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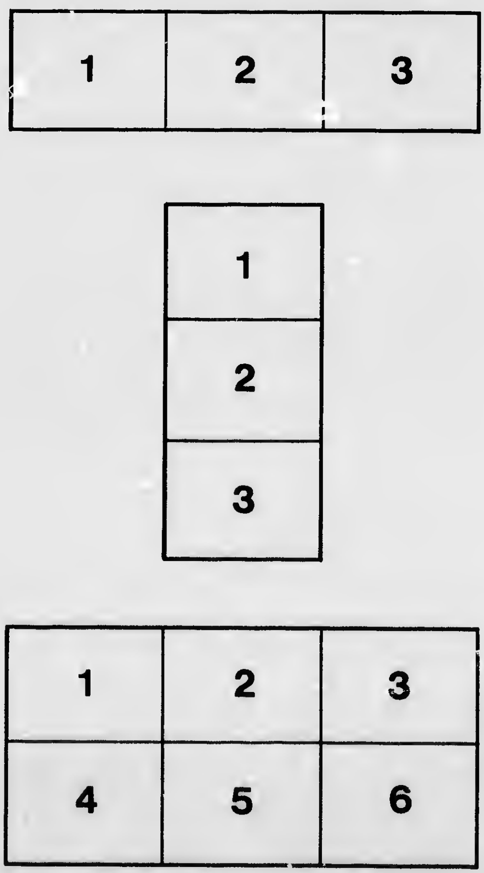
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REPORT

UPON

SMELTING IRON ORES

FROM

THE BRISTOL MINES,

PONTIAC COUNTY, PROV. OF QUEBEC,

—AT—

OTTAWA, ONTARIO,

—BY—

JOHN BIRKINBINE ENGINEER,

No. 25 N. Juniper St., Philadelphia, Pa.

OTTAWA:
PRINTED AT CITIZEN JOB DEPARTMENT, 48 & 50 QUEEN STREET.
1889.

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CHARLES MAGEE, ESQ.,

President Bristol Iron Company, Ottawa, Canada.

DEAR SIR,—The following data concerning the practicability of making pig iron in a blast furnace located in or adjacent to the City of Ottawa, using the ores from the mines of the Bristol Iron Company, are presented for your consideration. In the report some details are given concerning the location of mines, etc., which may appear unnecessary, but these are incorporated so that the whole subject may be fairly considered, and so that should it be desirable to bring the project to the attention of others, the report will be complete. Under these circumstances we may take up in order the source and character of the ore supply, the facilities for obtaining flux, the possibility of securing cheap fuel, the advantage of locating a blast furnace at Ottawa, the cost of producing pig iron there, and the possible market for the product of the furnace.

The exploitations at the Bristol mines are not new, for in "Notes on the iron ores of Canada and their development," by Prof. B. J. Harrington, he says that operations were commenced in 1872 and 1873, and that during 1873 some 4,000 tons of ore were mined.

Mr. Symons states that shipments of ore were made to the Charlotte furnace, New York, in 1884 and 1885 to the amount of 4,000 tons, and that 500 tons of ore had been hauled to the Pontiac Pacific Junction Railroad. An estimate of the quantity of ore on hand at the mines approximates 5,000 tons of roasted, and 2,500 tons of raw ore. The property has therefore been sufficiently exploited to demonstrate the character and extent of a portion of the deposit. A description of the mines accompanied by a map, a copy of which is attached hereto, appeared in the *Iron Trade Review*, of Cleveland, Ohio, July 16th, 1887. The publications concerning it above mentioned, and those to which reference will be made in the following pages, have therefore been sufficiently extended to have attracted attention, and to have exposed any fallacious statements had such been made.

At the time of my visit to the Bristol mines, the workings were inaccessible on account of flooding, due to idleness for a year. I requested Mr. C. C. Symon, manager, to write out a description of the location of the property, the apparent extent of the ore bodies, the exploitation which has been made, and other features which could only be obtained through persons familiar with the facts, and a copy of this letter is presented.

I, however, made a careful examination of the property, verifying in a general way the statements of Mr. Symons by means of a dip compass, and obtained corroborative evidence concerning the workings and the continuity of the ore from those who had examined the mine when it was operated about a year ago. I also inspected the plant of machinery, the roasting kilns, gas producers, and sampled the piles of raw and roasted ore.

The amount of ore removed has been sufficient to furnish ample testimony from those who participated in winning it to demonstrate the amount and character of the ore (or rock which was encountered), and additional developments can be made at any time to determine questions as to the future extent of the deposit.

Basing my conclusions on Mr. Symon's statement in view of the impossibility of personal inspection will therefore not appear as avoiding any responsibility, for abundant opportunity exists for proving or disproving his figures.

The extent of the magnetic attraction is so great that in view of the exploitation made the presumption favors finding the ore over a very considerable area, and the depth of the deposit can only be determined by actual development.

THE IRON ORE MINES.

The property of the Bristol Iron Company, Limited, is described by Mr. C. C. Symons, manager, as follows in a letter dated April 30th, 1889 :

"The Bristol Iron Company (Limited) own lot 21 and an undivided half of lot 22, Range 2, Bristol Township, Pontiac County, Province of Quebec, on which is found two lodes of iron ore, the general course of which is north north-west and south south-east ; what is known as the 'North' lode is apparently about 150 feet in width, and what is known as the "South" lode is believed to be about 250 feet in width. It is upon the south lode that most of the work has been done, two slopes having been sunk. The east slope has been carried down to a depth of 62 feet, and considerable ore removed. The centre slope is approximately 150 feet deep, and from this slope four drifts, two on each side, forming respectively the first and second levels, have been run. The first level starting at 30 feet from the surface, extends 20 feet south-east, and 50 feet north-west of the slope. The second level is 90 feet from the surface, extending 30 feet north-west of the slope and 100 feet south-east of the slope. On this latter drift a raise was made, and ore has been taken out of a chamber approximately 35 feet high, 50 feet long and 80 feet wide. The slope continues below this second level for about 60 feet, pitching at an angle of 60 degrees. The extent and general arrangement of the workings connected with the centre shaft appear on the accompanying sketch plan.

"The bottom and sides of the slope, the sides and ends of the drifts, the entire chamber, excavated, and in fact all the workings from within a few feet of the surface have been, and still are in good ore. In fact with the exception of occasional thin seams of rock a few inches in thickness, and one horse of rock 13 feet wide, which was struck in sinking the shaft, the entire workings have been and still are in ore, and neither foot-wall or hanging-wall have been found, nor are they expected until a closer approach to the limit of magnetic attraction is made. The north lode is about 250 feet from the south lode, and a test pit sunk on it showed ore from the surface for a depth of 20 feet.

