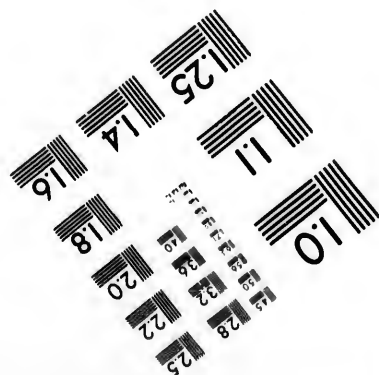
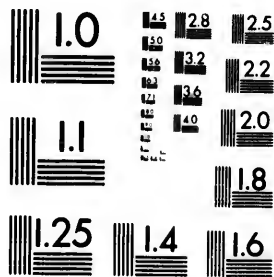


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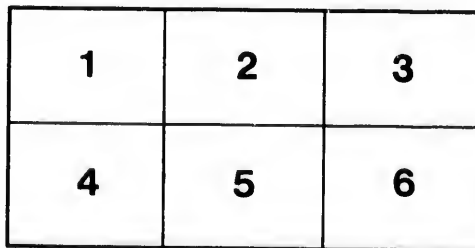
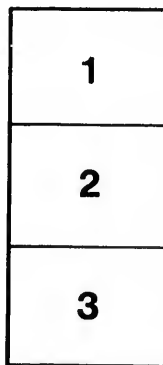
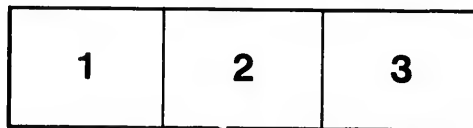
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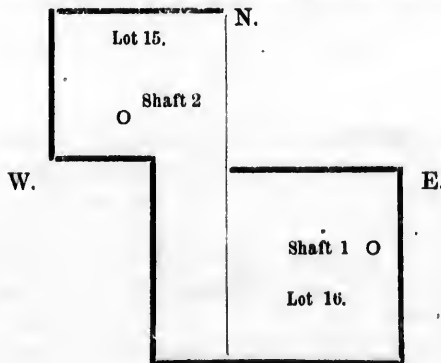
Frontenac Lead Mine

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FRONTENAC LEAD MINE.

This mine is situated about sixteen miles from the Port of Kingston, on Lake Ontario, by good roads. It comprises the south half of Lot 16 and the east and north parts of Lot 15 in the 9th Concession of Loughborough, containing about 200 acres, transversed diagonally for a distance of nearly a mile from south-east to north-west by the principal lead bearing vein, 10 to 12 feet wide, richly charged with galena, and cutting the country rock at right angles. On this vein two shafts have been sunk about half a mile apart. The eastern shaft, or No. 1, on Lot 16, has been sunk nearly 200 feet, with an adit of 450 feet at a depth of 40 feet and 18 and 28 fathom levels along the vein and between its walls. The western shaft, or No. 2, on Lot 15, has been sunk to about 30 feet, and the last ore raised from the bottom was a cubical mass of almost pure galena of about 200 pounds weight. This shaft is provided with a steam engine and hoist. At and near shaft No. 1 the following buildings have been erected:—(1.) Shaft house. (2.) Dry house. (3.) Office. (4.) Engine and crusher house, 82x44, with powerful engine and crusher. (5.) Dwelling house, 36x26. (6.) Boarding house, 48x21. (7.) Blacksmith's and carpenter's shop, 31x25. (8.) Barn, 36x24. (9.) Mill building, 60x60 and two storeys high, containing under one roof engine of 40 horse power, with two boilers, very complete pumping and hoisting machinery, drum, cables, &c., two sets crushing rolls, two sets jiggers, and other washing and dressing plant, Mackenzie blower, and American smelting furnaces. Lead to the value of \$25,000 was obtained from the mine by the late lessees. Phosphate of lime has also been discovered in several places on this property, and the Foxton phosphate mine on Lot 13, in 10th Concession, about 800 yards north-west, has just changed hands at \$30,000.

SKETCH OF PROPERTY SHOWING COURSE OF VEIN AND SHAFTS 1 AND 2.



REPORT OF H. G. VENNOR

In Canada Geological Survey, 1869, p. 164.

