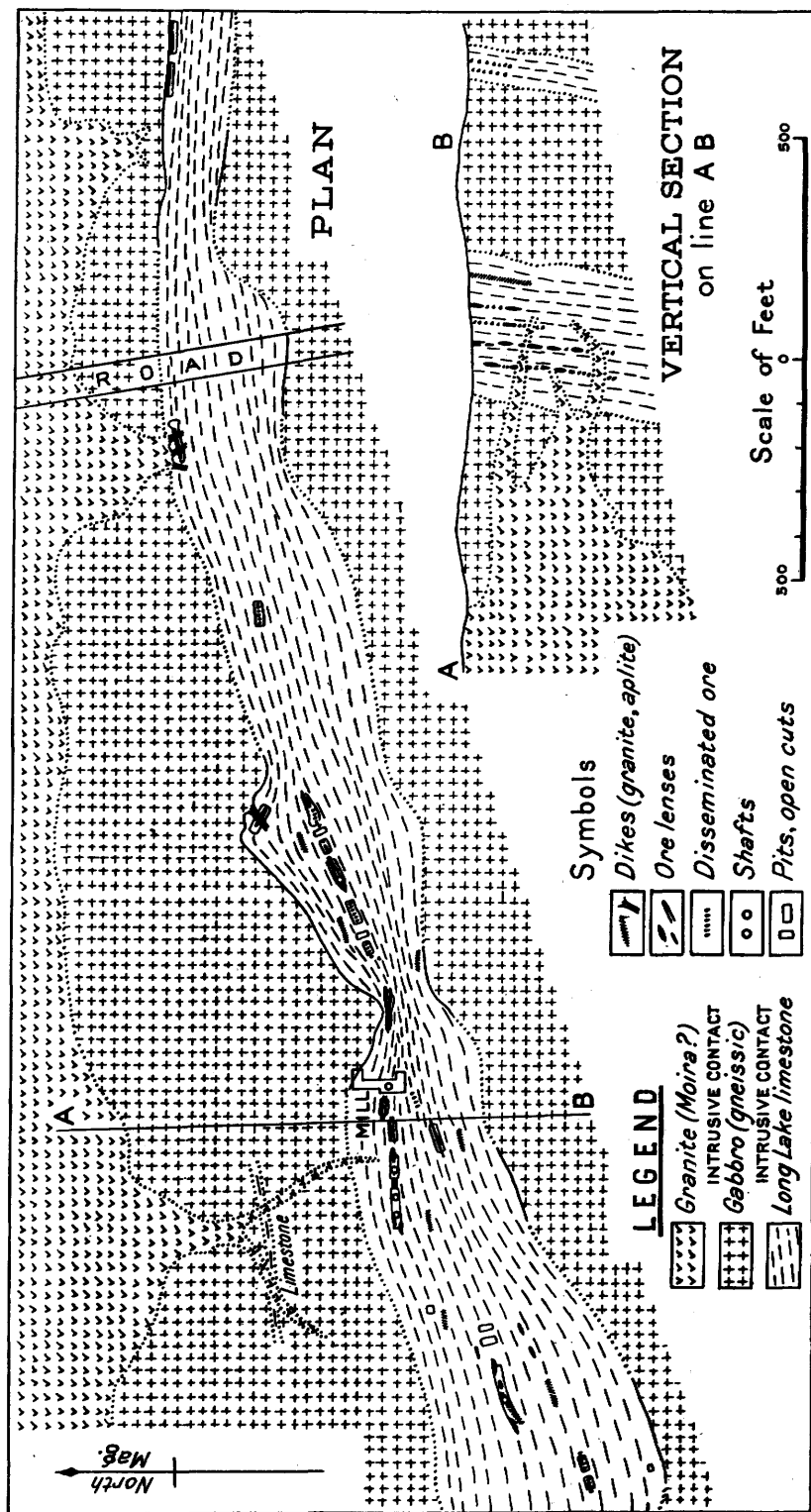


Fig. 3—Long Lake Zinc Mine, Frontenac county, Ont.

NOTE.—Geological boundaries in the above sketch map are accurate only where shown in full lines. The granite-gabbro contact in particular is very approximate. Broken lines within the limestone area do not represent the strike of single bands of limestone, but are drawn to indicate in general the tendency of the bands to conform with the strike of the gabbro-limestone contact.

from dominant ore to dominant gangue minerals within the space of an inch or two. Consequently it appears that the lenses are in reality made up of closely segregated sulphide disseminations.

There are three main ore horizons, as shown on the accompanying sketch (Fig. 3). The two chief ones lie within the limestone band, at distances averaging about 80 and 200 feet south of the northern contact. Another horizon occurs within the limestone along the northern contact, as shown in some trenches on the eastern half of the map. No mining has been done on this latter horizon. In addition to these main localities, thin "lenses" and disseminations of zinc blende may be seen at other horizons within the limestone.