"An apparently outlying body of ore, or a possible connection between the two lodes has been proven by a series of test pits, striking the ore at 5, 6 and 10 feet below the surface, one of which was carried down to a depth of 30 feet, and approximately 700 tons of ore mined."

The extent of the ore body as indicated by the dip compass and exposed outcroppings, and vouched for by a man of such experience as Mr. Symons, would appear ample to encourage the installation of a plant for smelting the ore, and personal investigations impress with me the belief that the Bristol mines should become as large a producer of iron ore as any of the ore properties which I have examined either in the Provinces of Quebec or Ontario.

It is, of course, impossible to state that all of the area over which the magnetic attraction is so marked will develop as favorably as the portions exploited. The compass may dip for a thin body of ore as much as for one which is thick, or be affected by alternating seams of ore and rock, as well as by a solid body of ore. But we may fairly expect that the strong attraction on either side of the workings which have been carried to a depth of 150 feet, to a length along the apparent strike of 160 feet, and to a width of 50 feet without finding foot-wall, hanging-wall or any end of the deposit, to demonstrate that there is an abundance of ore. An approximate calculation of the cubical contents of the working, and an estimate of the amount of ore on hand and rock removed, added to the ore which has been shipped, agree sufficiently to endorse the figures given by Mr. Symons.

A favorable feature of the deposit is the small proportion of lean ore which was found. The piles of ore and waste indicate that either good ore or rock was obtained from the workings. This may be different when the hanging-wall or foot-wall are approached.

The workings are reported to yield but little water, scarcely sufficient for the requirements of the machinery and kilns, therefore pumping will be but a light item of cost.

If a calculation based on the apparent width and length of the ore bodies and an assumed depth of workings was made, the resulting figures would be impressive, but such calculations are considered as more within the scope of promoter's statements than of an engineer's report, and will not be presented further than to show the possibilities of an area equal to that already developed.

Should mining operations be carried on at the mines on an extensive scale, the location offers some peculiar advantages, owing to the fact that four miles south-east of the mines the Ottawa river encounters a limestone ledge over which it falls in picturesque rapids and cascades about 40 feet. This water, power, locally recognized as the Chats rapids, could be utilized to advantange for producing power and compressing air which might be carried as a Quinnesec falls and Michigamme river, Michigan, to operate machinery at the mines, or by converting it into electrical force it may be conveyed so as to take the place of vegetable or mineral fuel in producing power.

In mining operations compressed air is now carried three miles, and the distance can readily be increased. The rapid advance made in utilizing electricity for power will commend itself without going into details at present.

CHARACTER OF THE ORE.

In a descriptive catalogue of the economic minerals of Canada, issued by the Geological Corps in 1886, the property under consideration is referred to as follows: "This ore occurs in a series of beds which are interstratified with reddish hornblendic gneiss, and glistening micaceous and hornblendic schists of the Laurentian age. The thickness of what appears to be the highest and most important bed has not been ascertained, but the lowest one exposed is about nine or ten feet thick. Openings were first made during the winter of 1873-74. Several thousand of tons of ore have been raised (see analysis A). The ore, though generally known as magnetite, contains a considerable proportion of hematite."

None of the analyses given below show copper, nor did I see any indication of it in inspecting the large amount of ore now on hand.

The following analyses have been collected from various sources. These analyses indicate a magnetic ore, rich in iron, very low in phosphorus, and carrying varying amounts of sulphur, but this latter in such proportion as to require roasting to obtain satisfactory results in smelting it.

ANALYSES OF MAGNETITES, BRISTOL IRON CO., P. Q.

	A.	B.	C.	D.	E.	F.
Metallic Iron.....	58.37	67.89	62.924	66.50	62.15	61.878
Sulphur.........	1.46	None.	......	.....	0.97	2.406
Protox. Manganese	0.11					
Alumina.........	0.60					
Lime	3.90					
Magnesia........	0.45					
Silica...........	11.45	0.2	......	5.556	8.52	7.32
Carbonic Acid....	1.64					
Phosphorus......	Trace.	None.	......	0.008	0.0075	0.006
Titanic Acid	None.	None.				
Water...........	0.14					

A. Geological Survey of Canada, Report of Progress, 1873-74.
B. Dr. S A. Lattimore, Rochester, New York, 1884.
C. A. McGill, Ottawa, 1888 (in slope 120 feet below surface).
D. S. W. McKeon, Youngstown, Ohio, 1884.
E. Prof. R. H. Richards, Boston, 1884.
F. Booth, Garrett & Blair, Philadelphia, 1887.

ROASTED ORES.

	G.	H.	I.	J.	K.
Metallic Iron.....	62.5	62.525	Not given	62.87	63.24
Sulphur.........	0.521	1.1673	0.279	2.221	1.08
Phosphorus	0.004	......	.....	0.014	
Manganese	.....	......	.....	0.09	

G. Lackawana Iron & Coal Co., Scranton, Pa., March, 1888.
H. McGill, Ottawa, January, 1888.
I. McGill, Ottawa, March, 1889.
J and K. Sherrerd, Troy Iron & Steel Co., Troy, New York, 1888.

Referring to Analysis A, Prof. Harrington says (vide Notes on the iron ores of Canada and their development): "The ore though generally called magnetic iron ore, is really a mixture of crystalline magnetite and hematite with a streak ranging in color from reddish to black. The specimen selected for analysis, and regarded as representing the average of what had been taken from the largest excavation up to July last (1873), was rather granular, of a dark grey color, and readily attracted by the magnet. The streak varied from reddish brown to black in places. Scattered here and there through the mass were nests of pyrites, some of them nearly a quarter of an inch in diameter, and with the glass disseminated grains of quartz, and calcite could be seen." The specific gravity was 4,32, and the results of the analysis as follows:

Peroxide of Iron	65.44
Protoxide of Iron	14.50
Bisulphide of Iron	2.74
Protoxide of Manganese	0.11
Alumina	0.60
Lime	3.90
Magnesia	0.45
Silica	11.45
Carbonic Acid	1.64
Phosphoric Acid	Traces.
Titanic Acid	None.
Water	0.14
Total	100.97
Iron as Peroxide	45.81
Iron as Protoxide	11.28
Iron as Bisulphide	1.28
Total Metallic Iron	58.37
Sulphur	1.46

"Combining a sufficient quantity of the peroxide with the protoxide to form magnetic oxide, we find the ore to be a mixture of magnetite and hematite, in the proportion of 46.72 of the former to 33.22 of the latter (1.40 : 1)."

