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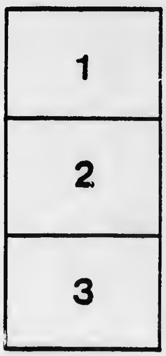

GEOLOGICAL SURVEY OF CANADA.

ALFRED R. C. SELWYN, DIRECTOR.

REPORT

ON THE

COALS AND IRON ORES

OF

PICTOU COUNTY, NOVA SCOTIA,

BY

EDWARD HARTLEY, F.G.S.,

MINING ENGINEER TO THE GEOLOGICAL SURVEY,

BEING AN

APPENDIX TO REPORTS ON THE PICTOU COAL-FIELD.

From the Reports of the Geological Survey of the Dominion of Canada for 1867-69.

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REPORTS ON THE PICTOU COAL FIELD,

BY

MR. EDWARD HARTLEY, F.G.S.,

MINING ENGINEER TO THE GEOLOGICAL SURVEY.

The following Report will furnish information concerning the economic value of the coals of Pictou County, Nova Scotia, together with a notice of some localities of iron ore likely to become of interest from their proximity to the Pictou coal-field; these deposits of iron ore having received examination during my field-work of the years 1868–69. It will be divided into three sections:—(I) Descriptions and analyses of Pictou coals; (II) Reports of practical trials of Pictou coals as steam and gas-producer and for other purposes of the mechanic arts;—(III) Iron ores and their occurrence in Pictou County.

I.

DESCRIPTIONS AND ANALYSES OF PICTOU COALS.

A number of published papers and reports contain analyses of coals rom the Pictou region; but with few exceptions, these publications are out of print, or otherwise inaccessible to the general public. In this section it is proposed to bring these scattered analyses together, supplementing them by a series made by myself during the spring of 1869, in the laboratory of Dr. T. Sterry Hunt, F.R.S., chemist to the Survey, and a few more careful determinations made still later, in Dr. Hunt's laboratory, by his assistant, Mr. Gordon Broome, F.G.S., Associate of the Royal School of Mines.

Classification of analyses.

Analyses of coal may be divided into three classes; (a) practical analyses in the large way, or the determination of the proximate constituents of the coal, that is, the moisture, volatile matters, coke and ash, by burning a large quantity; (b) proximate analyses in the laboratory, or the result of the drying, coking, and incineration of a few grains in a small crucible; and (c), ultimate analyses, being the careful determination of the ultimate elements of a coal or other fuel, such as carbon, hydrogen, oxygen and nitrogen; the class (c) being, of course, the most satisfactory for calculations of the theoretical value of a coal.

Of the analyses now given, by far the greater number belong to the second class, (b) in which may be included all those made in the Survey laboratory, as the great expense and amount of time necessary for their completion has rendered both practical and ultimate analyses out of the question. Although far from satisfactory as accurate *measures* of the true value of coals, the crudest analyses enable us to form some idea of their character, and, in the absence of practical trials, furnish us with elements on which to base an approximate opinion as to what practical service they are best fitted to perform.

Method of analysis.

The method of analysis pursued in the examination of the samples of coal obtained in the Pictou coal-field by myself, was somewhat as follows: Drying in a water-bath at a temperature of 212° Fahrenheit, to expel moisture; heating to bright redness in a closed crucible to obtain the percentage of volatile combustible matter; and finally incineration in an open crucible to obtain the amount of ash. In most cases two different samples of each coal were examined, one being coked by a sudden application of a high heat, to obtain the largest possible amount of volatile matter or *gas*, irrespective of its character, the quantity of coke being thus reduced to a minimum; while in treating the second, the heat was applied with the greatest care, and raised very gradually, by which treatment the gases obtained are more highly carburetted, and in smaller quantity than when the heat is suddenly applied. In a few cases, determinations of sulphur have been made, but from this impurity the greater part of the coals now worked in the Pictou region are quite free. The general very light colour of their ashes attests their freedom, when properly selected, from sulphur in combination with iron, as *pyrites*, and among the coals examined, the ashes of but few contain an appreciable amount of sulphate of lime, being generally very silicious or sandy in the best coals, and therefore not inclined to form a clinker adherent to the grate-bars. No full analysis of the ashes of any of these coals has yet been made, so far as I am aware.

Theoretical evaporative powers.

The calculations of the *theoretical evaporative power* of the different coals analyzed, are based upon the fact, that in burning bituminous coals of the class under consideration, in an ordinary furnace, such as has always been used for comparing their results in steam production with those of anthracites and other fuels, the combustion of the volatile matters of the coal does not, in most instances, produce more than enough heat to effect their volatilization, and therefore *theoretically*, the value of the coals for steam purposes, depends on their content of fixed carbon, or the carbon remaining in their coke when the coal is heated in close vessels.*

Method of calculation.

The calculation may be made as follows:—Let the weight of coke, less ash, in parts of one unit of coal—that is, the percentage of fixed carbon—be expressed by C; the co-efficient of the heating power of carbon by c, and the co-efficient of the latent heat of steam at 212° F., by l,—then:—

$$\frac{C \times c}{l} = x$$

x being the theoretical evaporative power of the coal, or the number of pounds of water which one pound of coal should evaporate from a temperature of 212° Fahrenheit, *theoretically*.

Values of co-efficients.

The values given to the co-efficients used, vary with different authors. To c—expressing the number of units of water which the combustion of one unit of pure carbon will raise 1° Fahrenheit—Regnault gives the value of 13.268, while by Dulong† it is given as 12,906.

To the co-efficient l, Regnault gives the value 965.7°; while the experiments of Professor W. R. Johnson indicate for it a value as high as 1030°.‡

Official reports on coals.

In my own calculations the values of Regnault have been used, although later experiments have shown a further modification,§ inasmuch as these values have been used in the Reports of the British Commissioners on the Naval Steam-Coal Enquiry,¶ with whose results a comparison will be most valuable, although in the American reports, (published before Regnault's

*Practical experiments have already shown that North Country (or Newcastle) coals burnt in proper furnaces calculated to prevent smoke, give a practical evaporative effect higher than the theoretical power based on this supposition, and I hope to be able at some future time to show a similar result with our coals; but as, with an ordinary furnace, the method of calculation to be given approaches correctness, and more especially as I wish to compare the theoretical values of these coals with results obtained from experiments conducted some years since, I still, for the time, adhere to the old rule.

†Vide Comptes Rendus, tom. 7, page 871, et seq.

‡W. R. Johnson's Report on American Coals, 1844, *p.* 22.

§The late researches of Favre and Silbermann (*vide* Ann. Ch. Phys. (3) xxxiv, 357—xxxv. 15—xxxvii. 405.), and of Andrews (Phil. Mag. (3) xxxii. 321, 425), have slightly modified Regnault's values. For a full digest of their results, see the admirable article on FUELS, by Prof. B. H. Paul, in Watt's Chemical Dictionary, 1864, vol. II., p. 718, et seq.

¶Reports of Sir Henry T. De la Beche and Dr. Lyon Playfair to the Lords Commissioners of the Admiralty, on trials of coals, 1848 and 1852. See also Johnson's Coal Trade of British America, 1850, p. 78

exhaustive memoir* appeared,) the values of Dulong for c, and Johnson for l, have been adopted.

Value of theoretical results.

The results obtained by these different values do not differ as greatly from each other as they will be found to differ from actual results, and they are useful only in the absence of reliable practical trials. In coals of this class, *i.e.* bituminous coals with 25% to 35% of volatile matter, these theoretical indices are generally slightly higher than figures obtained from furnaces of low-pressure boilers where no special arrangements are made for "*smoke-consumption*"—as it is called, or more properly, smoke-prevention, for smoke once formed cannot be consumed.

Values from ultimate analyses.

In cases where ultimate analyses are to be obtained, the theoretical value of *all* the combustible matter in a coal may be obtained by the following formula:—

$$\left(\frac{C \times 13268}{965.7}\right) \left(\frac{H—h \times 62470}{965.7}\right) = x$$

in which C represents the entire carbon content, both fixed and volatile, H the quantity of hydrogen in a unit of fuel, and h the quantity of hydrogen which will correspond to the oxygen in the coal; x expressing, as before, the number of pounds of water theoretically convertible into steam, from 212°, by one pound of coal, provided all the combustible constituents of the coal could be rendered available; or, in a word, the highest possible evaporative power of the fuel under any circumstances.

Expression of mechanical force.

The values of x, as used in the two preceding formulæ, or an evaporative value given by practical trial, may be converted into an expression of mechanical force by the formula:—

$$(Wn) \times 965.7 \times 782 = y,$$

in which W represents water, of which n pounds are evaporated by one pound of coal, (thus giving Wn the value of x in the preceding formulæ), and y representing the number of *foot-pounds* of work theoretically possible.†

*Regnault. *Relations des experiences entreprises* * * * *pour determiner les principales lois et les données numériques qui entrent dans le calcul des machines à vapeur. Paris*, 1847. See also a translation of the portion on the latent heat of steam at different pressures, in the Works of the Cavendish Society, vol. I.

† This formula is deduced from the fact that n pounds of water, multiplied by 965.7°, or the co-efficient of the latent heat of steam at 212° F., indicates the number of pounds of water which would be raised 1° Fahrenheit by the combustion of one pound of coal. The number 782 arises from experiments on the mechanical force denoted by the elevation of temperature of a pound of water 1° F., that force being equal to 782 lbs. raised one foot high, according to the careful experiments of Mr. Joule on the friction of oil, water and mercury.—(Extract from Report of British Commissioners, from which the formula is taken.)

Theory and practice.

It should be distinctly understood that no calculations based upon mere analyses can take the place of trials of the coals in the large way as steam and gas-producers, for smelting, heating iron, or for any other practical use; for though, as a rule, these theoretical values furnish us with a general idea of the use to which a coal is best fitted, it is of not unfrequent occurrence that theory and practice differ greatly. For further information on practical values of fuel, I would refer the reader to the works of Prof. W. R. Johnson, and to the second section of this Report.

COALS OF THE WEST SIDE OF THE EAST RIVER.

COALS FROM THE MAIN SEAM, ALBION MINES.

No favourable opportunity offered during my stay in this district for an examination of samples of the coal of the Main seam, which would enable me to satisfactorily separate the peculiar varieties of the different benches. I therefore reproduce the careful section prepared by Dr. Dawson, which well illustrates the character of all the different descriptions of coal of this seam.*

This section was prepared from an examination of a column of coal from the Main seam, extracted for the New York Industrial Exhibition of 1852 by Mr. Henry Poole, then manager of the Albion mines.

SECTION OF MAIN SEAM, BY DR. J. W. DAWSON.

Dawson's section of the Main seam.

		Ft.	In.
1.	Roof shale; vegetable fragments and attached *Spirorbis* (in specimen)	0	3
2.	*Coal*, with shaly bands	0	6½
3.	*Coal*, laminated; layers of mineral charcoal and bright coal; band of ironstone balls in bottom	2	0
4.	Worked in Old Mines: *Coal*, fine cubical and laminated; much mineral charcoal	3	2
5.	Worked in Old Mines: Carbonaceous shale and ironstone, with layers of coarse coal (*holing stone*), remains of large fishes and coprolites. This bed varies much in thickness	0	4½
6.	Worked in Old Mines: *Coal* laminated and cubical; coarse towards bottom	9	3
7.	Ironstone and carbonaceous shale in the coaly layers, and trunks of *Lepidodendron*, *Ulodendron*, *Sigillaria*, etc., all prostrate	0	8
8.	*Coal*, laminated as in No. 6; line of ironstone balls in bottom	1	2
9.	*Coal*, laminated and cubical; a few small ironstone balls; many vascular bundles of ferns in this and underlying coal	6	7
10.	Ironstone and pyrites	0	3
11.	*Coal*, laminated and cubical, as above	10	3
12.	*Coal*, coarse layers of bituminous shale and pyrites	1	0
13.	*Coal*, laminated, with a fossil trunk in pyrites	2	1
14.	*Coal*, laminated and cubical, with layers of shale passing downwards into black slickensided underclay, with coaly bands	2	3

* Acadian Geology, second edition, pp. 331-32.

	Ft.	In.
15. Underclay, to bottom of specimen	0	10
Total	40	8
Vertical thickness	38	6

Coal of Main seam.

The general character of the coal from the Main seam is that of a highly bituminous caking coal, generally of a laminated structure, and showing much mineral charcoal on the planes of deposition. Although much impurity exists in the form of shale, ironstone, and arenaceous material carrying pyrites, these may be easily separated from the good coal in taking out the different floors of the seam. The coal raised is also carefully examined at the shutes, any refuse or shale being thrown aside before the coal is put into railway cars for shipment.

Specific gravity.

The specific gravity of this coal is stated by Dr. Dawson to be from "1.288 (which is that of the best coal extracted,) to 1.447 (which is that of the coarsest coal that has been worked)."*

The mean specific gravity of six samples, taken from the top, middle and bottom of the seam, in the central part of the mines, is stated, on the same authority, as 1.325, which agrees exactly with the result of some trials made for the American Government, by Prof. W. R. Johnson, whose researches will receive attention in the second section of this Appendix.

The following, being an abstract of the statements of Dr. J. W. Dawson in his Acadian Geology, is extracted from Prof. How's late work on the Mineralogy of Nova Scotia, published by authority of the Provincial Government:—

" Numerous analyses were made by Dr. Dawson in 1854. shewing the character of the Albion Mines coal from different parts of the upper floor of the mine, and also the varieties existing throughout the whole thickness of their Main seam, in a series of assays of coals taken at distances of one foot in thickness. The general results were that the best coal was found on the N. W. side of the old workings, deterioration taking place at either extremity of the workings of the upper floor. In all parts of the mine the lower coal was inferior to that of the middle of the seam, and still more so to that of the upper part (above the "holing stone"), or "fall coal" of the miners. On the west, this fall coal disappeared, or was reduced to insignificant thickness. The assays made to show the variations in thickness of the whole seam were on coal taken at this western part. This valuable series of assays of the coal of this seam, so familiar to the world, is here given.

* Acadian Geology, p 333.

"*Assays of Samples taken at the distance of one foot in thickness in the Main Seam of coal of the Albion Mines, Pictou, by Dr. Dawson.* Dawson's analyses.

	Volatile by rapid coking.	Volatile by slow coking.	Fixed carbon.	Ashes.
1. Coal	26·0	19·9	63·8	16·3
2. do	27·8	24·1	63·8	12·1
3. do	27·4	25·7	60·0	14·3
4. do	27·2	25·0	65·5	9·5
5. do	25·8	25.1	64·8	10·1
6. do	25·2	24·9	62·5	12·6
7. do	27·4	22·0	68.5	9·5
8. do	26·8	22 9	63·7	19·4
9. do	27·0	23·9	61·3	14·8
10. Carbonaceous shale	16·4	15·9	26·3	58·8
11. Coal	28·8	25·8	59·7	14·5
12. do	27·2	25·4	62·5	12·1
13. do	27·6	24·7	62·5	9·8
14. do	26·6	23·9	61·0	15·1
15. do	26·8	23·1	65·1	11·8
16. do	28·8	24·9	62·3	12·8
17. do	30·4	26·0	65·0	9·0
18. do	26·0	26·1	63·0	10·9
19. do	26·0	25·0	66·3	8·7
20. do	26·8	22·7	63·6	13·7
21. Coarse coal	25·8	23·3	58·3	18.4
22. do	27·2	22·5	60·3	17·2
23. Coal	29·4	22·6	64·3	12·1
24. Coarse coal	25·8	22·4	57·6	20·0
25. do	25.8	23·1	60·2	16·7
26. do	27·8	21·9	54·8	23·3
27. Coal	27·0	24·3	65·5	10.2
28. do	25·6	22·4	65·0	12·6
29. do	25·8	22·7	62·7	14·6
30. do	27·2	23·1	67·4	9·5
31. do	32·6	22·4	66·5	11·1
32. Coarse coal	22·2	21·5	50·4	28·1

"The coal above the "holing stone" is not found at the part from whence these coals were taken, as before explained. At the N.W. side of the old workings it is three feet thick, and has this composition:—

	Dawson.
Moisture (hygroscopic water)	1.550
Volatile combustible matter	27.988
Fixed carbon	60.837
Ash	9.625
	100.000

"In these assays we have a most instructive and interesting set of experiments, the most complete of the kind, so far as I know, ever made on any bed of coal of considerable thickness. 'All the coals afford a fine vesicular coke, and their ashes are light-gray and powdery, with the exception of those of the coarse coals, which are heavy and shaly. The worst defect of this coal is its containing rather a large quantity of bulky ashes, which causes it to be less esteemed for domestic use than, on other grounds, it deserves. It is very free from sulphur, burns long, and with a great production of heat, and remains alight, when the fire is low, much longer than most other coals.' "*

Foord-pit coal.

These analyses, it will be seen, are of coals from the older workings of the Crushed mines and Dalhousie pits. Of the coal obtained from the new Foord pits, I have made the following analyses :—

	HARTLEY. By fast coking.	HARTLEY. By slow coking.
Hygroscopic water,	1.73	1.80
Volatile combustible matter	28.18	25.12
Fixed carbon	62.94	65.70
Ash (light-gray)	7.15	7·38
	100.00	100.00
Coke	70.09	73.08
Theoretical evaporative power	8.62 lbs.	9.03 lbs.
Sulphur (in average of coal)		0.32 per cent.

