V.—New Mineral Discoveries in Nova Scotia.—By Edwin Gilpin, Jr., A. M., Ll. D., F. R. S. C., *Inspector of Mines, Halifax, N. S.*

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The early operations in mining, metallurgy, engineering, etc., were much more simple than those of the present day. They were based of course upon the same general principles that underlie them to-day. The difference, however, in exactness and precision have permitted of vastly greater and cheaper productions. In smelting iron ore, for instance, the composition, weight, and relative proportions of the fluxes, fuels, and ores, are calculated to a nicety, so that the analysis and composition of the resulting pig iron can be safely predicted. The direct outcome of the application of exactness is the opportunity for increasing and cheapening productions. The day of the rule of thumb has passed in iron making as well as in other metallurgical processes.

In this Province we are to some extent interested in iron ore, but at present the adaptability of our coals for coke making is a subject of much enquiry. For many years coal was made into coke by burning off its volatile ingredients in round ovens, resembling bee hives, with more or less admission of air. The matter driven off somewhat resembled in composition the gas made in gas works, and contained a large amount of combustible matter. The illuminating gas made in gas works was produced from retorts into which no air was admitted during the operation of heating. The problem was the production of coke in ovens, on a large scale, equal to that used in the blast furnace, and at the same time to secure the largest amount of gas, or volatile matter, from the coking coal, with as little deterioration as possible from the admission of the nitrogen bearing atmosphere.

This problem has been gradually solved, and now it is possible to produce a good coke, on a commercial basis, and at the same time to save large volumes of gas adapted for illuminating and heating purposes. No doubt many improvements remain to be introduced.

The works of the Halifax Gas Company, at the North-West Arm, are the first established on this side of the Atlantic to carry out this principle, which has already been practised at several places in Europe. The experience gained here has led to the establishment of an enormous plant on similar lines, to supply gas in Boston. The result of this enterprise is being watched with much interest in the United States, and its success will lead to the establishment of similar plants at many commercial centres. The application of gas in that country for engine power, and many other uses, was no doubt largely due to the supply of natural gas available for many years. The gradual decrease of natural gas excites interest in any scheme proposed to fill its place.

The proposal to utilize Cape Breton coal in the new works at Boston led to a number of tests of the coal as to its gas, coke values, etc., as well as to the quantity and nature of the impurities present. This evening I propose to give briefly some results arrived at, that they may be on record for comparison with future tests. I have also a few remarks on new discoveries of ores in Nova Scotia.

At the Halifax works, the coal used is washed slack from the Phalen and Harbor seams, of the Dominion Coal Company, approximating 60 per cent of fixed carbon. The gas is divided into that available for illuminating purposes, and the poorer gas to be used for heating the ovens, and for sale for heating purposes. In 24 hours, 37 short tons yield 310,000 cubic feet of gas, of which 100,000 cu. ft., 32.26 per cent, are illuminating gas, and 210,000 cu. ft., 67.74 per cent, heating gas; of the latter 170,000 cu. ft. are consumed in the process of coking, and the balance 40,000 cu. ft. can be used as heating gas. A long ton furnishes, on the average, 5 lbs. ammonia gas, and 12 gallons, 120 lbs., of tar. The ammonia liquor is distilled with milk of lime, and furnishes a shipping ammonia liquor with 17 per cent ammonia. The tar is available for distillation for creasote, pitch, etc. Finally the coke, forming 75 per cent of the coking charge, is available as a very excellent fuel. No doubt these results will be improved on.

More interesting information is given by a test made of the Harbor seam at the Glassport, Pa., ovens of the United Coke and Gas Company. The coal used in these ovens was run of mine from the Upper Youghiogheny River, with the following composition: Moisture, 60; fixed carbon, 59.18; volatile matter, 33.01; ash, 7.21; phosphorus, .0071; total sulphur, 1.27. The resulting coke, 74.26 per cent, had the following composition:— Volatile matter, 1.00; carbon, 86.47; ash, 11.57; sulphur, .96; phosphorus, .0107. A net ton furnishes 10,000 cubic feet of gas, of which 70 per cent is used for heating the ovens, and the remainder is piped to steel works.

The coal from the Harbor seam was slack, washed in Cape Breton, and at the time of coking contained as much as 9 per cent of moisture, as the cars stood for some months exposed to winter weather. As under normal conditions this percentage would be very much less, allowances should be made for purposes of comparison.