The composition of the ore as shown above taken in connection with the inspection of the piles on hand, would indicate an ore obtainable for smelting purposes approximating 60 per cent. of iron, two per cent. of sulphur, with phosphorus much below the Bessemer limit, and when roasted this ore should exceed 60 per cent. of iron, with sulphur below one per cent.

To form an appreciation of the relative value of your ore with other similar ores, the following may be mentioned :

The Cornwall ore hills in Pennsylvania produced last year 722,921 gross tons of iron ore, and it is estimated that in the 150 years of their operation they have contributed nearly nine and a-half million tons to the total ore supply of the United States. This ore in its natural state will carry about 46 per cent. of iron, from one to four per cent. of sulphur, sometimes as high as one per cent. of copper, but it is below the Bessemer limit of phosphorus, and is very extensively used in the manufacture of Bessemer and other grades of pig iron.

The magnetic iron ores of New Jersey have also been very large contributors to the mineral wealth of the United States, and it is estimated by Prof. George H. Cook, State geologist, that the state has contributed about sixteen and a-half million tons, of which 447,738 tons were mined in 1888. The following table shows the composition of some of the New Jersey magnetic ores :

	46 Analyses of "Blue Ore" from Chester.	28 Analyses of "Green Pond Ore."	11 Analyses of "Red Ore."
Iron	48.60 to 57.68	52.153 to 58.32	53.955 to 57.497
Phosphorus	0.021 to 0.058	0.048 to 0.113	0.047 to 0.074
Sulphur	1.815 to 3.47	2.912 to 2.92	0.127
Silica	8.69 to 13.86	13.60	6.15 to 12.64
Lime & Magnesia	....	....	6.45 to 18.01

Extensive mines of magnetic iron ore at Boyertown, Pennsylvania, have been worked for years, the ores ranging from 35 to 60 per cent. of iron, sulphur 0.5 to 3 per cent., phosphorus 0.3 to 0.5 per cent.

The Tilley Foster mine in New York, which has produced over 1,000,000 tons of magnetic iron ore, averages about 49 per cent. of iron. It is of the Bessemer grade, and carries very little sulphur.

The Lake Champlain district has contributed fully fifteen million tons of magnetite to the iron ores of the United States, of which 789,-419 tons were mined in 1888. Some of these ores are of abnormal purity, but the majority of the ore shipped will show 50 to 60 per cent. of iron, and little or no sulphur, but some are quite high in phosphorus. The comparisons between the composition of your ore and those of Cornwall, Boyertown and New Jersey, are closer and more important than between the nearer deposits of Lake Champlain.

From the data above offered it is quite evident that large quantities of ore similar to those which are produced from the Bristol mines, are used, and that there will be little or no difficulty in smelting the ores, especially when properly roasted.

The following extracts from a paper by Mr. Edgar S. Cook,* whose reputation as a successful blast furnace manager is well recognized, will explain some objections raised to the use of all magnetic ores in the blast furnace.

"For special purposes, equally as good foundry iron can be made from all magnetites as from any other mixture of ores, but as a rule, irons made from magnetic ores exclusively will not rank as high as those made from mixtures consisting largely of brown or red hematites.

"The difficulty of producing a large percentage of foundry iron with magnetic ores was more marked with the small anthracite furnaces of former years than with the larger and better equipped plants of modern construction. The use of a portion of coke has made the

*Vide Journal of the United States Association of Charcoal Iron Workers, Vol. VIII., pages 21 to 25.

management, also, somewhat easier and consequently enabled the percentage of foundry iron produced to be increased."

"The difficulties attending the production of a large percentage of foundry iron from all magnetic ores, are due to several causes. Within certain limits, the greater ease with which the iron of an ore parts with its oxygen, the more regularly and rapidly will the furnace perform its work of reduction and melting, and the hotter will be the crucible with the same weight of fuel. That the reduction of magnetic ores proceeds more slowly than of brown hematites, or red oxides, is probably due as much to their mechanical structure as to any difference in chemical composition."

"The furnace gases experience more or less difficulty in penetrating, breaking up and deoxidizing dense ores ; they can be broken down more cheaply with hammers. Open porous ores, or ores containing considerable combined water, are quickly and thoroughly permeated, in consequence ; with magnetites there is a greater composition of heat in the lower parts of the furnace, and from the presence of ore only partially reduced, there is apt to be sudden variations in the temperature of the crucible. One of the conditions necessary to the production of a large proportion of the higher grades of foundry iron is almost absolute uniformity of the temperature of the lower parts of the furnace. The use of magnetic ores exclusively renders disturbances more frequent and less subject to control, owing to the difficulty of thoroughly deoxidizing them before reaching the crucible. With magnetites forming the burden, the rapidity of travel of the stock in the furnace needs to be very carefully watched, and the consumption of the slag kept as uniform as possible. Any considerable variation in slag or too rapid or too slow driving (variations that would pass unnoticed with easily reducible ores), are reasonably sure to produce marked changes in the furnace running on dense magnetites."

"The objections to structure do not hold good so far as the soft, earthy magnetic ores are concerned. These ores, on the other hand, usually carry considerable sulphur, an element which is well known as an unrelenting enemy of foundry irons. When present in the dense class of magnetic ores, it entirely unfits them for the economical production of foundry iron. When thoroughly roasted, however, these form fairly good mixtures, as the roasting not only removes the sulphur, but also opens the structure of the ores, rendering them porous and easily attacked by the blast furnace gases."

"Soft magnetic ores, free from sulphur, are fairly well adapted for making foundry grades ; with these forming a large part of the burden, no particular difficulty is experienced in making open grained iron ; this would indicate that the difference in chemical constitution between the magnetic and the red oxides is not responsible for the greater difficulty experienced in reducing magnetites."

"As a rule the gangue of magnetic ores contains but little free quartz or sand ; the silicon is usually in combination with alumina, lime or magnesia, and the slag to this extent is partially made, so that the limestone flux added to ore charge to produce slag of certain composition, combines with the gangue of the ore more readily, and at lower temperatures than when the gangue is chiefly quartz and sand. In consequence the iron made is less liable to contain reduced silica."

"Other causes effect the percentage of silicon in the pig-iron, but they pertain more to the management of the furnace than to the ores smelted. Large furnaces and super-heated blast permit of the production of high silicon foundry iron without particularly affecting the economy of the work."