The specimens analyzed were hand-samples from the bank at the Foord pits, and believed to fairly represent the whole mass, which supposition is confirmed by the agreement of my assays with the following analysis by Prof. How, of King's College, Windsor, Nova Scotia, of a sample of one barrel, sent him by Mr. Hudson, Chief Manager of the General Mining Association.

How's analysis.

" *Coal from Foord pits, Main seam.* An average of the large sample sent, gave :—

	How.
Moisture	1.48
Volatile combustible matter	24.28
Fixedcarbon	66.50
Ash	7.74
	100.00
Coke	74.24
Sulphur	0.55
Theoretical evaporative power	9.13 lbs.
Specific gravity, average of three specimens	1.294

" It follows that this is, for various reasons, a valuable coal. The volatile combustible matter is such in amount and character as to promise well in

*H. How, Mineralogy of Nova Scotia, p. 18--20.

gas-making. The coke is firm and abundant, and the high theoretical evaporative power, shewing the number of pounds of water which one pound of coal ought to evaporate from a temperature of 212°F., (rather above the practical average of 37 Welsh coals), places the coal very high as a steam-producer. The amount of sulphur is decidedly low, obviously an important fact as regards domestic use, gas-making, and preservation of grate bars. The coal lights up readily in a parlour stove, cakes moderately, and gives a hot lasting fire; the ash is nearly five per cent. less than in coal from the same seam examined by Prof. Johnson, in 1842-43, and one or two per cent. less than coal from the *best parts* of the seam, tested by Dr. Dawson, in 1854. This is an important feature, as the large quantity of light bulky ash was then considered the worst defect of the coal. The ash consists chiefly of sandy matters; there is so little lime that there will be but little tendency to form clinkers. The specific gravity is high enough to show good storage character. One cubic foot broken for use should weigh about 52½ lbs., and one ton of 2,240 pounds should occupy, in the same state, about 42½ cubic feet space in storage.

"From its hardness, and the appearance of the contents of the barrel after about 100 miles of railway carriage, I conclude that the coal would bear handling and land-carriage without making much *small*, or dust."*

These remarks and analyses comprehend all that can be theoretically said of the value of the Foord-pit coal. I may, however, state that the coke from this coal is of exceptionally good character, and though all the coals from this seam furnish good coke, that from the Foord-pit coal seems to take the first rank, from its coherent and yet very porous texture. It is very light, of a silvery-gray colour, and a metallic lustre.

COALS FROM THE DEEP, OR CAGE-PIT SEAM, ALBION MINES.

Deep-seam coal.

In general appearance, the coal of the Deep seam much resembles that of the Main. A section of the different beds of this seam was examined by Dr. Dawson, in 1854, of which he publishes the following description, with assays of the different beds.†

SECTION OF DEEP SEAM, BY DR. J. W. DAWSON.

Dawson's section of the Deep seam.

1. Gray argillaceous shale (roof).
2. Tender laminated coal; much mineral charcoal.
3. Laminated compact coal; less mineral charcoal.
4. Laminated compact coal; less mineral charcoal.
5. Carbonaceous ironstone, crusts of *Cyprids*.

*Extract from letter of Prof. H. How, of King's College, (late chemist to the British Admiralty Coal Enquiry), to James Hudson, Esq., G.M.A.

†Acadian Geology, p. 335-336.

6. Laminated compact coal ; much mineral charcoal.
7. Laminated coarse coal.
8. Laminated compact coal.
9. Laminated coarse coal.
10. Laminated compact tender coal.
11. Laminated compact coal.
13. Laminated compact hard coal.
14. Laminated compact hard coal ; thick layer of mineral charcoal.
15. Laminated compact coal.
16. Laminated compact coal ; much mineral charcoal.
17. Laminated compact coal ; much mineral charcoal.
18. Shaly coal ; impressions of plants.

The results of assays of the above samples of coals taken, at distances of one foot, in the Deep seam are given in the following table :—

Analyses.

		Dawson.			
		Volatile by rapid coking.	Volatile by slow coking.	Carbon fixed.	Ashes.
2.	Good coal	24.8	21.0	67.6	11.4
3.	Good coal	25.2	25.2	67.3	7.5
4.	Good coal	28.4	23.9	70.8	5.3
5.	Ironstone and coal	26.8	27.5	18.5	54.0
6.	Coarse coal	23.2	20.5	59.1	20.4
7.	Coarse coal	23.6	20.4	48.0	31.6
8.	Good coal	26.2	22.4	70.3	7.3
9.	Coarse coal	25.2	21.1	49.3	28.6
10.	Good coal	24.8	20.4	68.9	10.7
11.	Good coal	24.8	22.3	64.3	13.4
12.	Coarse coal	23.4	20.5	51.2	28.3
13.	Coarse coal	23.0	20.1	55.3	24.6
14.	Good coal	27.4	23.9	68.1	8.0
15.	Good coal	29.0	22.9	71.5	5.6
16.	Good coal	26.8	21.9	69.6	8.5
17.	Good coal	24.6	19.9	63.8	16.3
18.	Shale and coal	17.6	21.1	23.0	55.9

Coal now worked.

The following analysis of a small sample of the coal now being worked at the western face, has been made by Mr. Broome:—

	Broome. Coking.	
	Rapid.	Slow.
Volatile matter	28.1	25.5
Coke	71.9	74.5
	100.0	100.0

Hygroscopic water	1.296
Volatile combustible matters	25.443
Fixed carbon	61.650
Sulphur	.861
Ash	10.250
	100.000
Specific gravity	1.33

Character of ash.

The ash from this sample contained 75 per cent. of matter insoluble in hydrochloric acid, which was chiefly aluminous silicate. Iron was estimated in the soluble portion, which, by the volumetric method, gave of metallic iron equal to 2.762 per cent. of the ash. Supposing all the iron to exist in this coal as pyrites, this amount would correspond to 0.4243 per cent. of sulphur in the coal. As experiment gave a larger proportion, it is evident that some of the sulphur present exists as a sulphate, probably of lime. The ash was gray, with a faint tinge of pink. This colour of ash is usual with the coal of this seam. Coke, by rapid carbonization, hard; by slow coking, a pulverulent mass was obtained.

To this analysis may be added the results of Prof. How, from an examination of a large sample; probably a better average of the whole seam than the specimen examined by Mr. Broome:—

How's analysis.

" *Coal from Deep, or Cage-Pit Seam.*—An average of the large sample sent, (one barrel), gave :—

	How.
Moisture	2.54
Volatile combustible matter	20.46
Fixed carbon	68.50
Ash	8.50
	100.00
Coke	77.0
Sulphur	1.69
Specific gravity (average of three specimens)	1.345
Theoretical evaporative power	9.41 lbs.

" This is an excellent coal, especially for domestic and steam purposes. As compared with that of the Foord pit, it gives a larger quantity of coke, and its theoretical evaporative power is decidedly higher, so that it must prove a valuable steam coal. It burns well in a stove, affording a strong enduring heat; its ash not being much above that of the Foord-pit coal, it will also be found superior for domestic uses to the coal formerly raised at your mines. The sulphur is not high, as compared with many coals, though it is rather above the average of that in Welsh steam coal.

" The ash is chiefly sand; there is very little lime, so there will not be much clinker formed. From the high specific gravity, one cubic foot of the coal should weigh about 53 lbs., when broken, and a ton of 2,240 lbs. should be stored in about 42 cubic feet.

" The coal is harder and less easily broken than that from the Foord pit."*

* Extract from a letter from Prof. How to James Hudson, Esq., G.M.A.

COALS OF THIRD AND PURVIS SEAMS, ACADIA MINES.

Third and Purvis seams.

These seams are now abandoned, and no analyses have been made of the coal from them, as no samples lately taken from the seam could be procured.

COAL OF THE MC GREGOR SEAM, ACADIA MINES.

The following extract is from the Report of Mr. Hoyt to the Acadia Coal Company, 1866:—

McGregor seam.

"It has been found that the thickness of this coal (the McGregor seam) increases as we progress westwardly, but diminishes as we work to the east.* The same remark will also apply to the quality of the coal. At present, only the upper divisions of the seam are worked. The bottom coal, which is of a coarse nature, is unsaleable, but would be very suitable for iron-smelting†; and in case of the developement of the iron deposits on the East River of Pictou, a good market would be created for it. The slaty band, between the top benches, is a source of much inconvenience and expense in mining; and with all the care exercised in picking, this foreign matter will, to some extent, get mixed with the good coal, which is thereby injured in character for gas purposes.

"The quantity of ash produced by the two top benches presents a marked contrast in the character of the coals, as will be seen by the following analyses, which have been obtained from the former proprietor, Mr. J. D. B. Frazer:"‡

Analyses.

	First bench.	Second bench.
Volatile matter	22.50	23.30
Fixed carbon	65.70	70.00
Gray ash	11.80	6.70
	100.00	100.00
Coke	77.50	76.70
Specific gravity	1.334	1.301
From these analyses the theoretical evaporative power would be	9.03	9.62

This coal cokes well when the better portions of the seam are selected. A very large amount of iron pyrites exists in the slaty portions of the seam, which, if not most carefully removed, makes the coal worthless as a gas coal. Careful attention in hand-picking, will probably obviate this objection to the coal.

* See p. 96 of my Geological Report.

† I have not analysed this coal from the bottom of the McGregor seam, but it appears to contain too much sulphur and ash to be very suitable for iron smelting.

‡ Name of analyst unknown to me.

The theoretical evaporative power resulting from the second analysis above given is large; it should render the coal a good steam coal, if the pyrites were removed.

COAL AND OIL-COAL FROM THE STELLAR SEAM.

Stellar oil-coal seam.

On page 70 of the Geological Report, it is stated that the Stellar coal seam of the Acadia mines has the following section:—

Section.

	Ft.	*In.*
Good coal	1	4
Stellar oil-coal	1	10
Bituminous shale	1	10
	5	0

Divisions of stellar seam.

These three divisions of the seam are quite separate and distinct in character. The substances from each were examined some time since by Prof. How, who first described the peculiar substance forming the middle bench, to which, from a likeness in some of its qualities to the so called oil-coals, torbanite and albertite, he has given the name of stellarite, from its throwing off sparks or stars of fire when lighted. From the three benches Prof. How obtained the following results:—*

Analyses.

	Coal.	How. Stellarite.	Shale.
Volatile matters	33.58	66.56	30.65
Fixed carbon	62.09	25.23	10.88
Ash	4.33	8.21	58.47
	100.00	100.00	100.00
Moisture		.23	
Specific gravity		1.103	

Coal bench.

Coal. The coal appears to be merely an ordinary fat caking-coal, with an unusually small percentage of ash for this region, but the bench being thin, the value of the seam depends principally on the two lower divisions, stellarite, and oil-shale.

Stellarite bench.

Stellarite. This peculiar substance was first known and worked at these mines by the former owner, the late Mr. J. D. B. Frazer, of Pictou. It appears to be an earthy bitumen, or, to quote Dr. Dawson, "a fossil swamp-muck or mud," † which he has elsewhere‡ shown, is the character of the earthy bitumens and highly bituminous shales of the coal formation generally.

* How, Mineralogy of Nova Scotia, p. 24.

† Acadian Geology, p. 339.

‡ See Dawson, "*On the conditions of accumulation of coal.*" Journal Geol. Soc. xxii. p. 95 et seq.

Oil-shale bench.

Bituminous shale or oil-shale. This is a rather heavy brownish-black shale. The following analysis and remarks thereon, include both this bench and the stellarite.

The first series is taken from Mr. Hoyt's Report to the Acadia Coal Company for 1866. Analyses under the heading of No. 1 refer to stellarite, No. 2 to the oil-shale :—

Analyses for oil, etc.

	WALLACE.*	
	No. 1.	No. 2.
Volatile matters	68.38	38.69
Fixed carbon	22.35	8.26
Ash	8.90	52.20
Sulphur	.05	.25
Moisture	.32	.60
	100.00	100.00
Specific gravity	1.079	1.568
Weight per cubic foot	67½ lbs.	97 lbs.
Crude oil per ton	126 gallons.	63 gallons.
Gravity of oil	.844	.850
Coke, per cent	31.25	60.46
Ash in the coke of stellarite, 28.48 per cent	....	....

	PENNY.†	
	No. 1.	No. 2.
Volatile matter	67.26	34.16
Fixed carbon	24.03	12.30
Ash	8.40	52.00
Sulphur	.11	.74
Water	.20	.80
	100.00	100 00
Specific gravity	1.069	1.612
Weight per cubic foot	66¾ lbs.	100 lbs
Crude oil per ton	123 gals.	60¾ gals
Gravity of oil	.844	.850

QUANTITY OF OIL BY VARIOUS TRIALS. (per ton.)

(1)	Trial by J. De W. Spurr, St. John, New Brunswick, (No. 2) crude oil	74 gals.
(2)	" by J. Howarth, Boston, Mass., by steam process, crude oil.	65 "
(3)	" by F. Macdonald, Portland, Maine, (No. 2), crude oil..	50 "

Comparison with other oil-coals.

For comparison, the following results from these and other oil-coals are introduced ; the table is taken from How's Mineralogy of Nova Scotia :

* Prof. Wallace, of Glasgow, Scotland.

† Prof. Penny, Andersonian University, Glasgow, Scotland.

	Crude oil per ton.
Union oil-coal of West Virginia affords	32 gals.
Elk River " " " " "	54 "
Kanawha " " " " "	88 "
Leshmahagow cannel, Scotland "	40 "
Albertite, New Brunswick,	92 to 100 "
Torbanite, Scotland,	116 to 125 "
Stellarite,	53 "
" No. 2 (shale)	50, 60¾, 63, 65, 74 "
" No. 1,	123 to 126 "
" picked samples gave in Boston	199 "

In practical working at the Frazer mine the result was about 60 gallons of crude, and from 30 to 35 gallons of fine clarified oil to the ton.

It will be noted that the three oil-coals, or bitumens, known as torbanite, albertite, and stellarite, in the list just given, appear to afford the best results in oil-manufacture. It will, therefore, be of interest to compare full analyses of these three, forming a class by themselves, and again to compare this class with other mineral combustibles from which they differ to a greater or less extent. This subject has been thoroughly investigated by Prof. How, and the following tabulation of analyses, and conclusions drawn therefrom, are taken from his late work. Although most appropriately introduced here, many of the facts will be found useful for comparison with coals of other seams, and the remarks on the theoretical value of fuels is also of general interest.

Dr. How's remarks on oil-coals.

" Having, on account of my former connection with the British Admiralty Coal Enquiry, been one of those engaged to furnish chemical evidence in the famous first trial in Edinburgh of the question whether the mineral known as "Boghead coal," found at Torbane Hill, Linlithgowshire, should properly be called a coal, I was naturally much interested on the discovery of the stellar oil-coal, and got ultimate analyses made of it and of the "Albert coal," also the subject of a trial on the ground that it had been improperly called coal. These analyses were very kindly made for me through Prof. Anderson of Glasgow, who generously met my deficiency in the necessary apparatus, which I had not brought out with me. The results were most interesting, especially when compared with those obtained from bituminous and cannel coals. As to the former, I selected from those I had made in the Admiralty Enquiry, analyses of English, Scotch, and Welsh bituminous coals, and as to the latter, analyses of English and Scotch cannels made by other chemists. The following table shews the differences which obtain between these minerals in proximate and ultimate analysis, and in specific gravity, and the ratio existing between the two most important constituent elements :—

Mineral.	Locality.	Specific gravity.	Proximate analysis. Volatile matters.	Fixed Carbon.	Ash.	Ultimate analysis. Carbon.	Hydrog.	Nitrogen.	Sulphur.	Oxygen.	Ratio of carbon to hydrogen.	Authority.
Welsh bituminous coals.	Duffryn	1.326	15.70	81.04	3.26	88.26	4.66	1.45	1.77	0.60	100 : 4.82	H. How.
	Newydd	1.310	25.20	71.56	3.24	84.72	5.76	1.56	1.21	3.52	100 : 6.79	"
	Ebbw Vale	1.275	22.50	76.00	1.50	98.79	5.15	2.16	1.02	0.39	100 : 5.73	"
Scotch bituminous coals.	Grangemouth	1.290	43.40	53.08	3.52	79.85	5.28	1.35	1.42	8.58	100 : 6.61	"
	Fordel	1.025	47.97	48.03	4.00	79.58	5.50	1.13	1.46	8.33	100 : 6.93	"
English bituminous coals.	Broomhill	1.025	40.80	56.13	3 07	81.70	6.17	1.84	2.85	4.37	100 : 7.55	"
	Lydney	1 283	42.20	47.80	10.00	73.52	5.69	2.04	2.27	6.48	100 : 7.73	"
Eng. cannel.	Wigan	1.276	39.64	57.66	2.70	80.07	5.53	2.12	1.50	8.08	100 : 6.90	Vaux.
Scotch cannels.	Lesmahagow	1.251	56.70	37.26	6.03	73.44	7.62	....	1.14	*	100 : 10.43	Miller.
	Capeldrae	....	....	....	25.40	56.70	6.80	1.90	0.35	8.80	100 : 11.99	A. Fyfe.
Torbanite.	Torbanehill, Scotland	1.170	71.17	7.65	21.18	66.00	8.58	0.55	0.70	2.99	100 : 13.00	H. How
Albertite.	Hillsboro, New Brunswick	1.091	54.39	45.44	0.17	87.25	9.62	1.75	....	†	100 : 11.02	Slessor & How.
Stellarite.	N. Glasgow, Nova Scotia	1.103	66.53	25.23	8.21	80.96	10.15	0.68	....	‡	100 : 12.53	"

* Nitrogen and oxygen 11.76. † Sulphur (if any) and oxygen, 1.21. ‡ N, S, and oxygen .68.