The "lenses" vary considerably in size and shape. In general they are approximately circular. They vary in length from 5 or 6 feet to about 100 feet, and in width from a few inches to 14 feet. At the western shaft a "lens" of ore has been mined that was 14 feet thick at the surface, and which outcropped throughout a length of 90 feet. This "lens" was mined to a vertical depth of about 40 feet, and constituted the largest individual body so far encountered. It consisted very largely of the coarse-grained variety of zinc blende, which was hand-picked for a shipping product. Other "lenses" of considerable size have also been encountered from time to time.

The individual "lenses" may pinch and swell several times between their centre and circumference. As a general rule, they appear to be entirely separate bodies with no connection between adjacent ones. Exceptionally, small connecting links may be seen between two comparatively large bodies of ore. These connecting links usually consist of thinly disseminated zinc blende and pyrite along one or two thin bands of limestone, and may escape the attention of one not searching for them.

The disseminated character of the ore and its intimate association with the gangue minerals strongly suggest that in their present condition both ore minerals and limestones are of simultaneous crystallization. Dikes of granite and gabbro from the main intrusive masses cut both ore and limestone, and prove that the ore minerals were in their present form within the limestone previous to the period of dike intrusion. The dikes, therefore, do not interfere with the extension of the ore.

(g) Genesis of the ore:<sup>3</sup> As suggested in the introduction to this division, the deposits, of which the Long Lake mine is the best known example, are believed to be simply the segregated products of the disseminations of sulphide minerals originally present in the limestones. There is no evidence indicating that the ore minerals have been introduced from any foreign source. The intrusive rocks are believed to have produced conditions of high temperature and pressure within the limestone of such a character as to allow the sulphide constituents to segregate into "lenses."

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<sup>3</sup>A complete discussion of the evidence for this hypothesis will be given in an article by the writer to be published in a forthcoming number of "Economic Geology," entitled "Ore Genesis and Contact Metamorphism at the Long Lake Zinc Mine, Ontario."

(2) *Sheffield Township Zinc Deposit, Addington County, Ont.*

(a) Location: This prospect is situated on the west half of lot 10, concession XV, Sheffield township, county of Addington, Ontario. The nearest railway station is Enterprise on the new Chicago-Montreal Lake Shore line of the Canadian Pacific railway, and is eight miles distant.

(b) Geology: The rock succession is very similar to that at the Long Lake zinc mine. White crystalline limestones, associated with micaceous gneisses are intruded by a massive, coarse-grained granite, all of pre-Cambrian age.

(c) Nature of the ore and gangue minerals: The chief ore mineral is zinc blende of a dark chocolate-brown colour. This is associated with small amounts of galena and pyrite. The gangue is chiefly crystalline limestone, with minor quantities of lime silicates.

(d) Occurrence of the ore: The sphalerite occurs disseminated through the crystalline limestone near the granite contact in grains varying from the size of a pea to that of a walnut. No massive ore was seen. Certain belts within the limestone seem to be richly mineralized, while others are almost barren.

(e) Development: Scarcely any development has been done on the property. There are two pits on the zone of mineralization, one of which is about eight feet and the other two feet deep. The mineralized belt may be followed by intermittent outcroppings for at least 150 feet. In no place is this belt wider than five feet.

(f) Genesis of the ore: It is believed that the zinc-sulphide minerals were original constituents of the limestone, and were simply segregated at the time of the granite intrusion, which produced conditions of flowage in the limestone. No specific data as to the origin of this deposit was obtained, but all the evidence suggests that it is an occurrence similar to the disseminated phases of mineralization at the Long Lake zinc mine.

#### **BOUNTIES ON LEAD AND ZINC PRODUCED IN CANADA**

In order to encourage the production of the refined metals in Canada from Canadian ores, and to stimulate the exploration and development of Canadian deposits, the Dominion Parliament has placed bounties on zinc and lead produced in Canada from home ores. For the purpose of general information the following statements concerning the operation of these bounties are here introduced.

#### **The Lead Bounties Act, 1913**

*An Act respecting the payment of bounties on Lead in Lead-bearing Ores mined in Canada.*

*(3-4 George V. chap. 29. Assented to 6th June, 1913.)*

Whereas, under the provisions of chapter 31 of the statutes of 1903 and of chapter 43 of the statutes of 1908, as amended by chapter 37 of the statutes of 1910, the amount of bounty payable on lead contained in lead-bearing ores mined in Canada was not to exceed two million four hundred and fifty thousand dollars; and whereas the time within which the said amount is payable for the purpose aforesaid expires, under the provisions of the said chapter 43, on the thirtieth day of June, nineteen hundred and thirteen, and there will

then remain unexpended of the said sum approximately six hundred thousand dollars; Therefore His Majesty, by and with the advice and consent of the Senate of the House of Commons of Canada, enacts as follows:—