"The low silicon foundry irons, made from magnetic ores, give varying results in the foundry, depending upon the knowledge of the foremen of the smelting departments ; these irons, when also low in phosphorus, require more fuel to melt and run them as fluid as irons rich in silicon and phosphorus, but the difference in cost of fuel per pound of iron melted is but trifling."

"While this fact is known to many founders, yet others conduct their cupolas without regarding the different requirements of irons of various compositions, and as a result, many imperfect castings are charged to the iron used when the fault really lies in the management of the cupola."

Sulphur is a less objectionable ingredient in iron ore than phosphorus, for it can be partially removed by roasting, and also decreased by proper fluxing in the blast furnace, as will be noted from the analysis given above of other magnetic iron ores which are in large demand in the United States; the amount of sulphur in the Bristol ore is no greater than in ores of which probably a million tons are annually used in the United States. The tendency of sulphur is to make iron "red short," i.e., to break readily when passing through rolls at a high heat, but in the manufacture of cut nails, etc., sulphurous iron is in demand. In foundry pig iron sulphur is conceded to give strength and also to increase the shrinkage, but as explained in the excerpts from Mr. Cook's paper, it interferes with obtaining a regular product.

Notwithstanding the fact that the amount of sulphur in the Bristol ore is not abnormally excessive, the erection of the plant of kilns hereinafter described, is considered to have been judicious for the ore after being treated in them will make a better iron than if used raw, and fully compensate for the outlay expended in roasting.

A large amount of the pig iron made from the Cornwall, Pa., ores enters into the manufacture of Bessemer steel rails, and the Bristol ore, owing to its low phosphorus contents, would, if there were steel works in existence in Canada, be in demand for the same purpose. If the ore continues of the composition as found by the analysis quoted, it will produce an iron lower in phosphorus than is necessary for foundry or other ordinary mill purposes, but will permit of mixtures with irons carrying this element in excess.

Emphasizing all the objections which can be made to a product such as will be obtained from the use of the Bristol ores alone in the blast furnace, there would appear an ample market for the product of several good-sized blast-furnaces, to displace a portion of the 250,000 tons of iron which are annually imported into the Dominion.

As the iron industry is developed, and the manufacture of iron and steel is extended, the product of furnaces using such ore will be in special demand, and to-day in the United States would command a price in advance of ordinary grades of pig iron.

With the local demand at Ottawa, and the Cities of Montreal, Toronto and Hamilton and intermediate points within convenient reach, offering a market, protected by customs duties of 1-10 cent per pound against foreign pig iron, there would seem to be sufficient encouragement for the establishment of an iron producing plant, if the figures of cost as hereinafter given are correct.

MINE EQUIPMENT.

An examination of the property of Bristol Iron Company, Limited, shows that it is well equipped for immediate operation. The machinery plant consists of a 14 x 20 steam engine, driving by friction brake one drum 6 feet in diameter, by 6 feet wide, so set as to allow room for a second drum; the one-inch wire rope from this drum passes over appropriate head sheaves, and thence down the slope to the bottom of of the mine. A small exploring hoisting engine is also in place for carrying ore from the bin at the head of the slope to the top of the roasters. An 18 x 30 Ingersoll air compressor, the necessary air receiver, and six Ingersoll drills with piping, furnish means for breaking down the ore. A 100 horse power steel return tubular boiler is connected to this machinery, and also to feed pumps, and the entire plant, together with a water tank, is accommodated in a frame building, 40 x 70 feet, covered with corrugated iron. The capacity of the hoisting appliances is about 300 tons of ore per day; this could be increased readily, but estimates will be made upon working the mine to this amount, viz., 300 tons daily.

There are also on the ground two 25 H. P. portable boilers, the necessary rope, sheaves, skip and skip tracks on the slope, in the mine and about the roasters. A frame blacksmith shop 20 x 30 feet with two fires, bellows and tools, and also the necessary tools for operating the mine and roasters, are in good condition. The roasting kilns and producers are protected by suitable buildings, and there are on the property an office building, two tenements, a stable, a magazine, a thaw house, and flatted timber sufficient for the other buildings. In short, the plant is equipped ready for immediate operation, having in addition to the buildings and machinery several hundred cords of wood, and probably 100 tons of coal on hand for fuel, and a large number of sills for extending mine and surface railroad tracks where necessary.

In describing the equipment it is proper to note the fact that a railroad has been projected which connects with the Pontiac Pacific Junction Railroad, passing through the property of the Bristol Iron Co. (limited), to the Ottawa river.

The portion of the road between the Pontiac Pacific Junction Railroad and the mine is now graded, and bridges built, railroad ties distributed, and I understand the rails are ordered; under these circumstances the railroad may properly be considered as ready to handle ore, for by the time that arrangements could be made for shipping on a liberal scale, such would be an accomplished fact. This road is, I am informed, 4¼ miles in length; should it in the future be continued across the Ottawa river, it would give additional railway connections, but for the present it will be proper to estimate all the ore as being carried to Ottawa.

ORE ROASTING PLANT.

The ore roasting plant connected with the mine is in advance of anything of which I have knowledge, consisting of three gas roasters of the two designs most approved, and four gas producers. Two of the roasters are of the Taylor-Langdon pattern, used in New Jersey and Pennsylvania, each 14 feet in diameter and 27 feet high, with seven ore compartments and eight drawing arches. The other kiln is patterned after the Davis-Colby kiln, used at the Katahdin Iron Works, Maine, and for which plans were supplied by Mr. Sjostedt. It is 17 feet in diameter, and 20 feet high. The four producers which are of the Taylor-Langdon pattern are thoroughly equipped and connected with the roasters.

The roasting equipment should satisfactorily treat 150 to 200 tons of ore per day, but to reach the maxiumum it may be necessary to add to the producer capacity. There is no question but that better results are possible by roasting ores with gas than in connection with solid fuel, and careful experiments show that in roasting kilns and gas producers such as you have constructed, the consumption of fuel (generally anthracite "buckwheat," or bituminous "slack" coal), is from 3 to 6 per cent of the weight of ore treated. The cost of fuel to roast one ton of ore at the mine should therefore not exceed 30 cents, or allowing for labor, handling, interest, repairs and renewals, the gross cost of roasting one ton of Bristol ore and delivering it on cars may be safely assumed at 55 cents. From the data obtained from the operation of the kilns at the Bristol mines, these figures would appear to be ample. The examination of the stock of roasted ore at the mines (probably 5,000 tons), shows that some of it has been imperfectly treated, but I feel confident that the difficulties will be overcome, and as the workmen become more thoroughly conversant with the different kilns, they will be able to handle them so as to produce uniform and satisfactory results.