"In the paper in question I pointed out that the true comparative value of combustible minerals, while partly indicated by the relative amounts of volatile matter and fixed carbon, is only truly shewn when account is taken of the oxygen; which is sometimes large in quantity, as is seen above, and is reckoned as volatile matter, to the credit of the mineral, while its real effect is reduction of value. I showed that when the hydrogen equal to the oxygen present is deducted, taking only those cases where there is an apparent equality in the ratio of carbon to hydrogen, the last three minerals in the table above, stand apart from the rest, thus :—

Ratio of carbon to hydrogen after deducting hydrogen equal to oxygen present.

Cannel coal from Wigan	100 to 5.65
" " " Leshmahagow	100 to 8.71*
Capeldræ	100 to 10.05
Torbanite from Scotland	100 to 12.43
Albertite " New Brunswick	100 to 10.85
Stellarite " Nova Scotia	100 to 12.43

* Allowing two per cent. for nitrogen.

and that theoretically they should be excellent 'oil-coals,' as is abundantly shewn by experience."*

Description of stellar seam.

The size of the stellar-coal bench in the oil-coal seam varies from our or five inches in thickness to some two feet, and its content of oil varies also. As a rule, this seam appears to improve going eastward, as stated by Mr. Hoyt. The general appearance of the stellar coal is peculiar; it is irregularly bedded, the different layers seemingly interlaced, giving it a sort of an entangled appearance, or a structure like

* How, Mineralogy of Nova Scotia, p. 25–26.

felt. Sometimes the layers are much curved, and have smooth surfaces like slickensides, which appear to have been produced by lateral movements, corresponding very nearly with the plane of the bed, rather than by vertical motion, the better portions generally possessing this peculiarity, whence the statement in many notices of this substance that the *curly* oil-coal is the best. The surfaces of these curved faces have a bright, resinous lustre, and a brownish-black colour, while a block sawn across shews a uniform *dead*-brown surface. It breaks with a splintery fracture, very irregularly, but approximately with the surfaces of deposition ; the streak has a brown colour and a dull resinous lustre.

A large splinter of this mineral may be easily lighted with a match, and burns with a very bright, carbonaceous flame, throwing off sparks like stars, (whence the name), and leaving but a small amount of coke, from which, on burning off the fixed carbon, a grayish-white ash is obtained. Further remarks on the use of this mineral in gas-making, will be found in Section II of this Report.

COAL OF THE ACADIA SEAM, ACADIA COLLIERY.

Acadia steam coal.

ACADIA STEAM COAL. The principal value of this coal, is (as its name indicates) as a steam-coal, though a portion of the seam at this colliery may be suitable for gas-making. As the character of the coal as a steam-producer will receive the fullest attention in the second section of this Report, it has been deemed unnecessary to make any analyses of it as yet, though when time permits I hope to obtain a full series of analyses of the coals from different benches of the seam, by examination of a series of specimens presented by Mr. Hoyt. In the meantime I offer my practical locomotive and steamer-trials, with some other tests of considerable interest, in Section II, which I consider will give abundant evidence of the excellence of the Acadia steam-coal.

Third bench.

Only one analysis of this coal has been made in the laboratory of this Survey, that of samples of the coal taken from the third bench, or the four feet immediately underlying the fireclay parting. (See page 97 of my Geological Report.) These specimens were selected for analysis, because I believe this bench to be better fitted for gas purposes than the rest of the seam, being apparently the softest coal afforded by the Acadia seam at this colliery.

The analysis has lately been made by Mr. Broome, with the following results :—

Analysis.

	BROOME. Coking.	
	Rapid.	Slow.
Coke..	65.12	68.70
Volatile matters	34.88	31.30
	100.00	100.00

Hygroscopic moisture	2.100
Volatile combustible matter	32.274
Fixed carbon	57.570
Sulphur	.506
Ash, (pinkish white)	7.550
	100.000
Specific gravity	1.32

The coke by rapid carbonization was firm, but by slow heating a pulverulent mass was obtained.

This analysis shows that a portion of the seam at the Acadia colliery will coke well, and that it contains sufficient volatile matter to make a gas-coal. The greater part of the seam is a much harder coal than the specimen examined, and, when all the benches are mixed, does not coke satisfactorily in open heaps, and is therefore sold only as a *free-burning* or steam-coal. Were it desirable, however, I think the third bench could be easily separated in the working of the seam

The coal of this seam is rather more compact in appearance than that from the Main at the Albion mines, and shows but little mineral charcoal on the deposition-planes. The cleat planes and cross fractures of the coal are usually very brilliant, and do not show the laminæ or deposition-planes very clearly.

COAL OF THE ACADIA SEAM, DRUMMOND COLLIERY.

Drummond coal.

From a careful examination of the different benches of coal in the working, and subsequent examinations of a series of large samples of the coals presented by Mr. Dunn, manager of the Intercolonial Coal Company, I am enabled to present the following description of this fine seam of coal, as worked at the Drummond Colliery. With my description of the benches, analyses will be given, forming what I believe to be the most careful and complete series of assays ever made of different benches of any seam of considerable thickness. These analyses have lately been made in the Survey laboratory by Mr. Gordon Broome, F.G.S., chemical assistant to Dr. T. Sterry Hunt, chemist and mineralogist to this Survey.

Description of seam worked.

Description and analyses of the benches of the Acadia seam at the Drummond Colliery, Pictou County, Nova Scotia.

Roof-shale.

Roof-shale; black, highly carbonaceous shale, giving a dark brown streak, and containing *Spirorbis* and *Cythere* shells, with *Antholites*, *Lepidodendron*, *Lepidostrobus*, not specifically determined, and *Cordaites borasifolia.*

Top coal.

1. *Top coal;* not taken out in the workings. This is left in as a support for the roof. Coal good, principal partings show mineral charcoal, and have

rather a dull lustre. On cleat surfaces the general lustre is brilliant, but the laminæ of deposition show plainly in lines of brilliant and dead black. The joints are rather irregular, generally inclined about < 80° to 85° to the deposition-planes, but the surface next to the lower parting, (*a smooth parting*,) shows two regular sets of joints at right angles, giving the coal a *cubical* appearance.

Thickness of *top-coal* bench, 2 feet, 6 inches.

ANALYSIS NO. 1; TOP COAL.

Analysis.

Volatile at 100 C., (moisture)	.72
Volatile at 220° C.,	7.83
Total volatile, 1. By slow coking	27.56
" " 2. By fast coking	30.19
Coke, 1. By slow coking	72.44
" 2. By fast coking	69.81
Volatile matter	29.928
Fixed carbon	60.350
Ash, (gray)	9.460
Sulphur	.262
	100.000
Specific gravity	1.309

2. *Fall Coal;* immediately above the fireclay parting, or *holing*, this being the first bench taken down. Coal good; surfaces of deposition show dead-black patches of mineral charcoal, with bright points, and patches of bright bituminous matter. Cleat surfaces brilliant, the joints running in two systems, giving this bench in some parts of the workings, a cubical, or as it is technically called, *dicey*, structure. The surfaces of one system of joints show oblong or oval scars, as of *shrinkage*, while of the second system the surfaces are quite regular and brilliant. Fall coal.

Thickness of *fall-coal* bench, 3 feet, 3 inches.

ANALYSIS NO. 2; FALL COAL.

Analysis.

Volatile at 100° C., (moisture)	1.56
Volatile at 220° C.	13.61
Total volatile, 1. slow coking	29.78
" " 2. fast coking	31.92
Coke, 1. slow coking	70.22
" 2. fast coking	68.08
Volatile matter	31.694
Fixed carbon	60.320
Ash (gray)	7.560
Sulphur	.426
	100.00
Specific gravity	1.328

First bench.

3. *First bench;* (below the holing.) Coal good; all of the surfaces, whether of cleat and fracture, are brilliant, and the deposition-planes show very little mineral charcoal. The joints are irregular in direction and angle, cutting the coal up into oblique prisms. This is a remarkably clean and bright coal.

Thickness of *first bench*, 4 feet.

Analysis.

ANALYSIS NO. 3; COAL OF FIRST BENCH

Volatile at 100° C., (moisture)	1.80
Volatile at 220° C	16.45
Total volatile, slow coking	26.49
" " fast coking	34.11
Coke, slow coking	73.51
" fast coking	65.89
Total volatile matter	33.526
Fixed carbon	55.390
Ash, (gray)	10.500
Sulphur	.584
	100.000
Specific gravity	1.327

Second bench.

4. *Second bench;* (so marked in specimens sent me.*) Good coal, laminated and cubical; in some parts of the seam the cubical structure is very distinct. On the surfaces of the deposition-planes, there is some mineral charcoal, but all the other surfaces are of a brilliant black.

Analysis.

ANALYSIS NO. 4; COAL OF SECOND BENCH.

Volatile at 100° C., (moisture)	1.31
Volatile at 220° C	14.61
Total volatile, slow coking	28.73
" " fast coking	31.02
Coke, slow coking	71.27
" fast coking	68.98
Total volatile matters	29.973
Fixed carbon	60.310
Ash, (gray)	8.670
Sulphur	1.047
	100.000
Specific gravity	1.343

Third bench.

5. *Third bench;* the lower two feet of good coal, next above the coarse coal; forming the bottom of the seam. Coal good, laminated distinctly; it is not so bright as the first and second benches, though an excellent coal. Deposition-planes are a dull black, showing much mineral charcoal. Cleat

*In my Geological Report, p. 100, I have associated this bench with the one below it, which is now called the third bench.

planes show laminæ of deposition plainly, and in the joints, in many cases, are seen scales of calc-spar.

ANALYSIS NO. 5; COAL OF THIRD BENCH.

Analysis.

Volatile at 100°C., (moisture,)	1.43
Volatile at 220°C	13.12
Total volatile, slow coking	29.14
" " fast coking	31.32
Coke, slow coking	70.86
" fast coking	68.68
Total volatile matters	30.756
Fixed carbon	59.890
Ash (gray)	8.790
Sulphur	.564
	100.000
Specific gravity	1.335

Coarse-coal bench.

6. *Coarse-coal bench,* bottom of seam; thickness about 2 feet, 9 inches. Coal coarse and shaly; deposition-planes show uniform dead-black surfaces. Coal breaks with irregular fractures in all directions, giving fracture surface of a dull lustre and brownish black colour. Not worked.

ANALYSIS NO. 6; COAL OF THE COARSE-COAL BENCH.

Analysis.

Volatile at 100°C., (moisture)	1.58
Volatile at 220°C.,	undet.
Total volatile, slow coking	29.89
" " fast coking,	31.81
Coke, slow coking	72.44
" fast coking	69.81
Total volatile matters	32.81
Fixed carbon	37.16
Ash, (red)	31.03
Sulphur	undet.
	100.00
Specific gravity	17.65

Cokes.

The cokes of Nos. 1, 2, 3, 4, 5, obtained by the carbonization of the coal in the small way, (in a crucible), were all strong and light, whether by slow or rapid heating, though of course more compact with a slow carbonization. When heated rapidly the coke swells greatly, and is of a silvery-gray colour and metallic lustre. All these benches should, if properly managed, furnish an excellent coke in the large way. With the single exception of the Foord-pit coal, no coal from this region which I have examined has given as good a coke in the crucible. The coke from No. 6, or coarse coal, is soft and brittle.

Ash.

The amount of ash in the different samples is lower than the average of Pictou coals, and the sulphur-content is, in samples I., II., IV., V., decidedly low. The coal of the second bench appears to give the greatest amount of sulphur, being somewhat over the average of the best Welsh coals, but in the coal of the whole seam, when mixed together, the amount of sulphur will be found to be exceptionally small.

Drummond coal for gas-making.

From the amount of volatile matter, as shown by these analyses, these coals, (*i. e.* the good coals of the seam,) should all belong to the class of gas-coals; in the first bench, No. 3, the content of volatile matter is very large, and about equal to the average of Newcastle coals, when rapidly carbonized. A reference to the report of Mr. Thompson, of the Pictou gas-works, on this coal, (which is published in Section II of this Report,) will show that in this case the conclusions of theory agree with practical results.

With regard to their use as steam-producers, theory gives the following indices of their evaporative powers:—

Theoretical evaporative powers.

I.	Fixed carbon	60.35	per cent	= 8.29 lbs.	water	to 1	of coal.
II.	"	60.32	"	= 8.29 lbs.	"	"	
III.	"	55.39	"	= 7.61 lbs.	"	"	
IV.	"	60.31	"	= 8.29 lbs	"	"	
V.	"	59·89	"	= 8.27 lbs.	"	"	

It will be seen that a remarkable uniformity exists between the coals of I., II., IV., V., and that their theoretical evaporative powers are rather high for coals of this class, while III. falls rather below the average in fixed carbon. In this connection, however, I would draw attention to the fact that coals of this class are now burnt so as to give an evaporative power considerably above the theoretical index calculated from the fixed carbon of the coal alone. This subject has already been incidentally referred to in the introduction to this Section,* and will also receive special attention in Section II.

COAL OF THE ACADIA SEAM FROM THE NOVA SCOTIA COLLIERY.

Nova Scotia Co.'s Coal.

A section of this seam, giving details of the character of the coals of the different benches, has been included in the Geological Report, † and the following analyses of three specimens of the coal, by Prof. B. Silliman, of Yale College, New Haven, Connecticut, have been sent me by Mr. F. W. Northrop, Secretary of the Nova Scotia Coal Company:—

Silliman's analysis.

	SILLIMAN.		
	(1) Top.	(2) Middle.	(3) Bottom.
Volatile matters............................	32.68	32.39	33.45
Fixed carbon,............................	62.08	62.40	61.41
Ash..	5.24	5.21	5.14
	100.00	100.00	100.00

* See note on North Country coals, page 3.

† Pages 103-104 of the Geological Report.

From these analyses the theoretical evaporative power of the different samples would be :—

Of No. 1, 8.53 lbs. ;—of No. 2, 8.57 lbs. ;—of No. 3, 8.44 lbs.

In the letter accompanying these analyses, Prof. Silliman makes the following statements :—

"The coke is firm and strong, while the ashes are light coloured, and so nearly free from oxide of iron as to warrant the belief that they will not give much clinker when the coal is used in a furnace. The amount of sulphur in the coal was not determined, as the quantity is too slight to render an experiment in the small way of any practical value."

Change in the Acadia seam.

It would appear from these analyses that there is a change in the character of the coal of the Acadia Seam between the Acadia and Nova Scotia collieries similar to that between the Acadia and Drummond collieries, and if the specimens analyzed by Prof. Silliman were fair representative samples of the whole seam, this should be, theoretically, a good gas-coal.

COAL OF THE MONTREAL AND PICTOU SEAM.

MONTREAL AND PICTOU COLLIERY.

Montreal and Pictou Co's. coal.

The works of this company having been abandoned before my visit, and the pit being full of water, during my stay in the region I was unable to procure samples of the seam or seams met with in the workings. The following note by Prof. How is, I believe, the only reliable information at present attainable concerning this coal :—

How's analyses

"*Coal of the Montreal and Pictou Mines.* I examined several samples of the coals raised on the first opening of the seams ; the following is an abstract of my Report made to the company as respects the qualities of the coals.

First bench.

"Sample No. 1, from the first bench, gave :—

Moisture	4.40
Volatile combustible matter	24.95
Fixed carbon	61.07
Ash	9.58
	100.00
Coke	70.65
Theoretical evaporative power	8.39

"This coal has considerable evaporative and heating power, and would give a moderate amount of gas of good illuminating quality. The appearance of the coal is much in its favour ; some that I saw taken from the seam was very clean and bright.

"Sample No. 2, from the second bench, gave :—

Second bench.

Moisture	5.47
Volatile combustible matter	19.93
Fixed carbon	68.55
Ash	6.05
	100.00
Coke	74.60
Theoretical evaporative power	9.41
Specific gravity	1.36

"This was an extremely bright and clean coal. Its very high evaporative power makes it occupy a good position among British and American coals for steam purposes."*

COAL OF THE MONTREAL AND PICTOU OIL-COAL SEAM.

Montreal and Pictou oil-coal seam.

On page 106 of the Geological Report, mention is made of a small seam known on the Montreal and Pictou area, which I am inclined to identify with the Stellar seam of the Acadia mines. I have been unable to procure a good sample of the oil-coal from this seam, but a small specimen taken from the out-crop on the quarry road, much weathered and by no means fairly representing the seam, has been analysed by Mr. Broome with the following result:—

Analysis.

	Broome.
Volatile at 100° C., (moisture)	2.40
Volatile at 200° to 250° C	34.20
Total volatile matter	47.35
Fixed carbon	34.05
Ash, (very red and ferruginous)	18.60
	100.00

Description.