An average of several analyses gave the following as the composition of the coal:—

Carbon	75.10
Hydrogen	3.75
Nitrogen	1.51
Oxygen, Sulphur	13.80
Ash	5.84
	100.00
Volatile matter	34.60
Fixed Carbon	59.56
Ash	5.84
	100.00

In the destructive distillation of coal the sulphur is divided between the gas and the coke. From the former it can be removed by increasing the purification plant, but its removal from the latter is still practically an unsolved problem. It may be said in general terms that about half the sulphur is usually driven from the coal in the coking process.

As the sulphur in the coke is largely transmitted to the pig iron made in a blast furnace, its presence in any large amount is a serious matter. As yet, attempts to lessen the amount of this impurity have been confined to taking advantage of its higher specific gravity, as compared with that of coal, to separate it more or less thoroughly by washing processes. In this connection some figures on the practical use of Cape Breton coke in the Ferrona furnace may be of interest. The percentage of sulphur in the coal may occasionally reach 3 per cent; again it runs down to a few tenths of 1 per cent. This difference exists between different layers of the same bed, and different localities in the same mine. The average percentage is low. The coke made from unwashed Dominion coal contains, as impurities, 1.08 per cent of sulphur, and 8.2 per cent of ash. Coals running higher in sulphur are washed before being coked. In the manufacture of Bessemer pig the amount of phosphorus in the coke is an important item. It is exceptionally low in this coke, averaging .0028 per cent. The calorific value of the dry fuel, containing 5.84 per cent of ash is, according to the Dulong-Mahler formula, 12.437, B. T. U. The coke is of good quality, hard and compact.

The pig iron has the following composition:—

	Basic pig.	Foundry pig.
Silicon	.50	2.32
Manganese	.87	.65
Phosphorus	1.23	1.20
Sulphur	.017	.02
G. Carbon	....	3.64
C. Carbon	....	.23
Iron	97.00	92.00

In an oven 18 inches wide, if the coke be not required for blast furnaces, the time of coking would be about 23 hours.

The following summary shows the results obtained per long ton from a series of charges coked under usual working conditions at Glassport :—

	Lbs.	Per cent.
Coke, total. { large coke $>1''$ — 66.69 p. cent; small " $\frac{1}{2}$—1" 1.64 "; dust " $<\frac{1}{2}''$ 2.80 " }	1,593.4	71.13
Tar....................................	75.7	3.38
Ammonia (1.373 per cent sulphate)	7.6	.34
Gas, total, 10,390 cu. ft. of .466 sp. gr..........	368.0	16.43
Sulphur compounds in gas :—		
Hydrogen Sulphide	10.8	.48
Carbon Disulphide	1.6	.07
Gas Liquor and Loss, by difference	182.9	8.17
Totals..........................	2,240.0	100.00

Of the gas produced, 49.5 per cent was "surplus" gas, that is, gas not required for heating the ovens. This had the following composition :—

Olefines, $C_m H_n$	5.2
Marsh gas, $C H_4$........................	38.7
Carbon monoxide, $C O$..................	6.1
Carbon dioxide, $C O_2$.....................	3.6
Oxygen, O	.3
Nitrogen, N..........................	7.7
Hydrogen, H..........................	38.4
	100.0

Its calorific power, the hydrogen burnt to water, was 686 B. T. U., its candle power 14.7, and its specific gravity, .51. The coke contains in addition to the fixed carbon, volatile matter, 1.27 ; ash, 8.91 ; phosphorus, .0041 ; moisture, 3.67. The ash contains 27.71 per cent of silica, 13.04 per cent of aluminia, and 50.60 peroxide of iron, with small quantities of alkalies and alkaline earths.

The yield of tar per long ton was 75.7 lbs., or 3.38 per cent. The following table shows its behaviour under fractional distillation :—

Fractions.	Temperature. °C.	
Light oil	80-170	3.7
Middle oil	170-230	9.8
Heavy oil	230-270	12 0
Anthacine oil	over 270	4.3
Pitch		67.0
Water		2.3
Loss		.9

As the ultimate analysis shows 1.51 per cent. of nitrogen in the coal, and the .34 per cent. ammonia, 7.6 lbs. per long ton, in the gas liquor requires .28 per cent. nitrogen, it follows that 18.5 per cent. of the total nitrogen in the coal is converted into ammonia, instead of usually 13½ to 15 per cent.

Three periods may be observed during the process of coking, in the composition and value of the gases given off. At first the proportion of marsh gas (CH_4) is high but gradually lessens.

The following is the surplus gas produced during the first 14¾ hours :

Average calorific value	685.8	B. T. U.
Average illuminating value	14.7	C. P.
Volume per long ton	5143.	C. F.