UTILIZATION OF THE ORE.

The value of the Bristol Iron Mines are dependent upon the use of the ore which can be mined from them, and the annual capacity multiplied by a fair retnrn in profits, would when capitalized represent the money value of the property. A market can be obtained either by shipping the ore to existing blast furnaces, or by erecting blast turnaces to smelt it. Some years ago a large amount of ore was sent from mines near Hull, P.Q., to the United States, and as above mentioned some 4,000 tons of ore from the Bristol mines were also forwarded. I am informed that contracts can be made for delivering this ore (using the new railroad constructed to the mine) in the city of Ottawa for 45 cents per ton, the distance being about 35 miles. I also learn that ore was formerly carried from Ottawa to Prescott, a distance of 53 miles, for 50 cents a ton.

Up to the present time ore has been mined very cheaply, but to allow for greater depth, possible faults, etc., the cost of delivering ore from the present workings on to cars or to the roasters is placed at 85 cents per ton. This will make the raw ore cost at the mine 85 cents per tor, and the roasted ore $1.40. If now we allow a royalty of profit on mining of 60 cents per ton, and take the freight rates as above, we have the following figures :

	Raw Ore.	Roasted Ore.
At the mines	$1 45	$2 00
At Ottawa	2 00	2 55
At Prescott, Ont	2 50	3 05

To reach furnaces in the United States the ore would be loaded on boats and carried to some favorable receiving port on the lake system, or sent direct in cars by all rail routes. In either case there would be a duty of 75 cents per ton assessed. This duty added to the price above given would make the ore delivered on the Canadian border ready for carriage to the United States blast furnace cost $3.25 per ton for raw ore, and $3.80 per ton for roasted ore, or approximately 5½ to 6 cents respectively per unit of iron in the ore. It is doubtful whether a market could be found for the raw ore which would compensate for the above items, agents' commisions, risks and transportation, but it is highly probable that a considerable amount of well roasted ore could be disposed of at satisfactory rates.

The better plan is to construct blast furnaces to smelt the ore, and considering this problem it is necessary to select a location which would be most advantageous for the purposes. All the transportation of the ore might be saved by erecting furnaces at the mines, but the fuel would have to be carried to, and the product brought away from the smelting plant. If the furnaces were located on the St. Lawrence river, or on Lake Ontario, the ore would meet the fuel at an intermediate point. My instructions were to report on utilizing the ore from the Bristol mines in blast furnaces to be located at Ottawa, and examination demonstrates that owing to the city being a railroad centre of importance, a consumer of considerable quantities of iron, that it is within convenient distance of other large consuming points, and that it has water connections by means of the Ottawa river and the Rideau canal, there does not appear any material disadvantage which Ottawa would possess as compared with points on the border, and in the present condition of railroad connections it appears to offer some important advantages over points at or near the mines, for while 1⅔ tons of ore would have to be carried from the mines to Ottawa, 1¼ tons of fuel, and one ton of pig iron, and also all the supplies would have to be transported to the furnace site from Ottawa.

No attempt has been made to investigate all the available sites for blast furnaces, but taking into consideration the facilities now existing in the city of Ottawa, it appears to be the most advantageous location for utilizing the ores from the Bristol mines. An examination of the vicinity of Ottawa developed four very satisfactory points where blast furnaces could be located to advantage, and where facilities are offered for adding other manufacturing industries in the future. Some of these points possess special merit as to certain features, but all are convenient to transportation and have ample cinder room, water, etc. The possibilities of making pig iron at Ottawa may now therefore be considered in addition to the ore, limestone, fuel and labor required. These features will next be taken up.

LIMESTONE.

Limestone is abundant in the territory about Ottawa, and the Geological Survey officers state that both limestone and dolomite, as well as intermediate qualities of magnesian limestone are obtainable. It is therefore possible to find either near the mines or the furnace location an abundance of limestone suitable for flux.

The prevailing price for limestone for building purposes in Ottawa is $6 per toise (one cubic fathom or 216 cubic feet), while stone for road building sells for $4 per toise delivered. Estimating a toise to weigh 11 gross tons, we find that the cost of limestone would approximate 50 cents per ton, to allow for a special selection of stone suitable for the purpose of fluxing the cost of limestone delivered at the furnace will be taken at 65 cents per ton. This figure is closely approximated by some blast furnaces in the United States, the flux for which is obtained from quarries convenient to them.

FUEL.

Inquiry made from various parties in Ottawa make the price of anthracite lump or steamboat coal delivered at the furnace site $5.20 per gross ton. This figure is about one dollar in advance of what it costs at the blast furnaces in New York State on Lake Champlain, and as the fuel could be carried by boats to Rouse's Point, and from thence by rail brought to Ottawa, a distance of 135 miles, the price named seemed to be a fair one. The location of Ottawa also permits of obtaining coal by all rail routes from the upper anthracite districts of Pennsylvania, or of transporting coal in boats received at lake points and carried via the Rideau canal.

With the data at hand it is impossible to form a comparison of the relative cost and value of Nova Scotia and Pennsylvania coke, but basing an estimate on prevailing prices elsewhere, Pennsylvania coke should cost but little, if any more per net ton, than anthracite coal per gross ton at Ottawa, except the duty, we will therefore assume the cost of one net ton of coke delivered at the blast furnace at Ottawa as $5.80. The fact that with a duty of 60 cents per ton against it, the bulk of the bituminous coal used in Ontario comes from the United States, and not from the eastern provinces of the Dominion, indicates that it is proper to base calculations upon the United States prices.