This substance is, in external character, very much like the stellarite. It presents the same dead-brown fracture, and shows glistening points of bituminous matter, which, on being ignited, melt and drop from the forceps. The facility of its ignition and continuity of combustion of a small piece, when removed from the flame in which it has been lighted, is only equalled among the oil-coals of the region, by the stellarite, and these facts, together with the results of Mr. Broome's analysis, tend to confirm my identification of the seams.

COAL OF THE CULTON SEAM; CULTON ADIT.

Coal of the Culton seam.

I have been unable to obtain a specimen of the coal of this working. Its character has been described to me by several who have burnt it, as that of an exceptionally good, and very highly bituminous coal.

* How, Mineralogy Nova Scotia, p. 27-8.

COALS OF THE EAST SIDE OF THE EAST RIVER.

COALS FROM MCBEAN'S EIGHT-FEET SEAM, MCBEAN'S SLOPE.

Coals of McBean's 8-feet seam.

First bench.

First Bench. Upper twelve inches of the seam.

The coal is a bituminous coal, with dead-black planes of deposition, showing little mineral charcoal. It is inclined to be a little shaly, but the cleat and cross-fracture surfaces are brilliant. The following analysis is the result of an examination of two specimens from quite near the out-crop :—

Analyses.

	Hartley. I.	II.
Hygroscopic water	1.57	2.67
Volatile combustible matter	29.29	28.65
Fixed carbon	52.36	49.66
Ash (white)	16.76	19.42
	100.00	100.00
Coke	69.14	65.08

These samples analysed were taken by myself from the seam, and were apparently an average of the bench. The coal burns well, forming a very hot flaming fire, and the ash, though bulky, is perfectly white, free from iron, and would fall at once through grate bars. No sulphur was discovered by ordinary tests. The coke does not hold together well.

Second bench.

Second bench, (about twelve inches below first bench.)

In appearance this coal is similar to the last. except that there appears to be no mineral charcoal visible on the planes of deposition, and the lustre of the cleat planes is very brilliant. The specimens analysed are from the slope about 40 feet from the crop, and show scales of calc-spar in the joints. Analysis I is from the top of the bench. Six inches below is a smooth parting, and analysis II, is from coal just below the parting.

Analyses.

	Hartley. I. Top of Bench.	II. Bottom.
Hygroscopic water	2.67	1.94
Volatile combustible matter	27.20	23.95
Fixed carbon	54.86	57.17
Ash (white)	15.27	16.94
	100.00	100.00
Coke	70.13	74.11

Bottom bench.

Bottom bench (lower six feet of seam).

This coal shows but little tendency to break with the lamination, and no mineral charcoal is seen, even the deposition-planes being brilliant. Fracture conchoidal. It burns freely, giving a very hot fire ; the ash is very light, sandy and not inclined to clinker ; it would fall at once through the grate bars of a furnace. No sulphur was found by ordinary tests.

The samples analysed were taken about 50 feet from the crop. The coke, if the coal is properly carbonized, is very fair. The following analyses of averages have been made :—

Analyses.

	Hartley. I.	Hartley. II.
Hygroscopic water	2.22	3.00
Volatile combustible matter	30.23	29.61
Fixed carbon	59.70	59.51
Ash (white)	7.85	7.88
	100.00	100.00
Coke	67.55	67.39

This coal should make an good gas-coal, as the percentage of volatile matters is quite large in comparison with many of the coals of the district. I am not aware that any practical trial has ever been made of it as a gas-producer. From its rapidity of combustion and freedom from sulphur, it would also appear to be well fitted for ordinary steam purposes.

COAL OF THE GEORGE MACKAY SEAM, MARSH COLLIERY.

George Mackay seam.

This coal is coarsely laminated ; the deposition-planes have a very dull lustre, and show a great many patches of mineral charcoal. The cleat planes are inclined <83° to the bedding ; the joints show many scales of calc-spar, which is not adherent to the coal, but crumbles under the finger.

Coal of Marsh Colliery.

The following analyses of two specimens from the Marsh pit, 240 feet deep, and striking the coal seam about 1,000 feet from the crop, show this coal to be of very good quality, notwithstanding its rather coarse appearance :—

Analyses.

	Hartley. I.	Hartley. II.
Hygroscopic water	none.	none.
Volatile combustible matter	29.72	29.98
Fixed carbon	62.28	62.15
Ash, (buff coloured)	8.00	7.87
	100.00	100.00
Coke	70.28	70.02

The percentage of ash is decidedly low. A trace of sulphur was found, but being, probably, under one-half of one per cent., was not estimated. As the specimens examined do not coke particularly well, it would appear that this coal is best fitted for a steam-coal.

COALS OF LAWSON'S SEAM ; LAWSON'S SLOPE.

Lawson's seam.

The specimens examined were taken from the slope sunk by Mr. J. P. Lawson, M.E., for the Montreal and New Glasgow Coal Company, on the left bank of Potters' Brook, near the Merigomish telegraph road. At this working, the seam, as measured by me, was divided into the following benches:—

Section at Lawson's slope.

	Ft.	In.
Cannel coal, (varies in thickness,) about	0	6
Mineral-charcoal bench	0	2
Good coal	2	7
Coarse (but good) coal	0	5
	3	8

Cannel-coal Bench.

Cannel-coal bench.—This coal appears to be a true cannel, being of a homogeneous texture, and dead grayish-black colour. The fracture is conchoidal, lustrous, streak brownish-black. In some places this cannel becomes shaly, breaking roughly with the deposition-planes, which are a dull black and in many cases tinged dark red with iron rust from iron pyrites, which occurs in small lenticular masses; cleat planes vertical to the bedding. One specimen shows a coprolite. A picked sample of this bench gave:—

Analysis.

	Hartley.
Hygroscopic water	.47
Volatile combustible matter	41.18
Fixed carbon	48.19
Ash, (reddish or purple)	10.16
	100.00

This specimen gave a very large quantity of very highly carburetted gas, but the coke is not of the best quality.

Mineral charcoal bench.

Mineral-charcoal bench. Interlaminations of mineral charcoal and bright bituminous coal form the material of this bench. The specimens examined show small veins of calc-spar in the joints of the coal, which are in many cases inclined at an angle of only 45° with the bedding. This bench shows a great deal of iron pyrites, coating the patches of mineral charcoal with a bright film, and giving them the appearance of having been gilded. Not analysed.

Good-coal bench.

Good-coal bench. Colour of coal dull black, very compact and heavy, with occasional patches of mineral charcoal. It shows but little tendency to break with the planes of deposition, and has generally a sub-conchoidal and sometimes a ragged fracture. The specimen examined contains a great deal of sulphur, in the form of iron pyrites, which if present in the mass of the coal, would altogether unfit it for steam or domestic uses. It burns, however, with a very bright and hot fire, though the ash is very bulky, and sometimes chokes the fire if not properly cleaned.

The following analysis of this coal is given in a report by Dr. J. W. Dawson, to the owners of the East River coal area:—

Dawson's analysis.

	DAWSON.
Volatile matter, (moisture included)	25.4
Fixed carbon	50.0
Ash	24.6
	100.0

The ash from this coal is generally red or reddish-gray.

Coarse-coal bench.

Coarse-coal bench. The coal of this bench is very coarse in texture, having two sets of cleavage joints, very distinctly marked, which, with the planes of deposition divide it up into small cubical blocks, giving it the appearance known technically as *dicey.* The surfaces of the coal along the joints are generally rendered very dull in colour from the presence of fire-clay from the underclay of the seam, which softens when exposed to the atmosphere or percolating water, and is forced by the superincumbent pressure up into the open joints of the coal, presenting the phenomena of a *creep*, on a very small scale. This coal, were it not for its tendency to crumble (from its open texture), would be an especially good coal, as may be judged from its extreme lightness. The following analysis of a specimen from this bench presents a most remarkable contrast in content of ash (in spite of the fireclay in its joints) to the overlying bench :—

Analysis.

	HARTLEY.
Hygroscopic water	1.82
Volatile combustible matter	28.47
Fixed carbon	63.93
Ash, (buff-coloured)	5.78
	100.00

A determination of ash in another sample, gave 6.07 per cent.

COAL FROM THE "OLD FRAZER MINE." *

Foster seam.

I have not examined the coal from this seam, but on the authority of Dr. Dawson, it is stated to be "a good coal of uniform quality." † He distinguishes the seam in his Report, as the *Foster seam*, and gives the following analysis of the coal:—

Dawson's analysis.

	DAWSON.
Volatile matter, (including water)	29.0
Fixed carbon	53.4
Ash, (reddish gray)	17.6
	100.0

* Report of Sir William E. Logan, p. 44.

† Report of Dr. J. W. Dawson to East River Coal Company.

COAL OF THE RICHARDSON SEAM, (PIT AT THE CROWN POTTERY.)

Richardson coal.

In appearance this coal is rather coarsely laminated, and its only tendency to break is roughly with the deposition-planes. In colour it is jet-black, the only perfectly black coal examined, and in the specimens analysed, all the surfaces, whether of deposition-planes or fracture, were brilliant, showing no trace of dead-black mineral charcoal, a very unusual thing with coals of this district. It is the most highly bituminous *true* coal of the district (so far as I am aware,) and I should judge from the analysis that it would be an admirable gas-coal, for which purpose it should be tested. It gives a very good coke, and the ash is very light, perfectly white, and silicious or sandy, and therefore will not be inclined to clinker. On the whole this seems to be a coal of remarkable purity, if fairly represented by the specimens I have seen. The pit not being open during my visit, samples were taken from a small heap of coal lying beside it, which however, had been for some time exposed to the weather. The following is an analysis of an average of these samples:—

Analysis.

	HARTLEY.
Hygroscopic matter	.76
Volatile combustible matter	38.84
Fixed carbon	55.81
Ash, (white)	5.09
	100.00
Coke	60.90

No sulphur was detected by ordinary tests. The content of ash, it will be observed, is lower than in any other coal of the district of which an analysis is given in this Report, with a single exception. Should the Richardson seam be proven over any considerable area, it would seem probable that, although quite small, it might be profitably worked with fair prices of coal, especially if taken out in connection with a valuable bed of fireclay, which underlies it a few feet, and which has already been worked to a small extent for pottery and fire-brick manufacture, by the Crown Brick and Pottery Company of New Glasgow.

UPPER OIL-COAL OR OIL-SHALE SEAM.

Oil-shale seam.

The substance included in this seam varies very greatly in external character between the two extreme points where it is known, at Haliburton's pit on the Marsh Brook, and at Andrew Patrick's old slope on McLellan's Brook, a short distance below the Fulling-mill bridge.

OIL-COAL FROM ANDREW PATRICK'S MINE.

Andrew Patrick's oil-coal.

The oil-coal from this mine occurs both shaly and *curly*, the latter description appearing to be the most valuable. That portion having the curly texture much resembles the stellarite in appearance, but is much heavier, and has a lighter brown colour. It weathers a very dark gray. The following analysis has been made by Mr. Broome of some large samples selected by Sir William E. Logan in 1868 :—

	Broome.
Volatile below 200° Centigrade, water and some oil	.67
Volatile at 200° C., (oil)	14.73
Total volatile matter	33.91
Fixed carbon	6.11
Ash (grayish-brown)	59.88
	100.00
Coke	66.09
Specific gravity	1.747

This oil-coal has been used in the manufacture of burning-oil, I believe, but I am not aware of the quantity of oil produced per ton.

OIL-COAL OR SHALE, FROM THE MARSH BROOK.

Oil-coal from the Marsh Brook.

This substance appears to be an argillaceous shale, of a grayish-black colour, giving a brownish streak ; the bedding is not well marked, except on surfaces of fracture, where the lamination can be traced by numerous small brilliant points, apparently bituminous, which are included between the laminæ. A thin section of this oil-shale under the microscope presents the appearance of a dark brown or black ground, nearly opaque, with numerous spots of yellow, which are translucent ; the black ground being the shale, and the yellow points the included hydrocarbonaceous matter. The following analyses of this substance have been made, the first being of a specimen procured in 1868, by Sir William E. Logan, from the pit on the Marsh Brook known as Haliburton's pit :—

Analysis.

	Hartley.
Hygroscopic water	1.02
Volatile combustible matter	27.44
Fixed carbon,	9.26
Ash, (grayish-brown, shaly)	62.28
	100.00
Specific gravity	1.68

Since the above analysis was made, I have procured other specimens from the same pit, one of which was analysed by Mr. Broome, with this result:—

Analyses.

	Broome.
Volatile at 100° C, (water and some oil)	.596
Volatile at 200° C	11.250

No. 1, Rapid coking.

Total volatile matter	40.600
Fixed carbon	.400
Ash, (grayish-brown)	59.000
	100.000

No. 2, Slow coking.

Total volatile matter	35.540
Fixed carbon	5.260
Ash	59.200
	100.000

The above results show that this shale is composed almost entirely of volatile matter and ash, the amount of fixed carbon being dependent on the rapidity of carbonization. This shale has been tested for oil, but the results I have not heard. Theoretically, it should be a valuable oil-shale.

II.

PRACTICAL TRIALS OF PICTOU COALS.

Value of practical results.

In the first portion of Section I, I have already drawn attention to the great importance of practical trials of coals as steam and gas-producers, and for other purposes of the industrial arts; and I have incidentally mentioned that several series of experiments on coals, with a view of ascertaining their evaporative value, had been carried out, so far as the coals of Great Britain and the United States were concerned, by the British and American governments, respectively. My attention was especially called to this matter during my examination of the Pictou district, while endeavouring to collect materials for a report on the coals of that region; by the almost total ignorance prevailing, of what work the coals could practically perform, or for what work they were best fitted. With one exception no figures could be obtained which would prove any of the coals to be valuable as steam-coals, that exception being the values furnished by a trial incidentally made (for comparison) by the American Government, during the series of trials of United States coals;—of the Albion-mines coal shipped in 1843 or 1844, when the upper twelve feet of the Main seam was the only coal worked. Although fully satisfied, from observing the success with which the coals were burnt, in the region, under stationary, locomotive, and marine boilers, that many of the coals were well fitted for steam-producers, I was, at the same time, aware that a report merely giving my own opinion, would not have the value that would attach to a report of systematic trials, of which the results could be stated in figures. Being aware that no experiments could be undertaken similar to those of the Admiralty and American navy trials, it became necessary to devise some plan by means of which the use of the necessary apparatus could be obtained without great expense. The proper method would have been, of course, the use of the same boiler for all coals, which boiler should be fitted with proper grates, flues, etc., for burning each coal in the most economical manner. As this would have entailed the erection of such an apparatus at the public expense, it appeared out of the question, and the only plan seemed to be to make such trials on locomotives and steamers as could be carried out with a small expenditure, through the liberality of the coal-owners, or other parties interested in knowing the true value of the coals.

Plan adopted for steam-trials.

Having obtained the consent of Sir William E. Logan, then Director of this Survey, I broached the subject to the agents of the several collieries which were in active operation, about the middle of the month of October

Coal trials.

last, and, through their kindness, several trials were at once arranged for. Through Mr. Jesse Hoyt, Manager of the Acadia Coal Company, I was permitted to make a trial of the Acadia steam-coal on the Provincial or Nova Scotia) Railway, by Mr. Lewis Carvell, General Superintendent of the railways of the provinces of Nova Scotia and New Brunswick, and many facilities were granted me by him, and all the other officials of the Railway Department.* At Mr. Carvell's request, another trial was made, shortly after, on the same railway, with wood, for a comparison of the two fuels.

Through Mr. Hoyt, and Mr. Hales, Manager of the Prince Edward Island Steam Navigation Company, a second trial of the Acadia coal was then made, on the steamer " St. Lawrence," of the P. E. I. Navigation Company's line. As before, I was granted every facility by all the officers of the line, and especially by Mr. Hales.

Wood trial.

A third trial was that made with wood on the Provincial Railway, as above referred to. This was undertaken at Mr. Carvell's request, in order to institute a comparison between wood and coal by practical experiment. By reference to that portion of this section headed ' Comparison of Coal and Wood,' it will be seen that the results were greatly in favour of coal.

Coal from the Acadia West colliery had been used on the Windsor branch of this railway, for some months, but, so far as I am aware, no train had been run over the main line from Pictou to Halifax with a coal-burning engine previous to my experimental train—the fuel hitherto used having been wood, furnished the railway by contract. I believe that the final result of my comparative experiments will be the complete abandonment of wood as a fuel on this railway, (so soon as the engines can be fitted for burning coal,) with very considerable saving in expense and time.†

The fourth trial was made on December 3rd., through the kindness of Mr. Dunn, Manager of the Intercolonial Coal Mining Company, on that Company's railway, with a Scotch coal-burning engine, and a loaded coal-train. In this experiment I was materially aided by Mr. William Crawford, C.E., the Company's Chief Engineer, who accompanied me on the engine, and noted the times of passing many points, by means of which a very complete record of the performance of the engine was obtained. A previous trial had been attempted on this railway, but it was stopped by stormy weather (rain and sleet), which prevented a proper adhesion of the driving-wheels to the rails. I ammuch indebted to Messrs. Dunn and Crawford for the facilities given me in these trials.

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* I would especially acknowledge my obligations, for courtesies and information received, to Mr. Alex. MacNab, C. E., Chief Engineer of the Nova Scotia Railway.

† A detailed Report on these experiments will be made to Mr. Carvell, during the present season, by permission of the Director of this Survey.

Trials postponed.