In connection with my examinations of the lead deposits of Hastings region I visited the Frontenac mine in the rear of Kingston. The rock of the country consists of grayish and reddish gneiss, interstratified with thick bands of crystalline limestone, all striking N.N.E. and S.S.W., and dipping to the westward at a high angle. The vein cuts these various bands at right angles, having a course about N. 75° W., or W. 70° W. (mag.) The portion worked has a slight underlie to the north, at the surface, but becomes vertical at a depth of 60 feet in the main shaft. From this shaft an adit has been run about 400 feet west and 50 feet east. The average width of the vein appears to be about 10 feet, although at the main shaft it varies from 13 to 19 feet. The vein-stone, which consists of galena only, is arranged in bands, more or less coarsely crystalline, and sometimes of a purplish or lilac color. The only other minerals observed were very small quantities of iron and copper pyrites and blende. The galena is diffused in crystals and bunches throughout the whole vein, but appears to be more abundant towards the north wall. It also appeared to have a disposition to run in shoots, having a western slope of about 45°. Between 1000 and 2000 tons of ore had been mined. This had been sampled and portions of it assayed mechanically by Dr. Dawson, Prof. Chapman, and others, the mean of whose results gave from 12 to 15 per cent. of galena.

REPORT BY E. J. CHAPMAN, PH.D., LL.D.,

Consulting Mining Engineer, and Professor of Geology and Mineralogy, University College, Toronto.

In association with Professor Bell of Kingston, whose intimate knowledge of the location rendered his co-operation most valuable, I have visited and carefully examined the mineral property of the Frontenac Lead Mining Company.

This property comprises the south half of Lot 16 in the 9th Concession of the Township of Loughborough, County of Frontenac, and contains about 200 acres.

In its surface aspect the location presents very favorable conditions

for mining purposes. The southern portion consists of high ground, intersected by narrow valleys running in a general north and south direction, or parallel with the strike of the strata; whilst towards the north the high ground terminates in a more or less abrupt escarpment, the general trend of which is not far removed from east and west, its course being thus nearly at right angles to the direction of the valleys. North of the escarpment the ground slopes gently towards a small sheet of water known as Indian Lake. By this outlet water communication might be established, if thought desirable, with the Rideau Canal; but a more direct communication with the front is afforded by several roads, the distance from Kingston by one of those being under 16 miles. This lake is not the only water supply upon the property, A small but un-failing stream flows through the principal valley of Lot 16 and empties itself into the lake. It can be made available at a very trifling expense, for washing and dressing the ore derived from the mine. It runs in close proximity to the mouth of an adit, now being driven on the property, and is within a few hundred feet of the principal shaft. A farther important feature as regards surface conditions is the abundance of good timber present on the location. An inexhaustible supply for timbering the underground works is thus provided; and an abundant stock of fuel for smelting purposes can be obtained, at little cost, from the surrounding district.

The country rock of the location belongs essentially to the Laurentian or gneissoid series. It consists of alternate bands or strata of gray and reddish gneiss, interstratified with crystalline limestone. On one portion of the property there is also an outcrop of sandstone, apparently belonging to the Potsdam division, which would answer, if necessary, for the outer portions and casings of furnace work, and for other building purposes. The Laurentian strata dip at an angle of from 80° to 85° , in a westerly direction, their strike being N. 20° E. The valleys or depressions, referred to above, have been excavated by denudation and atmospheric agencies in the surface of the limestone beds, and are usually marked by swampy land.

These various beds are cut transversely, or almost at right angles, by a series of parallel veins, running N. 65° W. The principal vein occurs just below the foot of the escarpment described above, and runs roughly parallel with this throughout the entire location. It appears, indeed, to extend far beyond these limits, but probably presents at no other part of its course so striking a development. It averages on Lot 16 at least 12 feet in width, and cuts the strata almost vertically, or with only a slight underlie towards the north. It consists, at this part of its course, of very pure and crystalline carbonate of lime, carrying workable quantities of galena, but without the slightest admixture of quartz, zinc blende, or other minerals which so frequently impair the quality of ga-

lena veins. The mineral galena is the ordinary ore from which almost all the lead of commerce is obtained. When pure and freed from gangue it contains 86.6 per cent. of lead, and 13.4 per cent. of sulphur; but a portion of the lead is very generally replaced by a small amount of silver.

A shaft has been sunk and timbered on this vein to a depth of between six and seven fathoms, or nearly 40 feet, and an adit level is being driven on the course of the lode from near the stream on Lot 16, to intersect the shaft. It will cut the latter at a vertical depth (from the mouth of the shaft) of about 50 feet. The present length of this adit is about 25 fathoms, or 150 feet, but it is being rapidly increased. The adit is at too high a level to effect much beyond a surface drainage of the mine, but the nature of the ground renders this unavoidable. It will serve, however, effectually to intercept the flood water, resulting from the melting of snow, or from heavy rains, on the high ground; and it will also form a convenient channel for the outflow of the water pumped from the workings as the shaft progresses in depth, and stoping becomes regularly carried on. The present workings show no diminution in the width, richness or quality of the lode; and it may reasonably be inferred, from the great strength and continuous run of the vein, that these favorable conditions will hold good, if indeed they do not become more favorable, at greatly increased depths.