To appreciate the position of Otttawa to a fuel supply we may first consider its position in relation to the anthracite coal region, Pennsylvania, and taking Scranton, Pa., as a centre, we find that the circumference of a circle which passes through Ottawa, would also pass through or close to Cleveland, Ohio, London, Ont., Rouse's Point, N.Y., Portsmouth, N.H., and Richmond, Va. As the railroad connections between Scranton and Ottawa are nearly direct, and as there is no duty on anthracite coal, this fuel should be delivered in Ottawa at approximately the same all rail freight rates that prevail to the other points named. In the transportation of coke we find, making a similar circle with Connellsville, Pa., as a centre, that points approximately on its circumference would be New London, Conn., Springfield, Mass., Rutland, Vt., Crown Point, N.Y., on Lake Champlain and Chicago, Ill. Owing to the geographical position of Lake Ontario, the all rail route from Connellsville to Ottawa would probably be somewhat in excess of that to some of the other points. The furnaces on Lake Champlain use Connellsville coke as a mixture with anthracite, and the same is true of the furnaces at Troy, N.Y., which in a direct line is about 80 miles nearer Connellsville than Ottawa. Connellsville, Pa., and the boundary line of New Brunswick are practically the same distance from Ottawa. All of the blast furnaces at Chicago and vicinity which produced in 1888 517,238 gross tons of coke pig iron, employ Connellsville coke entirely for smelting the fuel costing them on an average about $4.50 per net ton delivered. It does not seem unfair, therefore, to expect that coke in quantity could be supplied at Ottawa at prices approximating those prevailing at Chicago, plus the duty of 60 cents, if the railroad companies will give rates of freight similar to those to Chicago, and the figures above given would therefore appear to be equitable. But very satisfactory coke for furnace use is now being produced in Pennsylvania 100 miles nearer Ottawa than Connellsville, and the use of such fuel would give Ottawa an advantage of fully 100 miles over Chicago in distance. In actual purchases a comparison of quality and cost will demonstrate whether coke would be best obtained from the eastern provinces or from the United States.

With coke a greater quantity and more uniform grades of pig iron would probably be made, in the same sized blast furnace, than by using anthracite alone, and although there is no doubt as to the possibility of employing anthracite coal entirely for fuel in smelting the Bristol ores, less coke than anthracite coal will be required per ton of product. The most advantageous method is believed to be to use 75 to 80 per cent. of selected anthracite, and 20 to 30 per cent of coke, and estimates will be made on this basis.

Allowing liberally for fuel consumption per ton of pig iron made the following comparisons are offered :

Using all anthracite :	
2,800 pounds of anthracite coal at $5.20 per gross ton	$6 50
Using ¾ anthracite and ¼ coke :	
2,000 pounds of anthracite coal at $5.20 per gross ton	4 64
650 pounds of coke at $5.80 per net ton	1 89
	$6 53
Using all coke :	
2,450 pounds of coke at $5.80 per net ton	7 11
Using charcoal :	
2,250 pounds of charcoal at $7.50 per net ton	8 44

These figures are higher than the best practice now requires, but in a report of this character it is advisable to make liberal allowances in fuel consumption, leaving advanced blast furnace practice to demonstrate that better results are possible.

No absolute data is at hand to form an estimate of the cost of obtaining fuel by water transportation, but I learn that when ores were sent from Hull to United States blast furnaces the freight rate by water from Prescott, Ont., to Cleveland, Ohio, was 75 to 90 cents per ton. This may serve in forming comparative figures.

LABOR.

Labor is abundant and of good quality, and in making an estimate of the cost of producing pig iron at Ottawa there appears no good reason for more liberal allowances than at iron producing centres in the United States, except such as should be made to provide for establishing an enterprise with new men. An estimate of $1.45 per ton is therefore made in the figures of cost.

ESTIMATED COST OF PRODUCING PIG IRON.

Taking the figures given in the report for the cost of ore, fuel and flux, we find that the materials necessary for the production of a ton of pig iron will amount to the following:

1⅔ tons of roasted ore at $2.55 per ton		$4 25
7/10 ton of limestone at 65 cents per ton...........		46
2,000 pounds anthracite at $5.25 per gross ton.	$4 64	
640 pounds of coke at $5.80 per net ton	1 89	
	——	6 53
Making a total for materials of............		$11 24
To this must be added for labor....................		1 45
Office expenses, supplies and incidentals............		35
Repair fund.................................		50
Interest, depreciation, insurance, etc...............		45
		$13 99

or say $14.00 per ton of pig iron made at Ottawa.

The present New York prices which are lower than for years past, owing to active competition, are as follows: No. 1 Foundry, $17 per ton; No. 2 Foundry, $16.00 per ton; Grey Forge, $15.00 per ton; say an average for the furnace of $15.00 per ton. The minimum prices now prevailing would give a profit of $1.50 per ton at New York quotations.

But New York prices do not prevail at Ottawa, and the present rate on No. 2 Foundry pig iron is given at $18.00 per ton at Montreal, to which must be added $1.25 for freight. The minimum price at which Scotch pig iron has been sold, is equivalent to $17.50 at Ottawa. Therefore at the present rates which are abnormally low, the establishment of an iron industry at Ottawa would seem to offer a good return for the investment proposed to be made.

As the industry grows the cost of production would be apt to decline, and permit of the proprietors meeting any efforts to capture the market by foreign iron works, particularly if the Dominion Government should continue or augment the present bonus, or in other ways assist the earlier enterprise to maintain itself and win the home trade.

In view of what has already been said, there seems no necessity for dwelling upon the possibilities of a market, for the volume of importations shows how large is the demand for pig iron in the Dominion of Canada, and familiarity with the prominent cities of Canada is sufficient to convince an inquirer as to the chances of the Dominion using Canadian pig iron.

BLAST FURNACE PLANT.

In recommending the erection of a blast furnace plant, one of moderate capacity is advised because it will require less immediate outlay, it will give the operators an opportunity to handle the product to better advantage, and an initial plant so constructed as to admit of enlargements in the future by adding additional furnaces will undoubtedly be better than the immediate construction of a more pretentious plant. In providing a location I would recommend, however, that ground sufficient for two or more furnaces be secured, and that if possible additional territory be provided so as to permit of extending the manufacture of the pig iron into bars, shapes, etc.

A blast furnace approximating the following dimensions is recommended: height 75 to 80 feet, bosh diameter 15 to 16 feet. With all coke and easily smelting ores, such a furnace should produce from 100 to 140 tons of pig iron per day, but with your ore, and the fuel which would appear to be the most economical to use, such a furnace is not considered to have a capacity greater than from 80 to 100 tons per day. This would appear to be ample for the immediate requirements of local consumption, and the product would not be so large as to give trouble in handling. For the amount of pig iron for which a market would have to be found, allowing for stoppages, etc., would be from 24,000 to 30,000 tons per annum.