A number of similar trials were planned for the middle of the month of December. Mr. Hudson, General Manager of the General Mining Association, placed the railway of that company, and a fine 26-ton English coal-burning engine at my disposal, for experiments on coals of the Main and Deep seams. Trips on the Association's steamer "Dragon," for a trial of Dalhousie-pit and Cage-pit coals, were arranged for, but continued stormy weather prevented these trials until it became necessary for me to return to Montreal, when it was decided to postpone them until the coming season, during which it is intended to complete the investigations.

In all of these experiments the greatest care was taken to burn the coals as economically as possible, and in notes of the performance of the engines and furnaces, the system of minute-blanks, first instituted, I believe by Messrs. Bunning and Richardson, in their experiments (at Devonport, and on the steamer "Weardale,") on North Country coals, was adopted. As my experiments are not yet complete, it is not deemed advisable to publish these notes in full, at present, and therefore, in the present Report, only an abstract of the principal facts of interest obtained, is given, the detail being reserved for future reports, when the series of trials for this region shall be completed.

To my own experiments on Acadia and Intercolonial coals, are added an abstract of the experiments on Albion-Mines coal, by Prof. W. R. Johnson, in 1843-1844, for the American Government; and a variety of statements concerning the value of the different coals of this region for gas-making and other purposes, which need not be here named in detail.

TRIAL No. 1, ACADIA STEAM COAL.

Railway trial of Acadia coal.

Date:—Nov. 3rd, 1869. On Nova Scotia Railway.
Trip:—From Pictou Landing to Richmond (Halifax).
Distance:—112 miles.

DETAILS OF EXPERIMENTAL TRAIN.

Locomotive used:—No. 7, N. S. Railway.

Description.—Coal-burner altered from wood-burner. Built 1857, by Neilson & Co., Glasgow. Tender-engine, four driving-wheels, 5′ in diameter; cylinders (2) $16\frac{1}{8}''$ diameter × 21″ stroke. Has a rocking grate, (six bars 2′ 9″ long × $7\frac{1}{16}''$ wide,) hung with $\frac{1}{8}''$ clearance, making grate 3′ 8″ wide, and giving about 10 square feet fire-surface. In each bar there are sixteen openings $1\frac{1}{16}'' \times 7\frac{1}{4}''$, which, with openings between bars, and at sides and ends, give about 8.5 square feet air-passage in grate. Grate is rocked by movable bar.

Experimental train.

Weight Train.	*Pounds.*
Engine.—The total weight of Engine No. 7, without tender is..... (Of this 35,650 lbs. is effective weight on drivers.)	66,130
Weight of tender, with water, without coal........................	40,340
1 supply platform-car, (coal); weight at start..................	35,380
5 box-cars, each carrying 100 barrels of flour	181,890

6 coal (platform) cars, (loaded)	205,090
1 first-class passenger-car	28,260
Officers and passengers	1,820
Total weight of train at start	558,910
Or about	249 tons, 10 cwt.

The length of this train, from front of leading-wheels of engine, (forward truck,) to rear wheel of last car, was 457 feet.

This train started from Pictou Landing at 10h. 23m. A.M., and with lengthy stoppages to pass up-trains, at several stations, arrived at Richmond station at 9.17 P.M. Trip.

The account of actual time and stoppages is as follows :—

	H. M.
Time of train on road	10.54
Length of stoppages	4.44½
Actual running time	6.09½

The character of the line run over, may be briefly described as being difficult for the first 39 miles, with up-grades as great as 67.58 feet to the mile ; easy, from 39 miles to 52 miles ; and with grades ranging from level to a rise of 50 feet to the mile, for the rest of the distance. The resistance encountered on these grades was materially increased by numerous curves, between Pictou Landing and Riversdale (39 miles), the sharpest of which was 955 feet radius ; and also by several sharp curves on the line between Windsor Junction and Richmond, the sharpest of which has a radius of only 792 feet. Line passed over.

During the trip, the coal had several severe tests as a steam-producer, as for instance between mile-posts 17 and 29, where the grades range from 51.90 to 67.58 feet per mile. These grades were ascended at an average speed of 10 to 13 miles per hour, and on the steepest, (Summit grade,) 67 feet per mile, with a curve of about 1000 feet radius, the engine kept up steam well, losing only 4½ lbs. in 6 minutes, with both pumps on ; * and making 59 revolutions per minute at the top of the grade.

The grate was shaken but three times ; at Glengarry (24 miles), Brookfield (60 miles), and Elmsdale (83 miles). No inconvenience was felt from ash, although the engine had a tight ash-pan, until Elmsdale was reached, when the throats of the dampers, forward and back, were found to be slightly choked with ash, and were cleaned, about 20 lbs. of ash being removed. The smoke-box was also opened, and about a bushel of cinders taken therefrom, which had covered a few of the lower tubes. With an

* Pumps of Engine No. 7, are two 2″ plungers ; 21″ stroke.

ordinary train, it is probable that neither of these cleanings would be needed, but this experimental train was, I believe, the heaviest ever run over the road.

STATEMENT OF COAL BURNT.

Coal consumed.

The following is a statement of the amount of coal consumed on this trip:—

	Pounds.
Weight of supply-car at Picton Landing	35,380
" " Richmond	29,530
Coal put on tender	5,850
Deduct coal left on tender	214
	5,636

Or in round numbers 2 tons, 10 cwt. = 50.3 lbs. per train-mile, or 3.87 lbs. per car-mile.

Ash and clinker.

The amount of ash and clinker from this coal was 552 lbs., or about 8.3 per cent. The ash was gray, with a reddish tint, the clinker brittle, with a flesh tint, in some places inclining to reddish. No clinker was observed adherent to the bars, and no pieces of clinker of a size exceeding three or four pounds.

Water evaporated.

The water evaporated was estimated by carefully gauging the tank of the tender at each water-station, and calculating the weight of the number of cubic feet passed into the boiler, as given by the gauge-marks. Although liable to errors, it is probable, from the number of gaugings, that these errors will nearly balance one another, and that the general totals will be correct. The following is the calculated weight of water evaporated between stations:—

		Pounds.
Between Pictou Landing and Glengarry.	24 miles	10,542
" Glengarry and Riversdale	15 "	4,869
" Riversdale and Pollybog	26 "	5,873
" Pollybog and Windsor Junction	35 "	10,291
" Junction and Richmond	12 "	3,137
Total, between Picton and Richmond		34,712

Result.

This is equal to 6.159 pounds of water evaporated, to one pound of coal burnt. The average temperature of the feed-water, for the trip, was about 40° Fahrenheit, and the evaporative power of the coal for water from this temperature being equal to 6.159 lbs., its evaporative power in pounds of water from 212° F., would equal 7.24 lbs., to one of coal. *

* This result is obtained without taking pressures of steam into consideration, which would involve a lengthy discussion of varying pressures at different points on the road. It is only an approximation.

This result, which I consider remarkably good, was obtained, not from a picked sample of the coal, but from a fair average sample of the product of the colliery. The supply-car was taken as an average of a train of ten platform-cars of coal raised at the colliery on November 2nd, the day before the trial; the weight of coal on these cars being somewhat above 100 tons.

TRIAL NO. 2, ACADIA STEAM COAL.

Steamer-trial; Acadia coal.

Date:—November 5th, 1869.—On Prince Edward Island Steam Navigation Company's steamer "St. Lawrence."

Trip:—From Pictou Landing, Nova Scotia, to Charlottetown, Prince Edward Island.

Distance:—About 59 miles.

DETAILS OF STEAMER "ST. LAWRENCE."

Steamer "St. Lawrence."

This vessel is a side-wheel coast steamer, of the American pattern, with saloon and promenade decks above the hull. Her tonnage, according to her papers, is as follows:—

	Tons.
Tonnage under deck	382.61
" for propelling power	170.53
" houses, over deck	463.02
Gross tonnage	845.63

Her dimensions are:—

	Feet.
Length, total	201.5
Main breadth, (amidships)	30.2
Depth from deck	9.9

Her engine is a vertical-cylinder beam-engine of the American pattern. The details of engine, boiler, etc., are as follows:—

Machinery.

Engine.—Cylinder 44″ by 11′ stroke with Steven's cut-off; cutting off at 5½ feet (half stroke). (250 Nominal H. P.)

Boiler.—Compound boiler, (return flues and tubes). Breadth across three fires 13′ 6″; length at furnace 8′ 6″; cylindrical shell, 15′ 6″ long, and 11′ 6″ in diameter. The details of the flues are:—Outside furnaces, three flues, respectively, 10,″ 17″, and 19″ diameter; centre furnace, four 14″ flues. Above these flues are 96 tubes, 17 feet long and 5″ diameter.

Steam was up at the commencement of the trial, but before putting on any weighed coal the furnaces were cleaned of coal and ash, about 300 lbs. of fire being left for the start. At 11.30 A.M. 1200 lbs. of coal were put on to the fires, making in all 1500 lbs. put on before starting. The start at full speed was made at 12 h. 35 m. P.M., and the engines were then run at regular speed during the entire trip to Charlottetown. The accompanying table shows all the detail of firing and performance of the engines, and gives almost all the information of value obtained during the trial. It shows the regularity with which the engines were run, and pressure of steam kept up with but little trouble on the part of the stoker. The reason that this table is given, is that in several published reports relating to Provincial coals, it has been stated that in using these coals a great amount of trouble is given to the fireman, through the coal clinkering and adhering to the bars, requiring perpetual raking and slicing to break up the fire in order to keep up a good draught. These statements are completely refuted by the notes given in the table, which shows that during the three hours commencing with 1, 2, and 3 o'clock, while the steamer was running regularly, no breaking up of the fire was needed; that the fires in all three furnaces were raked only four times, and that so far from the draught being obstructed, the fire-doors were frequently open for a number of minutes each hour, to admit air above the fires. The table is to be regarded simply as a transcript of the notes ; and as no similar trials have yet been made with which the results might be compared, any farther discussion of these notes will be of no practical value.

Behaviour of coal under marine boilers.

Coal consumed.

The weight of coal consumed upon this trial was as follows :—

	Pounds.
Left on fires at start, about	300
Fires banked before starting, with	1,200
Actually consumed during trip	6,441
Total	7,941

of which 1326 lbs., or 16.69 per cent., was ash, clinker, and unburnt coal ; the unburnt coal would probably equal about 100 lbs. No piece of clinker was observed of a size over four inches cube, and none adhered to the grate bars. The bars in the furnaces of the "St. Lawrence" had been in use for eight months, at the time of my trial, during which time Acadia coal has been burnt, and they showed no sign of fire-mark, and were every way in as good condition as when put in. I was informed by Mr. Turner, Chief Engineer of the P. E. I. Steam Navigation Company, that the bars in the "Princess of Wales," of the same line with the St. Lawrence, and also burning Acadia coal, had been in for some two seasons, (the running season being about eight months,) and that they were still in good condition. The importance of these facts will be appreciated by all engineers.

Grate

The officers of the steamer St. Lawrence, are : — Master, E. Evans ; Chief Engineer, Jas. Turner ; first assistant, Arch. Livingston ; to all of whom I am indebted for their courtesies during my experiment. I was

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TRIAL No. 2, ACADIA STEA

NOVEMBER 5TH, 1869,

On Prince Edward Island Steam Navigation C

TABLE SHOWING FIRING, AND PERFORMA

Minutes after each hour.		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37
Hour.	Starboard furnace																																		F		F	
	Centre "																																		F	St at full speed.		
12 o'cl Noon.	Port "																																		F			
	No. revol. per minute																															†	†	†				11¼
	Vacuum gauge, inches																												‡			23			27		27¼	
	Steam " pounds																												15						15½		14½	
1 o'cl.	Starboard furnace		*	*	*			*	*	*	*	*	*	*	*	*						*	*	*	*	F				½	×	×	×					
	Centre "	*	*	*	*	*	*																			*			*	*	*	*				F		
	Port "	*	*	*	*	*	*																								*	*	F					
	No. revol. per minute			16¼							16½					16						16½					16½							16½				
	Vacuum gauge, inches			27¼						27¼					27						27¼					27¼							27½					
	Steam " pounds			15¾						15¾					15						15¾					15¾							15¾				15	
2 o'cl.	Starboard furnace		F					½	×	×				*	*				F													F						
	Centre "	R	F					½	×	×	F		½	×	×							F				½	×	×	×	F				½	×	× *	×	×
	Port "																																					
	No. revol. per minute															16½												15¾					16					
	Vacuum gauge, inches													27½													27½					27½						
	Steam " pounds														16												16¼					16						
3 o'cl.	Starboard furnace				F			R	F						F		*	*	F	*		*	*	*					F				F					
	Centre "	F																					F														F	
	Port "																																					
	No. revol. per minute				16																	17													16			
	Vacuum gauge, inches			27¼																	27¼													27¼				
	Steam " pounds			15¾																	16¾												15¾					
4 o'cl.	Starboard furnace			*	*	*	*	F						F		*	*	*						*	*	*	*				F				*	† *	F	
	Centre "				*	*																			*	*	*						R	S	F			
	Port "	F																	F																			
	No. revol. per minute										16			16½									16								16¼							15¾
	Vacuum gauge, inches								27¼												27¾								27½				27¼	27½				27
	Steam " pounds								15½												16¾							16½					16					15¼
5 o'cl.	Starboard furnace			F																																		
	Centre "	F						Banking.					S		Stop'd Ch'town.	Cleaning fires.	Pump started.																					
	Port "	R	F																																			
	No. revol. per minute			16		§	* *	§	§	§	†	†	†	†																								
	Vacuum gauge, inches		27¼			28																																
	Steam " pounds	15¼	15	15	15½	15¾		16	15¼	17	13	13	13	13																								

General Notes and References.—The number heading the narrow columns indicates the minutes after tie hour named in the first, (right) column. In each hour three lines are devoted to the furna

indicates *slicing*, or lifting the fire from the bars, and breaking it up wth a slicer, and R indicates raking. The sta (*) placed under a minute indicates that during that minute the fire-door of the furnace—st

is placed under. The figures upon the three lines in each hour, marked "revolutions," "vacuum gauge," and "steam gauge" will be at once understood. They are placed in the minute column correspon

o. 2, ACADIA STEAM COAL,

{TRIP FROM PICTOU LANDING, N. S.,
{ TO CHARLOTTETOWN, P. E. I.

NOVEMBER 5TH, 1869,

EAM NAVIGATION CO.'S STEAMER "ST. LAWRENCE."

RING, AND PERFORMANCE OF THE ENGINES.

30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54	55	56	57	58	59	60	REMARKS.
	† 23	†	†	F F F 27 15½	Start full speed	F 27½ 14½	14¼		S 27½ 14	S				27½ 15				*	*	* 27½ 16½	* * 16½	* *	* *	* *	*	27½ 16	17		*	*	Commenced firing at 11.30 A.M., the fires banked with 1500 lbs of coal. † Slow, turning engines by hand. ‡ Weather-barometer 29.65".
× * *	× * *	× F 27½ 15¾	16½		F	15					F				27½ 16¼	½ * 16	× *	× *						F 27½ 15¾	R 16	F					
	F 27½ 16	16	½	×	× *	×	×	×	×	×	F		*	*	*	27½ 15¾	F	15¾			F			27½ 15	16¼						
		F 15¾	27¼	16		F				½ ½	× ×	× ×		*	* *	* *	F			F 27½ 15	R 16	F R		† † †			F				† Raking out ashes. † " " † " "
F 16¼		R 27¼ 16	S 27½	* F	† *	F	15¾ 27¾ 15¼			16 15½	S	R			R	F	S 27½ 15½	‡R 16¼		‡R ‡R				R R	R			F 27¼ 15¾	15½		† Raking out ashes. ‡ Preparing fires to enter Charlottetown.
																															Stopped at Charlottetown dock at 5.14 P.M. § Half speed. * * Full speed. † Turning engines by hand. B. Blowing off steam.

our three lines are devoted to the furnaces. In these lines the letter F indicates that at the minute under which it stands, the starboard, centre, or port furnace, (as the case may be,) was *fired*. In the same way S
t minute the fire-door of the furnace—starboard, centre, or port, (as the case may be,) was left wide open; or ½ followed by the sign × that the door was one half open, continuing so, as many minutes as the sign ×
placed in the minute column corresponding to the moment of each observation. Other signs in the table are explained in the column headed "Remarks," on the same horizontal line in which each sign occurs.

Behaviour o
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assisted by Mr. Thos. Lawther, of the Albion Mines, who took notes in the fire-room, of the firing and weight of coal used.

Beside the notes given in the table, minute-notes were taken, during several hours, of the smoke emitted from the funnel of the steamer, from which the smoke-equivalent of the Acadia coal, as burnt in the furnaces of the St. Lawrence, appears to be about 120 ; showing that the coal is not burnt by any means as economically as is possible.* Smoke.

It was first my intention to include the notes of the smoke, or *smoke-marks*, in the table of firings, but as the notes were taken by a person with but little experience in this matter, I reserve them for a future report, if corroborated by subsequent experiments.

TRIAL No. 3, WOOD.

(FOR COMPARISON WITH ACADIA STEAM COAL.)

Railway trial of wood.

Date :—Nov. 10th, 1869. On Nova Scotia Railway.
Trip :—From Pictou Landing to Richmond (Halifax).
Distance :—112 miles.

DETAILS OF EXPERIMENTAL TRAIN.

Locomotive used :—No. 19, N. S. Railway.