The extreme width of the vein makes the latter appear at first sight to be less rich in galena than is really the case. Here and there comparatively poor pieces of veinstone will of course occur; and, as pointed out to me by Prof. Bell, the vein appears to be less rich where it cuts the red gneiss than where it traverses the gray rock; but in places some very rich stones of ore have been taken out of both the shaft and adit. Without operating on several tons of material, it would be difficult to form a correct estimate of the average amount of galena in the ore; but careful examination of the heaps on the ground will warrant, I think, the assertion that at least one-tenth in bulk consists of galena. The miners on the spot estimated the bulk of galena as varying from one-fifth to one-ninth of the mass. On the assumption that one-tenth in volume consists of galena, the latter would amount in weight to one-fourth of the ore, or 25 per cent.; and the percentage of metallic lead would be equal to 21.65. The amount of ore obtained at the time of my visit (April 28th of this year) amounted to about 1300 tons. Allowing for the usual loss of lead in the mechanical and furnace treatment of the ore, and deducting the cost of the treatment by modern processes, the value of the ore (if reduced upon the ground) would amount to about \$11½ per ton, giving a value of nearly \$15,000 for that already brought to surface at the above period.

The vein possesses several conditions which add much to its value.

In the first place it is composed of comparatively soft material, and is thus easily and cheaply worked. Secondly, its great width enables the miner to leave the hard wall-rock altogether untouched, more than sufficient space for working being found within the vein itself. Thirdly, the veinstone contains neither quartz, zinc blende ("black Jack"), or other minerals, which so frequently interfere with the successful, or at least economic treatment of galena veins; and, fourthly, the lead extracted from this ore, as found by my experiments, is of exceedingly good and pure quality.

I have made several assays of the galena, in order to determine the amount of silver contained in it. These assays show a mean amount of 4 oz. 12 dwts. 11 grs. per ton (2000 lbs.) of reduced lead. This amount is scarcely sufficient to defray the cost of extraction in Canada, at least under existing circumstances; but it will add to the value of the lead in the British market. Being also much in excess of the amount usually present in Canadian galenas, it may be found to increase at greater depths, or where the vein traverses the beds of crystalline limestone.

The following statement may serve to convey a more definite idea of the value of the Frontenac lode. Confining our estimate to that portion of Lot 16 on which the works are now being pushed forward, and to which, in all probability, they will be for some years restricted, we may regard the length of the lode within this area as equal to about 166 fathoms. The average width of the vein throughout this length is at least a couple of fathoms, or 12 feet. Placing the drifts or galleries at 10 fathoms apart, and assuming the specific gravity of the mixed ore to equal 3.7 only, the stoping ground between two drifts would give, on an average, 82,678 tons of ore. This amount, allowing fully for loss in treatment, should yield at least 16,530 tons of lead. Putting the cost of obtaining this at \$7 per ton of ore (an estimate sufficient to cover every possible item), and assuming the value of lead in Canada to be \$80 (£16 stg.) per ton of 2000 lbs. (a price below the present value), the credit and debit account would stand thus:

Value of 16,530 tons of lead at \$80 per ton.....	\$1,322,400
Cost of mining and treating 82,678 tons of ore.....	578,746
	\$743,654

As it would be scarcely judicious to uncover the vein above the adit now being driven, the first drift or gallery would be placed at about 110 feet below the mouth of the shaft, the adit cutting the shaft at about 50 feet from the surface. If, consequently, the vein were to become altogether barren at that comparatively slight depth (a most improbable conjecture, it must be understood), a very large profit would be realized from that one portion of the mine alone.