The oven heating gas produced during the remaining 19 hours is as follows :

Average calorific value	566.7	B. T. U.
Average illuminating value	9.0	C. P.
Average per long ton.	5247.0	C. F.

The gas during the last few hours is very low in calorific and candle power, but owing to its carrying a large per cent. of hydrogen, it can after being purified, be enriched with benzole or oil vapors and be added to the first gas. Practically, however, the third gas is added to the oven heating gas, and the following table shows the composition of the two :—

	First, or Surplus Gas.	Second, or Oven Gas.	Average.
Olefines	5.2	2.4	3.8
Marsh Gas	38.7	29.2	33.9
Hydrogen	38.4	50.5	44.5
Carbon Monoxide	6.1	6.3	6.2
Carbon Dioxide	3.6	2.2	2.9
Oxygen	.3	.3	.3
Nitrogen	7.7	9.1	8.4
	100.0	100.0	100.0

The foregoing figures are interesting from a chemical standpoint, but no doubt as experience is gained the results will be modified and improved.

Oil shale in Cape Breton.

Experiments have been made recently on the oil values of some shale deposits in Cape Breton County, which may appropriately follow the notes on the distillation of Cape Breton coals. At Macadam's Lake, on the North side of East Bay, the lower carboniferous measures rest on silurian and precambrian strata. Here a number of beds of black lustrous shale are found associated with conglomerates, gray shales, and sandstones pitching heavily to the south, away from the older rocks. These black shales are so highly charged with carbonaceous matter as to be capable of combustion. Explorations have shown a number of beds of this character from two to ten feet in thickness, extending for several miles in an easterly and westerly direction.

The following results are stated to have been obtained from working tests. The distillation in retorts yields beside a little water, a quantity of heavy oil, a little gas, and coke available for fuel. The yield of oil is from 15 to 20 gallons per ton of 2000 lbs. In refining this crude distillate, the products may be divided into different varieties, according to the market. A convenient division yields 20 per cent kerosene, 20 per cent white spindle or sewing machine oil, 40 per cent heavy lubricating oil, and 20 per cent pitch.

The kerosene does not practically differ from ordinary American petroleum kerosene. It refines white and is very free burning. White Spindle oils are the most costly in the market. There are none, however, in the United States obtained from petroleum so white and so heavy as this from East Bay. The lubricating oil is heavy, while it is as light in color as the heaviest parafine oil in America. The yield of crude oil is found to be about 6.25 per cent, and the proportions per ton would be:—

Kerosene oil	1.25	per cent.
White Spindle oil	1.25	"
Heavy Lubricating oil	2.50	"
Pitch	1.25	"
Water	5.75	"
Coke	87.50	"
Loss, gas, etc	.50	"
	100.00	

It is also ascertained that this material is readily distilled and refined by methods and apparatus in general use in shale and petroleum industries in Great Britain and the United States. The pitch is of good quality.

If these statements are verified by actual practice, and the costs permit, a large and important industry may be counted on here. Should these oils find a market and demand abroad, no doubt the shales in various parts of the province, known to be bituminous, will receive attention.

Iron Ore.

The district lying between little Bras d'Or and East Bay in Cape Breton County is traversed diagonally by lower silurian strata and by the felsitic and limestone divisions of the pre-cambrian, which are flanked by lower carboniferous strata. The presence of iron ore near the junction of the George's River limestone and lower carboniferous has long been known near Gillies' Lake, and outcrops are known at Upper French Vale and near the mouth of the Barasois River, emptying into the Little Bras d'Or. At the latter place the silurian slates are literally soaked in iron oxide, and at several points they present deposits which may on further investigation prove of economic value.

To the south-west of the railway bridge at Barasois, on a line running towards Eskasonie on East Bay, are several large outcrops of magnetite. As yet little work has been done to test the value of these deposits. Should these deposits prove to be free from titanic acid, they should, judging from the following analysis, be available for the operations of the miner :—

Oxide of Manganese and Alumina	.60
Lime	.11
Magnesia	.10
Sulphur	.05
Phosphoric Acid	.04
Silica	2.12
Volatile...................................	.84
Metallic Iron	67.298