Description :—Wood burner by Neilson & Co., Glasgow. This engine is of the same pattern and dimensions as No. 7, and before the alterations in furnace and draught arrangements of No. 7, the two engines were precisely similar. This engine was not weighed, but the weight may be safely taken as the same as that of No. 7.

Experimental train.

		Pounds.
Weight of Train.—	Weight of engine without tender	66,130
	Weight of tender with water, (without fuel)	40,340
	5 box-cars, each carrying 100 barrels of flour	181,040
	7 coal (platform) cars, (loaded)	229,670
	1 first-class passenger car (same as No. 1 Trial)	28,260
	Officers and passengers	1,820
	Total weight of train, not including wood on tender, which amounted to 1½ cords, or about 3 tons, 3 cwt., at start	547,260
	Or about	244 tons, 7 cwt.
"	Add fuel, at start	3 " 3 "
"	Total weight with fuel about	247 " 10 "

*For discussions of the subject of the economical use of bituminous coals as steam-producers, see the Reports of Messrs. Richardson and Bunning, " On the experiments at Keyham, on the use of mixed Hartley (Newcastle) and Welsh coals in Marine boilers," Trans. North of England Institute of Mining Engineers, Vol. XIV ; — the " Report of a Committee on the Smoke Question," Ibid., Vol. XVIII, p. 37 et seq. ; and Mr. Bunning's Report on Experiments on Hartley coal, on the steamer Weardale, Ibid. Vol. XVIII, p. 105. These experiments will be again referred to, and some notes on this subject given, in the latter portion of this Section of this Report.

Or only about two tons less than the train in Trial No. 1. The length of train was, as before, 457 feet, the same number of cars of each class being used.

Trip.

This train started from Pictou Landing, at 8 h. 34 m. A.M., and after many stoppages, as before, to pass up-trains, and to allow regular down trains to pass, reached Richmond station at 9. h. 18½ m., P.M.

The account of actual time and stoppages is as follows :—

	H.	M.
Time of train on road	12.	44½
Length of stoppages	5.	55¾
Actual running time	6.	48½

The character of the line has already been described, under Trial No. 1 and the conditions of weather, track, etc., under which the two trials were made were as nearly as possible similar. Steam was kept up well by the engine, but with much greater labour of the fireman than during the previous trial. It is difficult to make a proper comparison between the two experiments in this particular, without a table showing the varying pressures on the different grades throughout the entire length of the line. Such a tabulation has been made in manuscript, but will not be here given, as it would necessarily extend the size of this Report. It shows no important difference between coal and wood. It has already been noted that on the Summit grade (67.58 feet to the mile, with a curve of about 1000 feet radius), the engine in the coal-trial made 59 revolutions per minute, with both pumps on. Under precisely similar conditions, the wood-engine, with a train of about two tons less weight, made 47 revolutions. Thus, in the severest test during the experiments, the coal gave the best result.

With wood, as may be expected, no attention to ash or cinder was necessary.

STATEMENT OF WOOD BURNT.

Wood consumed.

The following is a statement of the wood taken on to the tender during the trip :—

Wood taken on at Pictou Landing		1½	Cords.
" " " " Glengarry	24 miles	¾	"
" " " " Riversdale	38 "	¾	"
" " " " Pollybog	64 "	½	"
" " " " Windsor Junction	99 "	½	"
Total taken on to tender during trip		4	Cords.
Remaining on tender at Richmond		¼	"
Total wood consumed on trip		3¾	Cords.

This wood (dry), weighs about 2 tons 1 cwt. per cord; the total quantity consumed would thus amount to about 17.210 lbs., equalling 7 tons 14 cwt., nearly. This is equal to 153.66 lbs., per train-mile, or 11.88 lbs. per car-mile.

The weight of water evaporated was estimated as in the previous railway trial. The calculated amounts used between stations are:— Water evaporated.

		Pounds.
Between Pictou Landing and New Glasgow,	8 miles.	2,761
New Glasgow and Glengarry...	16 "	7,831
Glengarry and Riversdale	15 "	5,175
Riversdale and Pollybog	26 "	7,530
Pollybog and Elmsdale	18 "	5,330
Elmsdale and Windsor Junction	17 "	6,024
Junction and Richmond	12 "	2,886
Total between Pictou and Richmond		37,537

This is equal to 2.181 pounds water evaporated for one pound of wood burnt, the temperature of the feed-water being, as before, about 40° Fahrenheit. The quality of the wood used on this trial, was, in my opinion, considerably better than the average supplied to the railway; at least in a number of trips between Pictou and Halifax, I have never seen as good quality used; it was principally hard-wood, birch, etc. Results

COMPARISON OF COAL AND WOOD.

(DEDUCED FROM TRIALS OF ACADIA COAL AND WOOD, ON THE N. S. RAILWAY.)

In regard to length of trip, condition of track, and weight of train, the comparative trials may be said to have been made under nearly similar circumstances. The weight of train in the wood-trial was two tons less at the start than the train in the coal-trial, but the amount of wood added during the wood-trial at different points, and carried varying distances, probably equalled two tons carried the entire distance. The length of stoppages during the wood-trial was 1h. 1½m. longer than in the coal experiment, which would result, though to only a small extent, in favour of coal. All things considered, however, the conditions in each were practically the same, and it now only remains to compare the results, in the most important particulars of time, labour of men, first cost and expense in use of the two fuels. Comparison coal and wood.

Time.—It has been remarked on the preceding page that no important difference has been shown by the notes taken of the steam-gauge during the two trials. That there must be some difference in favour of coal, in capacity for keeping steam, will be seen by a comparison of actual running time, which stands as follows:— Time.

	H.	M.
Actual running time, wood trial....................	6	48¼
" " coal trial........................	6	09¼
Difference in favour of coal...........................	0	39

A saving of time might be effected if coal were used, from the fact that enough coal might be put on to the tender at the start from either terminus of the railway, for the entire trip. This could not be done in using wood, for several reasons:—first, because the capacity of the tender would not be sufficiently great; and second, even if the tender were of sufficient capacity, the great weight carried, (7 or 8 tons of wood, to say nothing of the greatly increased weight of tender,) would be a material objection.

Time lost in wooding-up.

In the first of the experiments under consideration, the greater part of the coal consumed was put on the tender at Pictou Landing, a small portion being added from the supply-car during the last 25 miles. As the entire quantity *might* have been added, without inconvenience, at the start, we may assume that no time was lost in coaling.

During the second trial, the record of time consumed in *wooding-up* stands as follows:—

At Glengarry.........	3 men employed in wooding			9 minutes.
" Riverdale..........	3	"	"	7 "
" Pollybog...........	2	"	"	6 "
" Windsor Junction..	3	"	"	5 "
Total time employed in wooding.................				27 minutes.

As it was generally known along the line that this train was an experimental one, it is but reasonable to suppose that, at least, the usual celerity in wooding was attained. The account includes only the actual time employed in throwing the wood on to the tender. Probably several minutes might be added for time consumed in getting the train in position at the wooding-station, starting, etc. If we suppose this extra time to amount to three minutes, we then have one half hour of time lost in taking in wood, between Pictou and Halifax.

Labour.

Labour of men.—It will be evident from the last paragraph that a considerable amount of labour would be saved at the various stations were all the fuel for a trip carried from each terminus. This, however, properly comes under the head of expenses, and the only point to be here considered is the difference in labour of the fireman, which is very considerable, as will be seen by a comparison of the two fuels burnt:—coal, 5,636 lbs.; wood, about 17,210 lbs.; divided into, respectively, 76 and 136 firings.

Comparative expense.

Comparative expense.—Not being connected with this railway, I have no means of estimating, except in the rudest manner, the comparative expense in the use of the two fuels. An approximate idea can be gained by a moment's consideration of the general management required to supply trains at the termini, and at various points along the road.

Wood.—After being cut, the wood is generally corded at or near some point on the main line, from whence it is taken on extra wood-trains to the different wooding-stations, to be used as need be. This not only requires many extra hands, but extra trains, with consequent wear and tear of rolling-stock and permanent way.

Coal.—With coal, but two coaling-stations would be required; at Pictou and Richmond (Halifax). The coal could be put into coal-cars at the mines, for transportation to the two termini, or, should a third station be required, to Truro also. At these stations a system of shutes could be arranged, by means of which the coal could be put into the tender very quickly, and without any handling. I shall not attempt to estimate the cost of running the line, but for general information it may be stated that the cost of coal, delivered at Coal Mines station, is about $2.25 per ton, (or, say $2.50 at Pictou Landing, and $3.00, without profit in carriage, at Halifax;) while the contract price of wood is, I believe, $3.50 per cord, delivered at the wooding stations. During about eight months in the year two regular passenger and freight trains are run each way per day, on this railway, between Pictou and Halifax, and two each way between Truro and Halifax (61 miles); to say nothing of the extra and coal trains. During the winter months, only one through-train is run, each way, per day.

TRIAL NO. 4; DRUMMOND COAL.

Drummond coal trial.

This trial was made on December 2nd, 1869; a previous trial, in the latter part of the month of November, having been abandoned on account of bad weather. The length of the Intercolonial Coal Mining Company's railway (about 6¾ miles) not being sufficient for a proper trial with a single trip; three round trips (from the colliery to the Drummond wharf at Granton, and back—13½ miles) were made with a loaded coal train. During these trials the usual careful notes were taken of the performance of the engine, and the line being staked out in miles and half-miles, the time of passing the stakes, as well as a number of other points on the road, were also taken, to a second, by Mr. William Crawford, C.E., Chief Engineer of the Intercolonial Company, who kindly accompanied me, and to whom I would express my obligations for the interest he has taken in my experiments, and the valuable aid he has afforded me.

The notes of this trial furnish a complete record of the performance of the engine upon each grade, and when time permits they will be given to the public, with a proper discussion of the facts elicited.

For the purpose of the present Report, however, it will be sufficient to give the general results, and the trial will be divided into two experiments; the first, (experiment A), from an improper arrangement of the ash-pan and grate-bars, not having been as successful as the second (experiment B). The same train was used in both.

Intercolonial Coal Company's railway.

Description of line.—The down-trip from the colliery to Granton was comparatively easy, as it included only about one and a-half miles of up-grade, ranging from 44 feet to $53\frac{1}{2}$ feet per mile. The average grade on the return-trip was about 50 feet up, per mile, for the first three miles; down about 45 feet per mile, for one and a-half miles, and then up, with grades ranging from $23\frac{1}{2}$ feet to 98 feet per mile, and averaging, perhaps 65 feet per mile. Some of the curves were very sharp; one of 600 feet radius, and one more than one-quarter of a mile long of 655 feet radius, besides a number ranging from 702 feet to 1,433 feet radius.

DETAILS OF TRAIN IN BOTH EXPERIMENTS.

Locomotive used:—No. 3, Intercolonial Coal Mining Company's Railway.

Description:—Coal burner by Dûbs & Co., Glasgow, Scotland—Tank-engine, six drivers, 5′ diameter (coupled). Cylinders (2) 14″ diameter × 22″ stroke,—with 75 per. cent. of steam on piston when in full gear. Firegrate area 12.12 square feet. 152 brass tubes, $1\frac{3}{4}$″ outside diameter—superficial area of which is 680.48 square feet. Wheel-base of engine, 11 feet.

Experimental train.

	Tons.	cwt.
Weight of Train.—Weight of engine No. 3, empty	20	0
Equipment	5	0
12 coal cars, loaded, (75 tons coal)	116	17
Officers and passengers	0	7
Total weight of train	142	4

The length of this train from tread of forward driver was 196 feet.

The coal consumed was carefully weighed on a Fairbanks scale, and the water evaporated estimated as in previous trials. The two tanks of the engine were rectangular, and being exactly filled each time of taking-in water, the estimate of water may be relied upon.

EXPERIMENT A.

First trial.

In this experiment the grate-bars in the furnace of Engine No. 3 were not properly arranged, every other grate-bar having been removed, leaving about 2 inches between the bars, through which a considerable amount of unburnt coal fell, choking up the dampers of the ash-pan (which was very small), and thereby obstructing the draught. Added to this, the day was so intensely cold that the steam-gauge was frozen on the up-trip, and the fires could not be properly regulated. The record of distance, time, etc., is as follows :—

Distance.

Trip 1. Down to wharf at Granton............	distance	6.60	miles.
" 2. Back to upper siding at colliery........	"	6.84	"
Total distance ; round trip....................		13.44	miles.

Time.

	Min.	Sec.
Trip 1. Time on road, no stoppage..........................	24	46
" 2. " " " 52 m. 20 s. stoppage 18 m., actual time...	34	20
Actual running time (13.44 miles)................	59	06

During experiment A, trip No. 2, the steam-gauge was frozen, and the fire could not be properly managed ; the 18 minutes stoppage was time lost in thawing the gauge, and getting up steam with the blower, while standing.

STATEMENT OF COAL BURNT AND WATER EVAPORATED.

The amount of coal burnt, while running and during stoppage, was 658 lbs ; the water evaporated being 3,423 lbs. This is equal to 5.202 lbs. of water, evaporated from the temperature of the feed water, (about 35° F.), to the pound of coal consumed, or 6.15 lbs. of water evaporated from 212°, to one pound of coal, not taking pressures of steam into consideration. The coal was divided into 12 firings ; 3 on the down-trip and 9 on return-trip to the colliery. The fire-door was open 9 minutes on the down-trip and 7 minutes on the return. The engine was on a down grade 18 minutes, during the down trip (and not using steam), and about 4 minutes during the return. The fire was broken up with the pricking-bar, once on each trip, which was all the attention it required, save firing. The coal steamed well, except at the close of the second trip, when the ash-pan damper became choked with ash and unburnt coal, (the engine being designed for Scotch coal, which gives very little ash.) Results.

EXPERIMENT B.

This trial was far more successful than the first, as the full set of bars were put in, leaving spaces of but $\frac{3}{4}$ of an inch between them. The ash-pan was removed, and the steam-gauge properly protected. Four trips (or two round trips) were made with the same train as in experiment A. The record of distance, time, etc., is as follows :— Second trial.

Distance.

Trip 3. Colliery to wharf.....................	distance	6.65	miles.
" 4. Wharf to upper siding at colliery........	"	6.80	"
" 5. Upper siding to points near wharf.......	"	6.62	"
" 6. Wharf to upper siding at colliery........	"	6.74	"
Total distance ; four trips................		26.81	miles.

Time.

		H.	Min.	Sec.
Trip 3.	Time on road 27m. 40s., stoppage 4m. 15s., actual time...	0	23	25
" 4.	" " " 35m. 00s., " 7m. 38s.. " " ...	0	27	22
" 5.	" " " 21m. 05s., no stoppage " " ...	0	21	
" 6.	" " " 41m. 25s., stoppage 8m. 10s., " " ...	0	33	15
	Actual running time, (26¾ miles)......................	1	45	07

STATEMENT OF COAL BURNT AND WATER EVAPORATED.

Results.

Steam being up at the commencement of this experiment, the amount of coal consumed was 1,236 lbs., during the four trips. The amount of water evaporated was 8,253 lbs.; thus the result was:—6.67 lbs. of water evaporated from 35° F., by one pound of coal, equal to 7.69 lbs. evaporated from 212°, without taking steam-pressures into consideration. This result not only proves the coal to be an excellent steam-coal for locomotive use, but also indicates that the coal was very economically burnt by the locomotive. In comparing this result with the results of railway trial No. 1, of Acadia coal, the fact should be taken into consideration that the result in the Drummond coal-trial was obtained with an engine built expressly for burning this class of bituminous coals, whereas the engine used in the Acadia steam-coal trial was a wood-burner, but slightly altered, and in all probability not burning the coal in the most economical manner.

The notes of the second experiment (B) give the following facts, which are, perhaps, worthy to be included here:—During the four trips, the number of firings was 17; the fire-door was open for draught above the grate, 62 minutes; and the engine was on an up-grade—or using steam—during 81 minutes.

Ash of coal.

The ash from the coal burnt was gray, with a faint reddish tinge. The coal clinkered somewhat, but no inconvenience was felt from that cause, as the clinker did not adhere to the grate bars.

Portion of seam used.

The coal used was believed to be a fair average of the 16 feet of the seam worked; being a mixture of all the benches except the *top-coal* and *coarse-coal* at the bottom of the seam.

AMERICAN NAVY TRIALS OF PICTOU COALS.

American coal-trials by Prof. Johnson.

In a very complete series of trials undertaken for the American government by Professor W. R. Johnson, in 1843 and 1844, were included experiments on two samples of Pictou coals, both from the Old Albion mines, and taken, I believe, from the upper twelve feet of the Main seam. These experiments were conducted with the greatest care, and with the exception of the British experiments, made by Sir Henry T. De la Beche and Dr. Lyon Playfair, for the Lords Commissioners of the Admiralty, the

American trials are probably the most complete and accurate series of trials of steam-coals ever made.

Report of Prof. Johnson.

As the results of Professor Johnson are of great value to the consumers of Pictou coals, I shall take the liberty of including an abstract of them in this Report, especially as the volume in which they are contained ("Report to the Navy Department of the United States on American coals applicable to Steam Navigation, etc.," by Walter R. Johnson,) has been for years out of print.

Apparatus employed.