The American hearth, giving a blast heated by the combustion of the

ore and fuel, will probably be found the most suitable furnace for the reduction of the Frontenac ore, notwithstanding the loss of metal entailed by its adoption. Workmen acquainted with the proper management of this furnace can be readily obtained, and the process of reduction by its use is very simple, and cheaply carried out. Pine wood is chiefly employed as fuel, and very little is required, the heat being derived, to a great extent, from the combustion of the ore. An ordinary furnace of this kind will give from $3\frac{1}{2}$ to $3\frac{3}{4}$ tons of lead, at a cost of about \$2 per ton (or rather less) for fuel and labor, in each shift of 24 hours. Much of the ore may be rendered fit for furnace treatment by simple hand dressing, but the amount of galena saved by a more complete system of separation, would soon cover the cost of a crushing mill and washing apparatus. The proper site for the erection of these would, of course, be in the immediate vicinity of the stream on Lot 16, and a light tramway should connect the dressing ground with the mouth of the shaft. The shaft itself is already well housed; and a large shed for storing ore, together with a boarding house, blacksmith's shop, stable, and powder magazine, have also been put up for permanent use.

In conclusion, I may express my conscientious opinion that, under judicious superintendence and liberal management, the property of the Frontenac Lead Mining Company cannot fail to yield an ample return for the necessary outlay expended in its development.

EDWARD J. CHAPMAN.

TORONTO, May 8th, 1868.

REPORT BY SIR J. W. DAWSON, F.R.S., F.G.S., &c.,

Principal of McGill University, Montreal.

I visited the Frontenac Lead Mine on the 15th instant, in company with Dr. T. Sterry Hunt, F.R.S., of the Geological Survey of Canada, Prof. Bell, F.G.S., and Mr. Romanes, of Kingston; and now beg leave to make the following statements with reference to the results of my observations.

I.—GEOGRAPHICAL AND GEOLOGICAL RELATIONS OF THE DEPOSITS.

The mine is situated in the 9th Concession of Loughborough, Ontario, 15 miles north of Kingston, and on the border of a small lake, known as Indian Lake. The rock formation in which it occurs is the Lower Laurentian of Sir W. E. Logan's reports, consisting here of thick beds of silicious and felspathic gneiss, alternating with crystalline limestone. The beds of gneiss are nearly vertical, their dip being to the westward

at angles of 80° to 85° . The strike of the beds is from $N. 15^{\circ} E.$ to $N. 30^{\circ} E.$ by compass. The gneiss constitutes ridges, traversing the country in the direction of the strike of the beds, while the limestones form intervening depressions, as is usual in the Laurentian districts. Certain felspathic bands or masses in the limestones produce occasional slight elevations in the valleys occupied by the latter.

The lead veins belong to a series of transverse fissures, traversing the beds nearly at right angles to their strike, or with a direction of $N. 60^{\circ} W.$ These fissures, or the larger of them, constitute weaker places in the ridges of gneiss, and thus form notches or rows of "sink holes;" and in some places movements of displacement have occurred along the line of the veins, causing abrupt transverse escarpments, the downthrow being to the north.

The veins of this district are not local merely, but belong to a series of fissures, traversing extensively the Laurentian district of this part of Canada, and extending into St. Lawrence County, New York, where they have long been mined for lead. In the locality, now under consideration, they appear to be exceptionally large and productive.

II.—NATURE OF THE DEPOSITS.

The principal vein, which we may designate No. 1, is well seen in an adit, excavated in the course of the vein from the level of Indian Lake, and in a shaft 500 feet distant, on ground elevated about 50 feet above the mouth of the adit; and also in some surface excavations on the crop of the vein.

It is a very large and regular fissure vein, with an underlie from the perpendicular of about 5° to the north. Its width varies from ten to 15 feet. With the exception of a small quantity of greenish argillaceous rock, lining the south wall, the vein is filled with white crystalline calcareous spar, holding numerous crystalline aggregates of galena, or sulphide of lead, the most important ore of the metal. The only other minerals observed were small quantities of hydrous peroxide of iron (gossan) and of iron pyrites, and these are limited to the argillaceous band or "selvage," before mentioned. As in most large mineral veins, the veinstone presents, especially near the walls, a series of parallel bands, produced by layers of calcareous spar and galena, and probably indicating successive periods of deposit. These bands are often so distinct that the veinstone readily breaks with smooth surfaces along their planes of junction.

The part of this vein which may be regarded as proved extends from the shore of Indian Lake about 650 feet to the eastward, in which space the ground rises in the course of the vein about 50 feet, and that to the south of the course of the vein much higher; the vein itself, as already mentioned, evidently constituting a line of downthrow to the north.

Throughout this distance the vein retains the thickness and composition above stated, and its walls consist of grayish silicious gneiss.