1. This Act may be cited as *The Lead Bounties Act, 1915*.

2. The Governor-in-Council may authorize the payment of a bounty of seventy-five cents per hundred pounds on lead contained in lead-bearing ores mined in Canada, on and after the first day of July, nineteen hundred and thirteen, such bounty to be paid to the producer or vendor of such ores; Provided that the sum to be paid as such bounty shall not exceed two hundred and fifty thousand dollars in any year ending on the thirtieth day of June; providing also that when it appears to the satisfaction of the Minister charged with the administration of this Act that the standard price of pig lead in London, England, exceeds fourteen pounds ten shillings sterling per ton of two thousand two hundred and forty pounds, such bounty shall be reduced by the amount of the excess.

The total amount of the bounty payable under the provisions of chapter 31 of the statutes of 1903, chapter 43 of the statutes of 1908 (as amended by chapter 37 of the statutes of 1910), and of this Act, shall not exceed two million four hundred and fifty thousand dollars.

3. Payment of the said bounty may be made from time to time to the extent of sixty per cent. upon smelter returns showing that the ore has been delivered for smelting at a smelter in Canada. The remaining forty per cent. may be paid at the close of the fiscal year, upon evidence that all such ore has been smelted in Canada.

2. If at the close of any year it appears that during the year the quantity of lead produced, on which the bounty is authorized, exceeds sixteen thousand six hundred and sixty-seven tons of two thousand pounds, the rate of bounty shall be reduced to such sum as will bring the payments for the year within the limit mentioned in section 2 of this Act.

4. If at any time it appears to the satisfaction of the Governor-in-Council that the charges for transportation and treatment of lead ores in Canada are excessive, or that there is any discrimination which prevents the smelting of such ores in Canada on fair and reasonable terms, the Governor-in-Council may authorize the payment of a bounty, at such reduced rates as he deems just, on the lead contained in such ores mined in Canada and exported for treatment abroad.

5. If at any time it appears to the satisfaction of the Governor-in-Council that products of lead are manufactured in Canada direct from lead ores mined in Canada without the intervention of the smelting process, the Governor-in-Council may make such provision as he deems equitable to extend the benefits of this Act to the producers of such ores.

6. The Governor-in-Council may make regulations for carrying out the intention of this Act.

7. The bounties payable under the provisions of this Act shall cease and determine on the thirtieth day of June, one thousand nine hundred and eighteen.

Owing to the high price of lead prevailing in London during the past two years, the bounty paid during this period amounted only to \$11,496. The amount still available, Dec. 1, 1915, therefore, for the payment of this bounty is \$625,171.

#### Proposed Bounty on Zinc

The following is a copy of a resolution introduced in the Dominion House of Commons by Sir Thomas White, Minister of Finance, on April 13th, 1916, *re* zinc or spelter bounty:

Resolved, That it is expedient to authorize the payment out of the Consolidated Revenue Fund of a bounty of two cents per pound on zinc or spelter, containing not more than two per cent. of impurities, produced in Canada from zinc ores mined in Canada provided the standard price of zinc or spelter in London, England, at the time of production is less than £36 19s. 3d. sterling per ton of two thousand two hundred and forty (2,240) pounds, when the bounty payable shall be an amount equal to the difference between such standard price per ton and £36 19s. 3d. per ton. Further provided, that in no event shall bounty be payable when the price received for zinc or spelter by the producer is eight cents or more per pound, and that no bounty shall be payable on zinc or spelter to the producer during the continuation of the war, and in no event on zinc or spelter produced after July 31st, 1917.

This bounty, therefore, would assure a market for zinc concentrates on the basis of 8-cent spelter at least until July 31, 1917, provided the concentrates are smelted in Canada.

### PRODUCTION AND CONSUMPTION OF LEAD AND ZINC IN CANADA

#### Lead

At the present time practically all of the production of pig lead and lead ore in Canada comes from British Columbia. In 1913 very small amounts of pig lead were produced from Ontario and Yukon ores, but of the total of 37,662,703 pounds for that year, 37,636,899 pounds were recovered from British Columbia ores.

The information with regard to the lead deposits of eastern Canada given in this paper shows that a very considerable amount of lead concentrates might be produced in Ontario and Quebec, if there were a lead smelter in eastern Canada which might afford a market. The extent of the demand for pig lead in Canada may be deduced approximately from a consideration of the following figures."

	Lbs.
Total Canada production of pig lead, 1913.....	37,662,703
"    "    imports of lead," 1913.....	26,229,000
	<hr/>
Total supply, 1913 .....	63,891,703
Canadian exports of lead, 1913 .....	329,960
	<hr/>
Total demand, 1913 .....	63,561,743

Consequently, in 1913, Canada produced about 59.4 per cent. of her total requirements. The chief consumption of lead is now in eastern Canada, which, in spite of its undeveloped resources in lead ore, produced only a very small quantity of pig lead.