The boiler employed in these experiments was 30 feet long and 3½ feet in diameter; set over a furnace, and the heated gases after passing from the fire through two interior return-flues, each of 10 inches interior diameter, escaped either through an opening, known in the Report as the *lower damper*, into the chimney, or when this damper was closed, it ascended from the ends of the two return-flues into an exterior flue on the *left* of the boiler, and passed along this once more to the rear of the boiler, crossed the end, and entered a *right hand* exterior flue, by which, through the *upper damper*, it arrived at its exit into the chimney, entering the latter at a level only 14 inches higher than when it passed by the direct exit-flue to the lower damper. The details of heating-surface, and lengths of flues traversed, together with the arrangements for heating the air before passing through the grate, are given in the following quotation from Professor Johnson's report. It follows the detailed description of the boiler and flues, a partial abstract of which I have just given:—

Draught arrangements.

"From this description, it will be observed that the air which supplies the combustion, passes first into a chamber beneath the ash-pit, about 7 feet long, and 3 feet 3 inches wide, along the sides of which are several openings, by which it finds its way into the two longitudinal side chambers, 30 feet long, 6 feet high, and 9 inches wide, between the two side walls; and having arrived, by these, at the rear of the boiler, passes 25 feet beneath the flue, arriving at the *centre* of the grate after a course of 60.5 feet. Thence a course of 58.5 feet brings the products of combustion to the aperture through the passage, by the lower damper, into the chimney; and of 62.5 feet farther, or 121 feet from the centre of the grate, to the point where they finally quit the boiler by the exterior flue. The part of the lower arch of the boiler, exposed to the action of heat, is 130 square feet, and that of the two return-flues is 157 square feet; so that when the combustion was conducted by allowing the products to make their exit through the lower passage, or after passing twice the length of the boiler, the heated surface was 287 square feet. The boiler-surface exposed in the exterior flue, or second circuit, is 90.5 feet; making the entire surface, when the products traversed four times the length of the boiler, 377.5 square feet. The grate being 5 feet long, and 3 feet 3 inches wide, when

Surfaces.

Grate.

at its full dimensions, its area was 16.25 square feet; and the ratio of the grate surface to the heated surface, when the combustion was carried on through the lower damper, was 1 : 17.66; when through the upper damper, making the circuit 121 feet long, this ratio was 1 : 23.23.

Air-plate bridge.

"When the air-plate bridge was introduced, it covered 8 inches of the length of the grate, reducing its area to 14.07 square feet, and increasing the ratio of heated to grate surface to $\frac{377.5}{14.07}$ = 26.83 to 1.

Coking-plate.

"During a few trials the grate was still farther reduced in area, by the introduction at the front end, next to the fire-doors, of a plate of iron 3 feet 3 inches long, 11¾ inches wide, and one-fourth of an inch thick. This is termed the "*coking-plate*," and was used while burning some of the samples of bituminous coal, which were so fine that large portions were liable to pass through the grate. With this plate in place, and the air-plate in its usual position, the size of the grate was reduced to 11.375 square feet, and the heated to the grate surface increased to $\frac{377.5}{11.375}$ = 33.18 to 1.

"On one occasion, instead of contracting the area of the grate by means of the coking plate, it was diminished by placing a row of bricks flatwise along each side of the furnace, reducing the grate surface to 10.291 square feet, and the ratio of *heated* to *grate* surface to $\frac{377.5}{10.291}$ = 36.68 to 1.

Depth of fire.

"The grate was, in general, about 9 inches at the front, and 10 inches at the back end, below the lower arch of the boiler. On one or two occasions, however, which are noted in the tables of experiments, it was varied a little from this distance; but as no advantage appeared to attend the change, it was restored to this, as the most convenient working distance for all the varieties of fuel employed.

Grate-bars.

"The grate-bars used were three-fourths of an inch thick, and the spaces between them half an inch wide. They were supported at the centre, as well as at each end, by a cast-iron bar 2½ inches thick, and 4 inches deep. Hence, when the grate was at its full size, the total amount of air passages through the grate was nearly 5⅝ square feet.

Capacity of boiler.

"The interior capacity of the boiler was such as to contain, when filled to the centre of the gauge-tube, or *normal* level of the experiments, with water of 66° temperature, 12,795 lbs. This is the result of an experiment made after clearing out and wiping dry the interior of the boiler, and refilling it through the measuring-cistern. Of this quantity, 493 pounds were then withdrawn, leaving 12,302 pounds, filling the boiler to within 1.1 inch of the normal level. On subsequently heating this to 230°, the water in the gauge, after taking all due precaution to withdraw the cold water from the glass tube, and filling it with that which was hot, stood once more at the normal level. Hence the apparent expansion of water in iron, by an addition of 164 degrees of heat, is equivalent to $\frac{493}{12302}$ = 0.0407, or a little more than one twenty-fifth part of its bulk at 66°."*

* Report on American Coals, pp. 12-13.

Other details omitted.

The details of supply of water, gauges and discussions of the method of conducting the experiments, though of very great scientific interest, occupy too much space to be given here. I shall therefore proceed to the results of the experiments, using as nearly as possible the arrangement of the original report. All the facts which follow, are taken from Johnson, and where advisable, his report is quoted *verbatim*.

Classification of Pictou coals.

Under Class IV, (p. 452) of the Report, Professor Johnson includes: "Foreign bituminous coals, and those of similar constitution West of the Alleghany Mountains." Among the foreign coals, he includes:—

Johnson's Class IV.

1. Pictou, (purchased in New York.)
2. Sydney.
3. Pictou, (Cunard's.)
4. Liverpool.
5. Newcastle.
6. Scotch.

General characters.

In description of the general characters of these coals, he says:—"In many respects this class of coals bears a strong analogy to the preceding.* The ratio of the fixed to the volatile combustible matter is, however, something less. The exterior presents often a resinous lustre. The surfaces of deposition are easily developed by fracture. Great facility of ignition and a high degree of activity in the combustion of their volatile constituents, are also general properties of this class. Their high proportion of volatile combustible matter renders these coals, when nearly free from sulphur, eminently suitable for the production of illuminating gas; and the tendency of their cokes, with few exceptions, to intumesce strongly, renders them, in common with the preceding class, highly serviceable for forming large hollow fires for smithing purposes."

(*Copy.*)

No. 1.

Bituminous coal from Pictou, Nova Scotia, procured from Messrs. Laing & Randolph, in New York, for comparative experiments.

Trial of the coal bought in New York.

This coal has a glimmering lustre, or a dull aspect, according to the part observed. The surfaces of deposition are, in some specimens, inclined at an angle of 83° to the main partings; thin scales of earthy matter are occasionally found in the joints, or vertical seams; but, in general, little impurity is observable on the exterior. Conchoidal fractures are of unfrequent occurrence. The coal was of average size, lumps and fine being intermixed in due proportion, to constitute a merchantable article for ordinary use in smith's fires, and for domestic purposes. The

* Class III. Bituminous coking coals from the eastern coal-fields of Virginia in the neighbourhood of Richmond. (Report, pp. 308-541.)

powder of this coal is of a dark brown colour, and its streak on a white earthern ground is of the same tint.

The specific gravity of one specimen (*a*) was 1.3546 ; that of another, (*b*) 1.2807 : from the mean of which, the calculated weight per cubic foot is 82.35 pounds.

By 39 trials in the charge-box, the greatest weight of any one charge was 112.25 pounds, or 56.125 lbs. per cubic foot. The least weight was 97.5 lbs. per charge, or 48.75 lbs. per cubic foot; while the average of the whole was 53.548, or 0.6502 of the above calculated weight. The space for the stowage of one ton of the coal is 41.832 cubic feet.

The moisture in specimen *a* was 0.97 ; and that in *b*, 0.935 per cent.

The volatile matter, other than moisture, in *a*, was 27.51 ; the sulphur, 0.7689 per cent.

The volatile matter, other than moisture in *b*, 20.105.

Four incinerations of *a*, gave of *ashes* 2.38 : and the same number of *b*, 2.65 per cent. Hence the composition is as follows, viz :—

Analysis.

	Specimen *a*.	Specimen *b*.
Moisture	0.970	0.935
Sulphur	0.769	(not tried.)
Other volatile matter	26 741	20.105
Earthy matter	2.380	2.650
Fixed carbon	69.140	76.310
	100.	100.
The volatile to fixed combustible	1 : 2.5132	1 : 3.7955

Two specimens of this sample of coal were assayed by Dr. King, and yielded, the one 36, and the other 33, per cent. of volatile matter, including moisture. These, combined with the above, give a mean of 29.63, which may probably be assumed as a pretty near approximation to the average yield of this ingredient.

By exposure for four days in the steam-drying apparatus, 28 pounds of this coal lost 0.71875 lbs. of moisture, or 2.567 per cent.

During the four trials of evaporative power, 4153.875 pounds were burned, and yielded 302.4 lbs. of ashes, (including those of 408.62 lbs. of pine wood,) 253.475 pounds of clinker, and 19.5 pounds of soot. The ashes lost by re-incineration 5.907, and the soot 65.42, per cent. of their weight.

Hence the absolutely incombustible materials are—

From the ashes	284.540	pounds.
" clinker	253.475	"
" soot	6.743	"
Total	544.758	"
Deduct for wood ashes	1.227	"
Leaves	543.531	"

which is 13.389 per cent. of the coal burned.

Practical analysis.

By these data we may assign the following as the proximate constituents of this sample, viz. :—

Moisture, (from 28 lbs.)	2.567	per cent.
Other volatile matter, (mean of 4 specimens)	27 063	"
Earthy matter (from 4153.87 lbs.)	13.389	"
Fixed carbon	56.981	"
	100.	
Volatile to fixed combustible	1 : 2.1054	

The above result in earthy matter, derived from a sample of two tons, exhibits a striking contrast with the analyses of single hand-specimens.

Clinker.

The clinker is of a dark reddish-brown colour, in sheets of considerable magnitude, somewhat porous; small shaly fragments are intermixed, and sometimes adhere to the vitrified masses. It weighed 43.12 pounds per cubic foot, and gained weight by calcination equal to 0.84 per cent., leaving the powder of a light brown, with its finer parts bright red.

Ash.

The weight of the ashes, as they came from the furnace, was 38.56 lbs. per cubic foot; and the residue of their re-incineration had a colour nearly flesh-red, while that from the soot was reddish-grey—a shade lighter than that from the ashes.

The ashes from specimens *a* and *b* are of a purplish-red colour, with specks of white.

Tried with the oxide of lead, 20 grains of specimen *a* gave 544.8 grains of metallic lead, or 27.24 times its weight. Deducting moisture and earthy matter, this gives to one of combustible matter 28.184.

In a smith's fire for ordinary work, this coal afforded a rather dull combustion; made a good hollow fire; left a fair coke, not unusually hard; produced a large quantity of cinder, and gave a tolerably fair heat.

Trial for chain-making.

In the chain-shop, it gave a heavy flame; formed a coke too hard to be easily broken up, as the work requires; was rather hard and unmanageable, and left a large proportion of cinder. Sixty pounds made but 11 links of a chain 1⅜ inch in diameter; while several other coals, tried by the same workman on the same chain, were found adequate to the making of from 13 to 20 links, by the same weight of coal.

* * * * * * * * *

The ignition of this coal is easily effected. It took, on an average of four trials, only 0.937 hour, or 56¼ minutes, to bring the boiler to a state of steady action. In conformity with this fact, is that relative to the unburnt coke, which was, on an average, only 5.689 lbs. at each trial.*

* Here follow tables giving the details of all the experiments; from which the deductions in the table on the next two pages are taken. It is extracted *verbatim* from Johnson's Report.

DEDUCTIONS FROM TABLES CLV, CLVI, CLVII.

Experiments on Pictou

Results of Trial No. 1, Class IV.

	Nature of the data furnished by the respective tables.	1st Trial. (*Table CLV.*)	2d Trial. (*Table CLVI.*)
		August 30.	*August* 31.
1	Total duration of the experiment, in hours............	22.033	23.95
2	Duration of steady action, in hours..................	6.333	6.333
3	Area of grate, in square feet	14.07	14.07
4	Area of heated surface of boiler, in square feet........	377.5	377.5
5	Area of boiler exposed to direct radiation, in square feet.	18.75	18.75
6	Number of charges of coal supplied to grate	9.0	10.0
7	Total weight of coal supplied to grate, in pounds......	978.50	1071.75
8	Pounds of coal actually consumed..........	974.88	1069.612
9	Pounds of coal withdrawn and separated after trial...	3.62	2.138
10	Mean weight, in pounds, of one cubic foot of coal.....	54.361	53.5875
11	Pounds of coal supplied per hour, during steady action.	120.77	119.69
12	Pounds of coal per square foot of grate surface, per hour.	8.583	8.506
13	Total waste, ashes and clinker, from 100 pounds of coal.	13.714	12.934
14	Pounds of clinker alone, from 100 pounds of coal......	6.6911	6.2139
15	Ratio of clinker to the total waste, per cent	48.788	48.0695
16	Total pounds of water supplied to the boiler..........	7759.0	8340.0
17	Mean temperature of water, in degrees Fahrenheit.....	82°.8	83°.0
18	Pounds of water supplied at the end of experiment, to restore level..................................	782.0	550.0
19	Deduction for temperature of water supplied at the end of experiment, in pounds.........................	99.0	69.0
20	Pounds of water evaporated p. hour, during steady action	882.36	908.88
21	Cubic feet of water per hour, during steady action....	14.12	14.54
22	Pounds of water per square foot of heated surface per hour, by one calculation.........	2.337	2.407
23	Pounds of water per square foot, by a mean of several observations.................................	2.347	2.397
24	Water evaporated by 1 of coal, from initial temp. (a) final result..................................	7.858	7.733
25	Water evaporated by 1 of coal, from initial temp. (b) during steady action.........................	7.301	7.5936
26	Pounds of fuel evaporating one cubic foot of water....	7.9537	8.0823
27	Mean temperature of air entering below ash-pit, during steady pressure............................	92°.59	92°.31
28	Mean temp. of wet-bulb thermo., during steady pressure	79°.08	80°.69
29	Mean temperature of air, on arriving at the grate......	254°.92	259°.125
30	Mean temp. of gases, when arriving at the chimney....	301°.25	334°.6
31	Mean temperature of steam in the boiler.............	229°.54	229°.5
32	Mean temperature of attached thermometer..........	84°.88	86.94
33	Mean height of barometer, in inches...............	30.161	30.079
34	Mean number of volumes of air in manometer	5.225	5.210
35	Mean height of mercury in manometer, in atmospheres.	0.5342	0.5366
36	Mean height of water in syphon draught-gauge, in inches	0.2907	0.3077
37	Mean temperature of dew-point, by calculation........	75°.9	77°.525
38	Mean gain of temp. by the air, before reaching grate...	162°.61	166°.535
39	Mean difference between steam and escaping gases ...	71°.71	105°.1
40	Water to 1 of coal, corrected for temperature of water in cistern....................................	7.8258	7.7013
41	Water to 1 of coal, from 212°, corrected for temperature of water in cistern............................	8.8059	8.6658
42	Pounds of water, from 212°, to 1 cubic foot of coal....	478.74	464.38
43	Water, from 212°, to 1 pound of combustible matter of the fuel.....................................	10.2055	9.9532
44	Mean pressure, in atmospheres, above a vacuum......	1.4213	1.4288
45	Mean pressure, in pounds p. sq. inch, above atmosphere	6.2219	6.3324
46	Condition of the air-plates, at the furnace-bridge	Open.	Closed.
47	Inches opening of damper, (U. upper)...............	U. 8	U. 8.

LVI, CLVII.

ments on Pictou

2d Trial. (*Table CLVI.*)
August 31.
23.95
6.333
14.07
377.5
18.75
10.0
1071.75
1069.612
2.138
53.5875
119.69
8.506
12.934
6.2139
48.0695
8340.0
83°.0
550.0
69.0
908.88
14.54
2.407
2.397
7.733
7.5936
8.0823
92°.31
80°.69
259°.125
334°.6
229°.5
86.94
30.079
5.210
0.5366
0.3077
77°.525
166°.535
105°.1
7.7013
8.6658
464.38
9.9532
1.4288
6.3324
Closed.
U. 8.

CLVIII, OF JOHNSON'S REPORT, PAGES 456-463.

coal (from New York.)

3rd Trial. (*Table CLVII.*)	4th Trial. (*Table CLVIII.*)	Averages.	Remarks.
September 1.	*September* 2.		
23.95	23.05		
10.00	7.083		
14.07	14.07		
377.5	377.5		
18.75	18.75		
11.0	9.0		
1179.5	947.0		
1166.61	942.89		
12.89	4.11	5.6895	
53.614	52.611	53.5434	
96.9	104.01	110.342	
6.887	7.392	7.842	
13.195	13.642	13.3712	
5.2321	6.3657	6.1257	
39.651	46.658	45.7916	
8743.0	6661.0		
84°.1	82°.7		
575.0	547.0		
72.0	69.0		
721.9	684.59	799.432	
11.55	10.953	12.7908	
1.912	1.813	2.1172	
1.893	1.794		
7.432	7.009	7.508	With damper drawn 8 inches, the first trial gave, with a clean surface of boiler and flues, and the air-plate open, 7.858 of water to 1 of coal; the second, with the same plate closed, and surfaces with one day's impurity on the flues, 7.733, or 1.6 per cent. less.
7.449	6.5802	7.231	
8.4096	8.9171	8.3407	
89°.8	90°.33		
79°.21	78°.87		
282°.05	278°.8	268°.724	
315°.42	306°.71	308°.702	
231°.0	228°.6		
85°.71	83°.0		
30.080	30.104		
5.227	5.247		
0.5343	0.5323		
0.2845	0.2443	0.2818	
75°.53	75°.7		
191°.72	189°.0	177°.466	
85°.33	77°.77	84°.69	
7.4009	6.9803	7.4771	
8.3207	7.8545	8.4117	
446.10	413.23	450.612	
9.5855	9.0953	9.7099	In the fourth trial, the decided inferiority of effect to the preceding is probably to be ascribed to the coating of soot upon the flues, and the want of sufficient draught to burn completely the products of combustion.
1.4219	1.4122	1.421	
6.231	6.0876	6.2182	
Open.	Closed.		
U. 4.	U. 4.		