Beyond the limit above stated, the vein No. 1 is not seen for about 400 yards, when it appears traversing a ridge of reddish felspathic gneiss, and reduced to a thickness of about nine inches of spar, with little galena. This seeming failure of the vein is apparently connected with the occurrence of another large vein, which we may designate No. 2, about 100 yards to the north of the course of No. 1. In a shaft sunk on Lot No. 17 this second vein is seen to be 11 feet wide, and to contain calcareous spar similar to that of No. 1, but apparently holding less galena. Its strike, at the point where the shaft occurs, is N. 54° W., but, judging from other exposures, it varies somewhat in its direction.

In tracing vein No. 2 back to the westward, it is seen, near the boundary of Lot No. 16, to turn, or give off a large branch running N. 75° W. toward vein No. 1, and here the galena again becomes abundant. This cross vein apparently connects at this place veins No. 1 and No. 2, and in my opinion, explains the dwindling of the former in proceeding to the eastward.

The veins have not yet been traced into the bands of crystalline limestone, lying on either side of the belt of gneiss above referred to. That they extend through these, is indicated by springs and accidental discoveries of galena in the soil, as well as by their appearance in the ridges beyond the limestone valleys. It will form a very interesting question in the exploration of the deposits, whether the veins, as is probable, improve in productiveness in passing through the limestone; and it would be desirable, as soon as possible, to ascertain whether this is the case. At present the elevation of the ridge of gneiss renders the vein more conspicuous and accessible than in the limestone; but when the mine becomes extended in depth there will be no obstacle to prevent the following of the veins into the limestone, should they prove productive.

III.—OPENINGS OF THE VEIN.

The principal openings are the adit and shaft already mentioned.

The adit was, at the time of my visit, 155 feet in length, and was being pushed forward. It is 6 feet in width, and as the vein curves slightly, it exposes in one place the north and in another the south wall of the vein, but in no place its whole thickness. The quality of the vein is apparently uniform throughout the length of the adit, and all the matter extracted from it is sufficiently rich for crushing, except a small quantity of barren calcareous spar, and a little gossan or yellow peroxide of iron. On the wall the veinstone is in direct contact with the edges of the strata of gneiss; on the south wall, the "selvage" of greenish argillaceous matter already mentioned, appears, with small quantities of iron pyrites.

The shaft exposes a thickness of 10 feet 6 inches of the vein to a depth

of forty feet. The whole of this thickness is calcareous spar with galena, without any other matter. The appearances are the same with those presented in the adit. It would appear that the total width of the vein at the bottom of the shaft is not less than 19 feet, of which 6 feet are occupied with the argillaceous matter already mentioned, leaving 13 feet of veinstone and ore.

The walls, as seen in the shaft, are similar to those in the adit, and there can be no doubt that the intervening portion of the vein, not yet opened, must be of the same dimensions and character. The shaft indicates that the vein widens somewhat in descending into the earth, and there is no indication that its quality becomes deteriorated. From the nature of the containing rocks, it may be safely inferred that it is continuous to a greater depth than mining excavations will ever reach.

There is no appearance in the shaft or adit of any faults affecting the vein. In the former the dip of the gneiss on the north wall, was seen, in one place, to change to N. 60° E., at an angle of 45°, without affecting the vein.

In both the adit and the shaft the gangue is more coarsely crystalline toward the centre of the vein, and more banded toward the walls, and the quantity of galena appears to be greater toward the sides, especially the north side; but the whole thickness is sufficiently rich to be profitably mined.

The quantity of water in the adit and shaft is not excessive or threatening; and from the texture of the rocks and veinstone, I should not anticipate any serious difficulty from this cause.

The above openings are on vein No. 1, which is evidently the most important for immediate mining operations.

IV.—QUALITY OF THE VEIN.

The gangue in vein No. 1 is composed entirely of crystalline calcareous spar containing galena in crystalline grains and masses of various sizes.

Observing that the estimates of Prof. Chapman and Mr. Robb are somewhat different as to the percentage of galena in the vein, we carefully examined the heaps of ore and veinstone taken from the shaft and adit, and amounting to a quantity estimated at 1300 tons, and agreed that the galena might amount to from one-fifth to one-sixth of the weight of the whole mass of the unsorted material; so that out of the comparatively small and superficial excavations above described, at least 213 tons of galena had been obtained.