In constructing a blast furnace plant there is but little of it which would be more expensive at Oattwa, than at iron producing centers in the United States. For the present you would probably have to import your fire brick, but a very large portion of the equipment could be provided by Canadian work shops. It is probable that you will find it advantageous to import some ot the special machinery required, for the reason that those manufactories that make the production of such machinery a feature could probably deliver the material at Ottawa and and pay the tariff assessed upon it, in competition with Canadian parties with whom the manufacture would be at best experimental. A furnace of the approximate dimensions above mentioned is estimated to cost at Ottawa from $155,000 to $170,000, add for railroad connections and ground say $20,000, therefore a blast furnace plant well equipped, and first class in every respect should be erected ready for operation at Ottawa for less than $200,000 including all cost of installation, etc. But to operate it a working capital should be provided sufficient to run the plant to the best advantage, and I would recommend that the organization start with a capital of not less than $250,000. In the estimate allowance is made for land, but it would appear that an industry which offers so many advantages, and which will do so much to develop Canadian resources, should meet with favor sufficient to secure the granting of the necessary land, a remission of taxes and possibly a bonus from the community or land owners who will be directly benefitted by its location, for the successful operation of a blast furnace will draw around it other industries, increasing the manufacturing population, and largely augmenting the value of adjacent land.

From the figures of cost, and the prevailing rates at which pig iron is now sold there is evidently such encouragement as will demonstrate that a satisfactory return for the money invested would be obtained as soon as the industry is fairly established, and from these figures a calculation can readily be made as to the possible earnings which a blast furnace plant would bring to its proprietors.

Although the instructions given practically confine the report to utilization of the ores from the Bristol iron mines it would be improper to close this review without calling attention to the fact of the existence of other ores within convenient reach of Ottawa which will permit of making such mixtures for iron as would meet special demands; but as this feature would be one for the consideration of the management, it will merely be referred to here as an additional endorsement of the project for a smelting plant at or near Ottawa, and as evidence that such deposits have not been overlooked.

IRON INDUSTRIES IN CANADA.

Surprise is often expressed that with its mineral wealth, and with its large demand for iron, Canada has produced so little of this important metal, but an examination of the records show that a large amount of money has been expended for the development of the iron resources of Canada, which as a rule has given unsatisfactory returns. Such a history has a demoralizing effect upon investors, who see results only, and fail to seek for causes. With but one exception, all the blast furnaces in Canada have used charcoal, and most of the iron made in the Dominion was produced with charcoal, using principally the lean bog ores, and making an iron especially adapted for chilling.

It is only within the last decade that iron received any protection from the Dominion Government, which protection amounted to but $2 per ton, until within five years, when a special bounty of $1.50 per ton of pig iron made in the Dominion was granted by the Government; this bounty will be reduced next June to $1, and will continue for three years, unless the Government should see proper to extend or increase it. The duty and bounty combined therefore is 15/100 of a cent per pound, or just one-half of that now paid by foreign pig iron entering the United States. Canadian development has thus had to contend with a moderate protective tariff as compared with that of the United States, and has been a large consumer of pig and manufactured iron brought chiefly from across the Atlantic ocean. From a report dated 1883 by the writer the following is copied, as it must be a feature for consideration in establishing a plant now: "It is not to be presumed that those now supplying Canada with pig iron will fail to contest for the market with home production, but with a duty and bonus representing $5.50 (now $5) per ton for product, I see no reason why Canadian pig iron should not be able to largely or entirely displace that now imported."

Another drawback to the development of the iron industry is that capital invested was largely devoted to experimental processes or put into plants more pretentious than a careful study of the immediate market demands would then encourage. Had the money devoted to experimenting with processes which would not be considered in the older iron producing districts as economical been devoted to erecting blast furnaces of moderate size, it is probable that to day Canada would have established within her borders an important iron industry. Unfortunately all such failures awaken distrust, and this taken in connection with the exhaustion of bog ore deposits, and the deforestration of woodland convenient to the charcoal iron plants, which prevents their continuing as competitors on any considerable scale with other iron works has apparently produced an impression that Canada is not in a position to make its own iron. It is highly probable that within a year or two this impression will be dispelled, for there is no doubt but what the Dominion can and will manufacture a large proportion of the iron which it consumes.

The Montreal *Gazette* echoes the prevailing sentiment when it says: "For a variery of reasons the manufacture of charcoal iron in Canada has not been attended with much success. A certain want of confidence exists in relation to it, and the conditions of success have been concluded as against it is partly due to the general ignorance of the trade, owing to its small extent so far."

Mr. J. H. Bartlett, of Montreal, in a paper presented to the American Institute of Mintng Engineers at their Halifax meeting gave a review of the various attempts to manufacture iron in Canada. He says that "The facts then presented were not such as to offer much encouragement to anyone to embark in similar enterprises under the conditions then existing, but, happily these conditions are now changed, and an early development may be anticipated."

"A variety of experiments have been made, which are counted as failures in the iron manufacture, bringing unwarranted discredit upon this industry. The experiments in many cases were costly, and were undertaken by patentees of all kinds, of no standing or experience in the trade. The only attempt ever made to manufacture coke pig iron and refined bar iron has proved the possibility of so doing. The quality of the article is in both cases superior to that imported and commands a higher price."

"The importance of the manufacture of iron to the country generally will be appreciated when it is stated that the total balance of trade against Canada from 1868 to 1886 was $381,000,000. The total value of the imports of iron and steel during that period was $253,250,000, from which it may be assumed that the balance of trade would have been in our favor had we made our own iron."

"For a young country with a small population, the amount of iron and steel consumed in Canada is remarkable. In the year 1878 a greater money value of iron and steel was imported into Canada than into the United States; and not making any iron of our own, the value of our consumption of iron and steel, per capita of the population, is always many times as much as the value of the imports per capita into the United States."

Further evidence of the appreciation of the importance of an iron producing industry and faith in its establishment could be offered from the budget speeches and other proceedings of the Dominion Parliament, and a history of the "Manufacture of iron in Canada" by J. B. Bartlett, (vide Transactions of the American Institute of Mining Engineers, vol. xiv., page 508) shows how and where the attempts to establish an iron industry were carried out. A perusal of this paper in connection with those above mentioned fails to demonstrate any cause for failure of an enterprise properly established at Ottawa.

RESUME.

Having discussed the project in detail the following brief recapitulation is presented for your convenience.

1st. The property controlled by the Bristol Iron, Company Limited, Pontiac County, P. Q., shows by the exploitation already made as per statement of Mr. Symons, by the large stock of ore on hand, by the shipment and use of some 4,000 tons of ore and by the extensive magnetic attraction, the evident existence of a considerable body of magnetic iron ore. See page 5.