#### Zinc

The production of zinc ore (concentrates and hand-picked products) in Canada in 1913 was 7,889 tons, which was estimated to contain 7,069,800 pounds of zinc. By far the greater part of this production came from the British Columbia mines, but small amounts were produced from the mines at Notre-Dame-des-Anges, Port-neuf county, Quebec. Until 1915, there was no zinc smelter or refinery in Canada, and all the concentrates had to be shipped to the United States or Europe for reduction. Consequently, all the metallic zinc and zinc oxide used in Canadian industry was imported.

During the last three years, experiments on the hydrometallurgy of zinc have been conducted in British Columbia by Mr. French, and by the Consolidated Mining and Smelting Company of Canada at Trail. The result of these investigations is the decision on the part of both companies to erect reduction plants to treat zinc ore on a commercial scale. The new hydrometallurgical plant at Trail is now in process of installation. During the summer of 1915, also, the East

<sup>1</sup> Ann. Rept. Min. Prod. of Canada, Mines Branch, Ottawa, 1913, p. 135, et seq.

<sup>2</sup> Includes, pig, old, scrap lead, sheets, bars, blocks.

Canada Smelting Company have erected an electrolytic zinc reduction plant at Welland, Ontario, and are, at the time of writing, treating small quantities of oxidized zinc ores. Consequently, in the course of another year or so, a considerable amount of Canadian-made zinc should be available for use in home industry.

The Annual Report on the Mineral Production of Canada shows the following figures for 1913:

	Lbs.
Total imports of spelter .....	10,784,500
Total imports of zinc <sup>16</sup> .....	9,931,100
	20,715,600
Total consumption .....	20,715,600

The total zinc content of the zinc ores sent to the smelters from the Canadian mines in 1913 amounted to only 7,069,800 pounds, or about 34.2 per cent. of the home consumption. If the new undertakings in the way of the electrolytic reduction of zinc ores prove commercially successful in Canada, there is no reason why they should not develop on a scale sufficient to meet the needs of Canadian industry. At the present time, the chief obstacle in the way of the development and operation of zinc properties in Canada is the lack of home reduction works of large capacity and the necessity of shipping ore into the United States.

#### DUTIES ON ZINC AND LEAD: CANADA AND UNITED STATES

- (a) Zinc ore entering the United States: 10 per cent. ad valorem on the contained zinc.
- (b) Lead ore entering the United States:  $\frac{3}{4}$  cent per pound on the contained lead in excess of 3 per cent.
- (c) Lead and zinc ores entering Canada: Free.
- (d) Zinc in blocks, pigs, sheets, zinc dust, old zinc entering the United States: 15 per cent. ad valorem.
- (e) Lead in pigs, bars, etc., lead dross, lead bullion or base bullion; in sheets, pipe, shot and wire, entering the United States: 25 per cent. ad valorem on the contained lead.
- (f) Zinc in blocks, pigs, sheets, etc., entering Canada: Previous to the war, this was admitted free of duty. The war tariff imposed a duty of  $7\frac{1}{2}$  per cent. ad valorem on these articles.
- (g) Lead in pigs, bars, sheets, etc., entering Canada: Previous to the war, the duty was 15 per cent. ad valorem. The war tariff imposed an additional  $7\frac{1}{2}$  per cent. ad valorem.

#### CONCLUSION

The descriptions of the deposits in this report have drawn attention to certain areas which deserve a more thorough exploration. The deposits along the north shore of lake Superior merit closer examination, and there seems to be no reason why some of those that have been described should not develop into

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<sup>16</sup> Blocks, pigs, sheets.

bodies of commercial importance. The presence of silver in these deposits makes them specially worthy of investigation.

Attention has been drawn to the fact that the calcite-barite-galena veins probably occur in a series of northwesterly striking fault fissures. The natural conclusion is that all such fault fissures would be worthy of exploration. Several of these are shown on Map No. 25c, and it is suggested that careful examinations in the area crossed by these faults might give results of economic importance.

At the present time mining operations for lead and zinc are being conducted at only three localities in Ontario and Quebec. As a market for the products of these mines, there is only the electrolytic zinc refinery at Welland, Ontario, which is at present operating necessarily on a small scale. The lead smelter of the North American Smelting Company at Kingston has been idle for about three years, although reports are in circulation that it may be blown in again in the near future.

It is hoped that the encouragement given to these industries by the Dominion Parliament in the way of bounties, intended to develop finished products so badly needed by Canada and Great Britain for military and other purposes, may result in the establishment of Canadian smelters capable of handling the products that might very readily be furnished to them by Canadian mineral deposits.

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