In order more correctly to estimate the value of the ore, an average sample of about 70 pounds was carefully selected, and having been broken and divided into portions, one of these was carefully washed, under my inspection, and gave 16.5 per cent of pure galena.* I am con-

*Dr. T. Sterry Hunt, F.R.S., of the Geological Survey of Canada, writing from Montreal, under date 9th May, 1868, says: "I have found my portion of the sample from the Frontenac Lead Vein, to contain, as near as may be, 16 per cent. of galena, which agrees closely with Dr. Dawson."

fidest that this proportion is not above the average produce which will be obtained on the large scale. It is equal to 330 lbs. of galena or 280.5 lbs. of lead, per ton of 2000 lbs. At the same rate, each cubic foot of the vein contains 25.7 lbs. of galena; each cubic fathom, 2.77 tons; and each square fathom of the vein, estimated at 10 feet thick, which is below the average width, 4.62 tons. At the rate of \$70 per ton of galena, each cubic fathom of the vein is worth \$193.90.

Taking the actually proved portion of the vein at 600 feet in length, and supposing this portion to be worked by means of the shaft already in progress, and by levels at 60 feet apart, the space between two such levels or between the floor of the present adit and the first level, would afford 4,400 tons of galena, worth \$308,000, without, as far as present appearances show, a yard of unproductive working. It is probable that the depth to which such working could be carried would be limited merely by the mechanical difficulties of deep mining; and no account is taken of the almost certain productive continuation of the vein to the east and west of the limits above mentioned.

With reference to the value and productiveness of the mine, the following conclusions may safely be drawn from the facts above stated:—

1. The Frontenac Lead Mine, as now opened on vein No. 1, has exposed a deposit of remarkable richness and extent, warranting the erection of all necessary machinery for crushing, washing and smelting, with a certainty of very large profits, under management ordinarily skilful.

2. The further extension of this and its companion vein, on the property of the Company, is of undoubted value, and points to an almost indefinite future development of the mine.

3. The gangue of the vein is of such a character as to be easily mined, crushed, and washed from the ore, being free from hard substances, such as quartz, which would damage mining tools, or render the crushing more difficult, and from heavy minerals, such as barytes, which would interfere with the washing. The ore is also remarkably free from those other metallic minerals, as blende, pyrites, &c., which often occur with galena, and impede its reduction, or affect the quality of the lead. For these reasons no difficulties need be apprehended in the treatment of the ore, and the whole working of the deposit should be of a simple and inexpensive character.

4. Calculations of the probable profits of the mine may be safely based on the above estimate of 330 lbs. of galena per ton of veinstone; or 4.62 tons per running fathom.

V.—GENERAL REMARKS AND RECOMMENDATIONS.

The estimates made by Dr. Hunt and myself, as to the proportion of lead present, are intermediate between those of Prof. Chapman and Mr. Robb; and I fully agree with both of these gentlemen as to the great value of the property, and also in advising that advantage should be

taken in the exploration of the deposit of the experience gained in similar works of the United States. More especially as the vein is very similar in character to those worked at Rossie, New York, though of larger dimensions, the methods in use there, in so far as they are good in themselves, would be found suitable to the Frontenac Mine.

The present workings and the buildings of the mine appear to me to be judiciously planned and situated, and no wasteful expenditure seems to have been incurred. The stream which feeds Indian Lake will afford the water required for washing the ore. Wood for fuel and other purposes can be obtained very cheaply, and there will be no difficulty in shipping the produce of the mine from Kingston.

The present works and the portion of vein No. 1 already proved should be made the basis of operations; and even if the deposit should prove richer in the limestone, the present site will be found sufficiently suited for working this extension, and also for collecting the produce of such smaller workings as may be made to prove the deposit east and west.

The property now in possession of the Company, appears to contain all the more valuable deposits, and to be sufficiently extensive.

The percentage of silver found by Prof. Chapman in the ore, though for the present not deserving of entering into the calculation of the Company, points to the importance, when the mine shall be more fully opened, of making trials of samples taken from the different veins in different parts of their extension longitudinally, and also in their depth and width, since it is quite possible that the silver may be accumulated in certain portions of the produce of the veins, in such a manner as to make a separate extraction with reference to it, profitable.

It is possible that when excavations are made in the limestone valley on the course of the veins, quantities of alluvial or stream lead ore may be found to have accumulated from the waste of the outcrops of the veins.

In conclusion, I would repeat the opinion expressed above, that the deposit is of unquestionable richness and value, and free, in so far as can be observed, of any circumstances of a prejudicial character. I may add that it is, in so far as I know, by much the most important deposit of lead hitherto found in Canada, or in the neighbouring parts of the United States.

J. W. DAWSON.

MONTREAL, 27th May, 1868.

N.B.—The Kingston & Pembroke Railway is now being extended to Sydenham, within five miles of the mine.