The question of the amount, quality, and cheapness of iron ore is one of the great problems of the day. The United States are exceptionally fortunate in having in its North-Western States what may be termed the greatest deposits of Bessemer ore yet discovered. The size of these deposits, their purity, their accessibility, and the lavish expenditure for their cheap mining and transportation have combined to build up at Chicago, Pittsburg, and other points, the greatest individual steel works of the world. Without the iron ores of Michigan, the United States would to-day occupy a position much less menacing to the commercial destinies of England and the Continent. It is true that the competition England has had hitherto to meet in the iron industry has come chiefly from the pig iron of Tennessee, but this can be largely met by the English furnace masters building larger furnaces and securing lower local railway freights. Although these precious deposits, more valuable than gold and silver mines, were heralded as everlasting already their exhaustion is a question of not many years, as new discoveries are seldom announced. Already the vast iron ore deposits on the Çanadian side of the great lakes are engaging the attention of the more far-seeing of the United States iron masters At present these deposits are not available. England, France and Germany draw large supplies of Bessemer ore from Spain and Algiers, This source now shows signs of weakening, and the magnetic ores of Sweden and Norway are gradually being drawn upon in amounts annually increasing.

There is no known geological reason why Labrador, Newfoundland, and Cape Breton should not contribute to this demand, ever increasing and never satisfied. The existence of iron ore at many points in Cape Breton is already known. The attempts made to find deposits, and to test them are scarce worth noticing. In the forest and swamp-covered tracts there may be masses of iron ore worth an empire's ransom.

It must, however, be remembered that these deposits, to be of any value, must be pure, extensive, and capable of cheap mining and shipping. The output must be large and the expenses low to enable the Cape Bretoner to enter into the world's competition in selling iron ore in the markets of the world.

Wolframite.

Last spring a discovery of this mineral was made at North-East Margaree, Inverness County. Full particulars of this deposit are not yet available. It is stated to occur in a vein, in places three feet wide, and to be present in amounts permitting readily of concentration to a high percentage. The mineral is of a dull gray color, in places almost black, and with a somewhat metallic lustre. Its specific gravity is 7.1—7.5, and its hardness 5—5.5. It is sometimes feebly magnetic, and contains 67.47 WO_3. The price quoted for the mineral on the continent is stated to be $375.00 per ton of 65 per cent ore. The demand at present is not large, and is met by an annual output of a few hundred tons. Its principal, if not its only commercial value, is as an alloy for steel. It is believed that, if a large and permanent supply of the mineral could be secured, it would be utilised for hardening armor plate and similar purposes.

Coal.

In 1897 I gave some analyses of the coal from the lower levels of the Springhill seams, and compared them with earlier analyses of the coal from parts of the seams nearer the outcrops. The analyses show that as the coals have been followed down they have increased in their percentage of fixed carbon, and consequently in their steam-raising qualities. This is borne out by the result of analyses made since that date. The average of a number giving the composition of Springhill coal at present is as follows :—

Moisture	2.05
Volatile combustible matter	30.21
Fixed Carbon	63.52
Ash	4.22
	100.00

During the past year a tunnel has been started in the lower workings of the underlying seam to cut some lower beds of coal known to exist some distance to the dip. It has already cut one seam holding about 4½ feet of coal, which gives the following analysis :—

Moisture	3.00
Volatile matter	31.30
Fixed Carbon	62.50
Ash	3.20
	100.00
Sulphur	1.19

The question of the adaptability of the coals of the Dominion Coal Company for iron ore smelting has been a matter of much interest for some time. The principal seam worked by this company is the Phelan. At its outcrop the sulphur average per cent was about 2.5. This would of course be a prejudicial amount in coals destined for blast furnace purposes. It is satisfactory to learn that as the workings in this seam are extended to the dip the percentage of sulphur has materially decreased. While of course it is possible to materially decrease the percentage of sulphur by crushing and washing the coal, it is the ambition of every mine manager to work a coal seam which can be charged into the coke ovens without preliminary treatment. While this point may not yet be actually reached in the Phalen seam, it is gratifying to notice that the lowering of the percentage of sulphur is rapidly reaching this desirable point. The following average of nearly two hundred analyses of this seam in the lower levels of the various workings will show approximately its present ash and sulphur contents:—

Average.	Per cent.
Ash	3.92
Sulphur	.81

The ash varying from 2.95 to 5.20, and the sulphur from .8 to .93. These results compare more than favorably with the percentages of the corresponding impurities met in the standard American coking coals, and warrant the presumption that in Cape Breton, now that the sulphur question is removed, there are available unlimited quantities of the highest grade of coking coal.

The importance of the possession of a store of such high grade coal is at once seen on reading an editorial in a late number of the *Engineering and Mining Journal*, New York, which states that parts of the great Pittsburg coking seam show signs of partial exhaustion, and that leading operators in the coke trade are turning their attention to the acqisition of coal lands in Virginia as containing the next best available coal for coke making.