2nd. The quality of the ore as demonstrated by the analyses furnished is very good. The yield of iron being high, and the only drawback a considerable percentage of sulphur, which can be largely reduced and the ore made less refractory by roasting producing an ore carrying over 60 per cent of iron, probably 0.5 per cent of sulphur and below the Bessemer limit in phosphorus. The roasted ore would be suitable for manufacture of steel rails, but in the absence of a tariff duty on rails there appears no immediate use for the ore except to produce ordinary foundry or mill iron. See pages 8 and 9.

3rd. The ore of the Bristol mines can be used alone in the blast furnace, but it would be unnatural to expect as uniform and good results as with the more readily smelted red hematites of Lake Superior. There, however, is ample ground for anticipating that the local demand for pig iron can be met by a blast furnace plant located at Ottawa using the Bristol ores. See page 14.

4th. The mine is thoroughly equipped with the necessary hoisting and drilling machinery, and is provided with the requisite buildings, tools and fuel ready for immediate operation. A railroad practically completed gives means of transporting the product of the mine to Ottawa or elsewhere. See page 15.

5th. The ore roasting plant is of the most modern type using producer gas for fuel, and embracing the two forms of kilns which have given the most satisfactory results. See page 16.

6th. The character of the ore after roasting in these kilns is such that it could be shipped to blast furnaces in the United States using Bessemer ore, and after paying a duty of 75 cents per ton return a satisfactory profit on the operation of the mine, but it is believed that a better return will be obtained by smelting the ores in blast furnaces in the Dominion. The following is an estimate of the cost of delivering the raw and roasted ore.

	Raw.	Roasted.
At the Mines	$1.45	$2.00
At Ottawa	2.00	2.55
At Prescott, Ontario	2.50	3.05

In the United States plus a duty of 75 cents per ton.

In the United States over 1,000,000 tons of iron ore, much of it inferior to the Bristol ore, are converted into pig iron annually. See page 14.

7th. The City of Ottawa offers unusual facilities to encourage the erection of a blast furnace plant, and several available sites for such industries were noted. See page 19.

8th. Abundance of limestone exists in the vicinity of Ottawa, which can be used for flux, the cost of which is estimated at 65c. per ton. See page 19.

9th. The use of mineral fuel appears to be more advantageous for a blast furnace at Ottawa than charcoal, and the large importations of both anthracite and bituminous coal indicate that facilities already exist for handling this material and marketing it at a close figure. The prices for imported anthracite are estimated to be $5.20 per gross ton, for imported coke $5.80 per net ton, for charcoal $7.50 per net ton. The price on coke includes the duty of 60 cents per ton. At the above rates, and using the quantities of the various fuels believed to be ample for the production of a ton of pig iron, the cost of fuel per ton of product is as follows ;—

	Cost per ton of pig iron.
Using all anthracite coal	$6 50
do anthracite and bituminous coals	6 54
do all bituminous coal	7 11
do all charcoal	8 44

10th. The abundance and character of the labor available will place Ottawa at no disadvantage with other points of production after the industry is fairly established. See page 22.

11th. Taking the values as estimated of the material required to produce a ton of iron, the total cost will be $11.24, and adding for labor, supplies, incidentals, repairs, interest and other items the average cost of a ton of pig iron prodnced at Ottawa is estimated at $14. This would allow a profit, if iron were sold at the present New York prices of $1.50 per ton, or at present rates at Ottawa at least $3.50 per ton. See page 23.

12th. A blast furnace 75 to 80 feet high and 15 to 16 feet bosh, costing less than $200,000 when ready for operation, and capable of producing 80 to 100 tons of pig iron per day using all Bristol ores, is recommended with a capital of not less than $250,000. With ground sufficient for future enlarged capacity, or for the addition of other industries, and with the possibilities of meeting special demands by a mixture of ores, such a plant is believed to be capable of making a very satisfactory return for the investment made. See page 24.

13th. The failures which have caused distrust in the iron production should not intimidate capital, but rather encourage it to follow in beaten tracks, instead of experimenting in untried fields, and, using judicious care to secure the best appliances, find a satisfactory return for the money invested in plants of capacities proportionate to the immediate demands. Page 27.

RECOMMENDATION.

To secure the establishment of a blast furnace at Ottawa two methods can be pursued :

1st. An independent company can be formed to build and operate the furnace, and contracts made for the purchase of iron ore from the Bristol Mining Company (Limited) at rates agreed upon.

2nd. The Bristol iron mines could be placed (at a valuation agreed upon) in a company which will smelt the ore, making the furnace company owner of the mines, or the mining company owner of the furnace, as is deemed advisable.

The second plan seems to offer the best inducement, for then the corporation could elect at any time, should it be necessary, any division of profits to either mine or furnace, and the cost of administration of the two properties would be less when operated together than it would be when operated independently. The price at which the mining property would be incorporated in the new organization could be determined upon a valuation made of what it could earn when properly operated, and any questions as to the continuity, character or extent of the ore body could be solved during the erection of the blast furnace, by making additional openings, driving other drifts, extending shafts, or by exploring with the diamond drill, together with suitable analyses, to demonstrate what can safely be relied upon in the future, thus protecting capital which is invested in the blast furnace plant, and giving the capital devoted to the iron ore mine its proper proportion of interest.

Respectfully submitted,

JOHN BIRKENBINE.

No. 25 N. Juniper Street,
Philadelphia, Pa., May 16th, 1889.

APPENDIX.

To J Birkenbine, Esq.

DEAR SIR,—Our lots here are one-third of a mile wide. The iron lodes angle through it; but call the lode 1760 feet in length, 250 feet in width, and say 1000 feet in depth. This would give 440,000,000 cubit feet. Call 7 ft. in the solid a ton of ore, and we have 62,857,142$\frac{4}{7}$ tons. Reduce these figures one-half for faults, breaks and horse backs, and we have 31,428,571 tons. Take another quarter for pillars, etc., and we have 23,571,429 tons of iron ore on what is known as the south lode. Take the north lode, and we find it to run about the same, say 1760 ft. long, 150 ft. wide, and say 1000 ft. deep, and we have a block of vein matter containing 264,000,000 cubit feet 7 ft. in the solid yield 37,714,285 tons. Treat this north lode as I treated the south lode; that is to say, take one-half for faults, breaks and horse backs, and one-quarter for pillars, and there remains in the north lode 9,423,571 tons of iron ore. Put the north and south lodes together and we have thirty-two million nine hundred and ninety-five thousand tons of iron ore (32,995,000).

Yours,

C. C. SYMONS.