(*Copy.*)

No. 3.

Bituminous coal from Pictou, Nova Scotia, sent by Mr. Cunard, agent of the General Mining Association of London.

Trial of sample from agents.

The coal of this sample is, in every external character, entirely similar to that from the same mining district obtained from New York. The specific gravity of one specimen (*a*) was 1.3155; that of another, (*b*,) 1.3352. The mean of these makes the weight of the cubic foot in the solid state 82.835 pounds. The actual weight, determined by 20 trials in the charge-box, is for the least 45.5, for the greatest 52·125, and for the average 49.25 pounds per cubic foot, or 0.5945 of the calculated weight. Hence the space to receive one ton is 45.482 cubic feet.

The moisture expelled by thoroughly drying specimen *b* was 1.079.

The coking of *a* caused a loss, including moisture, of 26.413 per cent. The process having been conducted very slowly, the powder did not become agglutinated; but another portion of the same powder suddenly exposed to a bright red heat, became converted into a well-formed mass. Of specimen *b*, a portion coked so slowly, and at so low a heat, that the gas did not take fire, exhibited a loss of 27.1 per cent. Another portion of the same powder, coked rapidly, so as to become completely coalescent, lost 29.34 per cent.

The earthy matter in *a* was 10.09, in *b* 11.404 per cent. Hence the proximate constituents of these two specimens are—

Analysis.

	Specimen *a*.		Specimen *b*.	
Moisture	(not separately determined)		1.079	
Volatile matter	26.413	other than moisture	26.021	by slow coking.)
Earthy matter	10.090		11.404	
Fixed carbon	63.497		61.496	
	100.		100.	
Volatile to fixed combustible	1 : 2.404		1 : 2.3633	

The moisture expelled from 28 lbs., dried in the steaming-apparatus, amounted to 0.7812 per cent. The volatile matter, including moisture, from the mean of the two specimens above given, is 26.756.

During the two experiments on evaporation, there were burned 1962.5 pounds of this coal, and the—

Weight of ashes withdrawn was	116.00 lbs.
of clinker	121.75 "
of soot	8.75 "

The ashes lost 0.04077 of their weight, and the soot 0.60144, by re-incineration. Reducing the weights of these two, and deducting 1.029 lbs., for the ashes of 355.25 lbs. of pine wood, we have left 245. 481 lbs., for the total waste from the above weight of coal, or 12.508 per cent.

From these data it would seem that the coal is composed of— Practical analysis.

Moisture, (from 28 lbs.) - - -	0.7812
Other volatile matter, (from two specimens) -	25.9753
Earthy matter (from 1962.5 lbs.) - -	12.5085
Fixed carbon, (calculated by difference) -	60.7350
	100.

Volatile to fixed combustible 1 : 2.5929.
The ashes weighed 39.01 lbs. per cubic foot.
The clinker " 38.00 " "
The soot " 3.82 " "

When re-incinerated or calcined, the clinker became of a dark drab or light brown colour, the ashes of a light reddish-gray, and the residue of the soot a light drab colour. The ashes from analysis of *a* were pure white; from *b*, dirty white. Clinker.

The clinker, as it came from the furnace, was black, vitreous, and porous, in masses tolerably friable, and not apparently prone to adhere to the grate. Much shaly matter attaches itself to the vitrified portions.

With the oxide of lead, specimen *b* gave 23.355 times its weight in metallic lead. Deducting moisture and earthy matter, we have left 0.87517 of combustible; by which, dividing the above, we get $\frac{23.355}{.87517}=$ 26.686.

For the reason assigned in regard to the preceding sample which accompanied this, the trial in smith's forges and in open grates was necessarily dispensed with. This is the less to be regretted in the present instance, as the sample of Pictou coal already described has been tested in the forge; and as the action of the two samples is in other respects almost identical, there is no reason to doubt that in this particular also they would be found to coincide.

The mean time required to bring the boiler to a steady rate of evaporation was 0.85 hour, or 51 minutes. The weight of coke left unburnt on the grate was very small, being on the first trial, 5 pounds, and on the second 2.5. The combustion commenced promptly, and the flame was long, and accompanied by considerable smoke. The large amount of clinker (more than 50 per cent. of the total waste) rendered it necessary to remove the heavier masses within a few hours after the fire was kindled.

DEDUCTIONS FROM TABLES CLXIII, CLXIV,

Experiments on

Results of Trial. No. 3. Class IV.

	Nature of the data furnished by the respective tables.	1st Trial. (*Table CLXIII*)	2d Trial. (*Table CLXIV.*)
		September 27.	*September* 28.
1	Total duration of the experiment, in hours	25.083	24 383
2	Duration of steady action, in hours	5.267	5.333
3	Area of grate, in square feet	14.07	14.07
4	Area of heated surface of boiler, in square feet	377.5	377.5
5	Area of boiler exposed to direct radiation, in square feet	18.75	18.75
6	Number of charges of coal supplied to grate	10.0	10.0
7	Total weight of coal supplied to grate, in pounds	992.25	977.75
8	Pounds of coal actually consumed	987.25	975.25
9	Pounds of coal withdrawn and separated after trial	5.0	2.5
10	Mean weight, in pounds, of one cubic foot of coal	49.6125	48.8875
11	Pounds of coal supplied per hour, during steady action	149.212	127.648
12	Pounds of coal per square foot of grate surface, per hour	10.6	9.072
13	Total waste, ashes and clinker, from 100 pounds of coal	11.62	12.505
14	Pounds of clinker alone, from 100 pounds of coal	5.7655	6.6199
15	Ratio of clinker to the total waste, per cent	49.347	52.935
16	Total pounds of water supplied to the boiler	7545.0	7204.0
17	Mean temperature of water, in degrees Fahrenheit	70°.5	67°.3
18	Pounds of water supplied at the end of experiment, to restore level	270.0	406.0
19	Deduction for temperature of water supplied at end of experiment, in pounds	37.0	57.0
20	Pounds of water evaporated p. hour, during steady action	1122.86	936.68
21	Cubic feet of water per hour, during steady action	17.96	14.987
22	Pounds of water per square foot of heated surface per hour, by one calculation	2.974	2.481
23	Pounds of water per square feet, by a mean of several observations	2.988	2.498
24	Water evaporated by 1 of coal, from initial temp. (a) final result	7.6049	7.328
25	Water evaporated by 1 of coal, from initial temp. (b) during steady action	7.522	7.338
26	Pounds of fuel evaporating one cubic foot of water	8.2174	8.529
27	Mean temperature of air entering below ash-pit, during steady pressure	64°.15	64°.33
28	Mean temp. of wet-bulb thermometer, during steady pressure	55°.08	55°.8
29	Mean temperature of air, on arriving at the grate	209°.15	233°.13
30	Mean temp. of gases, when arriving at the chimney	295°.0	330°.0
31	Mean temperature of steam in the boiler	231°.0	232°.0
32	Mean temperature of attached thermometer	62°.115	59°.67
33	Mean height of barometer, in inches	30.146	30.249
34	Mean number of volumes of air in manometer	5.0246	5.004
35	Mean height of mercury in manometer, in atmospheres.	.5546	.5572
36	Mean height of water in syphon draught-gauge, in inches	.3241	.3525
37	Mean temperature of dew-point, by calculation	46°.78	48°.63
38	Mean gain of temp. by the air, before reaching grate	145° 0	168°.8
39	Mean difference between steam and escaping gases	67°.66	107°.06
40	Water to 1 of coal, corrected for temp. of water in cistern	7.5864	7.3148
41	Water to 1 of coal, from 212°, corrected for temperature of water in cistern	8.6249	8.3446
42	Pounds of water, from 212°, to one cubic foot of coal	427.9	407.94
43	Water, from 212°, to one pound of combustible matter of the fuel	9.7589	9.5373
44	Mean pressure, in atmospheres, above a vacuum	1.4389	1.4408
45	Mean pressure, in pounds p. sq. inch., above atmosphere	6.4819	6.5104
46	Condition of the air-plates at the furnace-bridge	Closed.	Open.
47	Inches opening of damper, (U. upper)	U. 8.	U. 8.

OF JOHNSON'S REPORT, PAGES 478-481.

Pictou (N. S.) coal, (Cunard, agent.)

Averages.	Remarks.
3.75	In a very close approach to total combustion, as well as in many other of its properties and modes of action, this sample manifests its affinity with the Pictou coal procured in New York.
49.25	
138.43	
9.836	
12.0625	
6.1927	
51.141	
1029.77	The rate of evaporation with air-plate open is 16.5 per cent. less rapid than with the plate closed.
16.4735	
2.7275	
7.4664	
7.43	
8.3732	
221°.14	
312°.5	With the air-plate open, as in the second trial, the gases going to the chimney had a temperature 35° higher than with the same plate closed, as in the first experiment. The considerable coating of soot on the flues may have helped to keep the gases at their high temperature, and to diminish the evaporative effect, as seen in lines 41 and 43.
.3383	The second trial had the advantage of a stronger draught than the first.
156°.9	
87°.33	
7.4506	
8.4848	
417.92	
9.6481	
1.4398	
6.4962	

DRUMMOND COAL ON QUEBEC STEAMERS.

Drummond coal on Quebec steamers.

No opportunity for making a steamer-trial of the Drummond coal offered during last season, but a few facts concerning the success with which it is used on the Quebec and Gulf Ports Steamship Company's steamers, "*Secret*," "*City of Quebec*," and "*Gaspé*," may not be out of place here. These steamers run from Quebec to Pictou, touching at Gaspé, Baie des Chaleurs, and several other points on the Gulf of St. Lawrence. The following information was obtained through Mr. A. P. Ross, of Pictou, agent Q. and G. P. SS. Co., (to whom my thanks are due for his interest in this matter,) by sending blank forms to the engineers of the different steamers, including questions and suggestions, which forms, being filled up with the requested information, were returned to me. Without including the questions, or adhering to the words of the original blanks, a general abstract will be given of their contents.

STEAMSHIP "SECRET."

Form filled up and signed by Thomas D. Finegan, engineer.

SS. "Secret."

Steamship "Secret" is 622 tons register. Her engines are oscillating, two cylinders 50 inches diameter, 54-inch stroke. Two boilers; close bottom; return tubes. Working pressure of steam from 17 to 20 lbs.

This steamer has used Drummond coal about five months (Nov., 1869.) The quantity taken on board per trip is from 105 to 137 tons, and about 27 tons are used per day. In comparison with other coals, Mr. Finegan states:—"I have found in practice, 20 tons of best Welsh coal, in evaporative power, are equal to 27 tons Intercolonial (Drummond) coal, and 27 tons Intercolonial coal equal to 30 tons Scotch. All things considered, I would rather have Intercolonial coal." His further statements indicate:—That if the opening between the grate-bars of the steamer-furnace are only from ¾ to 1 inch apart, no slack is wasted by falling through the grate unconsumed; that the coal cakes but little on the grate; that but little clinker is formed, but that what there is, is in sheets of some thickness; and that compared with the English and Scotch coals as used on the steamer, this coal gives "considerably more" ash. In answer to the final question: "Is there anything else you can think of, either for or against the coal?" Mr. Finegan states: "Intercolonial coal has given me good satisfaction, all things considered. I look upon it as good quality steam-coal. Leaving so large an amount of ash occasions much extra work, but this is more than compensated by the saving in grate-bars, which are no small item of expense, and they last much longer with this coal, than when Welsh (or many other) coals are used."

STEAMSHIP "CITY OF QUEBEC."

Information received from Thomas Palaquie, engineer.

Steamship "City of Quebec" is 499 tons register. Engines oscillating, with two cylinders 57 inches diameter × 56 inches stroke. Two boilers with eight fires. Working pressure of steam, 18 lbs. SS. "City of Quebec."

The Drummond coal has been used on this steamer since 17th May, 1869, (Nov., 1869.) The quantity taken on per trip is about 130 tons, and with eight fires and running at full speed, about 36 tons are used per day.

The coal generally burns well, not falling to pieces when thrown on a hot fire, and not caking. It forms clinker in sheets, but this clinker does not stick to the bars, and the ash, which is white, is about twice the quantity produced by English or Scotch coal.

STEAMSHIP "GASPE."

Form filled up and signed by John Campbell, engineer.

The steamship "Gaspé" is of 231 tons register. She has oscillating engines (two cylinders 32 inches diameter × 3 feet stroke), and one tubular boiler. When this information was furnished (Nov., 1869), the Drummond coal had been used but two trips on this steamer. The quantity of coal taken in per trip stands as follows:—At Quebec, 70 tons Scotch; at Pictou, from 63 to 65 tons Intercolonial (Drummond); the amount of the last burnt per day, equalling about 12 tons. S.S. "Gaspe."

In comparison with other coals, Mr. Campbell states:—

"I find that Intercolonial coal lasts longer than Scotch; in proof of this: 4th trip from Quebec, 65 tons Scotch, 109 hours running time; 4th trip up, 58 tons "Intercolonial," 118 hours running time; 5th trip down, 62 tons Scotch, 98 hours. You will see that we ran 118 hours with 58 tons Intercolonial, against 65 tons Scotch coal in 109 hours."

Further statements indicate that no inconvenience is felt from the slack falling through the grate, when the bars are properly pitched; that the coal cakes on the grate when damp; that it forms whitish-brown clinker in sheets which does not adhere to the bars; and that it leaves a considerable quantity of yellowish-gray ash, which is "sometimes nearly black."

PICTOU COALS ON OCEAN STEAMERS.

For some months past, coals from the Acadia-West and Drummond collieries have been used on the large ocean-steamers of the Montreal Ocean Steamship Company (Allan's line), on the homeward voyages from Montreal in summer and Portland in winter, to Liverpool and Glasgow. Trials on the Allan Line of Steamships.

The regular supply of coal has, I believe, been furnished by the Acadia colliery (Acadia steam-coal), though several thousand tons of Intercolonial (Drummond) coal have also been used. Through the kindness of Messrs. H. & A. Allan, I have been allowed to examine the reports of the engineers of a number of their steamers, concerning comparative trials of these coals (as supplied at Montreal and Portland), with the Welsh steam-coals supplied for the outward voyages, at Liverpool, and have permission to include the more important results of these trials in this Report. The general result appears to be satisfactory, except in one particular, viz.:—the large amount of ash produced; but the inconvenience felt from this cause is in most cases counterbalanced by the small amount of sulphur in the coals, the absence of adherent clinker, and the consequent preservation of grate-bars.

Daily consumption.

Consumption, as compared with Welsh.—The record of comparative daily consumption of these and Welsh coals during some of the trials, is as follows:—

1. S.S. "Peruvian," (Report Jan., 1869.)
   63 tons 10 cwt. Acadia = 50 tons 10 cwt. Welsh = 57 tons 10 cwt. mixture of the two coals = 124:100:115.
2. S.S. "Nestorian," (Report 1st Feb., 1869.)
   68 tons Intercolonial = 55 tons Welsh = 123:100.
3. S.S. "Hibernian," (Report 9th Feb., 1869.)
   62 tons Pictou (principally Intercolonial,) = 50 tons Welsh = 124:100.
4. S.S. "Nestorian," (Report 17th Feb., 1869.)
   69 tons Intercolonial = 59 tons Welsh, (pressure of steam being as 18:25.) This (taking steam-pressure into consideration,) = 162:100.
5. S.S. "Hibernian," (Report 1st March, 1869.)
   $58\frac{1}{2}$ tons mixed Acadia and Intercolonial = (estimated) 51 tons Welsh as received in Portland, or 48 tons as received in Liverpool = 121:106:100.
6. S.S. "North American," (Report has no date.) It states that 45 tons of Acadia coals are consumed per day, being same consumption as with Welsh, but pressure of steam is 4 or 5 lbs. less than with Welsh. If pressure of steam with Welsh = 25 lbs. (?), then ratio of Acadia and Welsh would = 118:100.
7. S.S. "Nestorian," (Report of 28th March, 1870.)
   66 tons Acadia = 59 tons Welsh coal, steam-pressure being $22\frac{1}{2}$:25 lbs. This indicates the ratio of 122:1.00, taking steam-pressures into consideration.

AVERAGE RATIOS OF DAILY CONSUMPTIONS, FROM ABOVE TRIALS.

Comparison Pictou and Welch coals.

1.	Welsh* to Acadia	100.0 : 121.3
2.	" " Intercolonial, including trial No. 4.†	100.0 : 136.3
3.	" " Intercolonial, rejecting trial No. 4	100.0 : 123.5
4.	" " mixture, Welsh and Acadia	100.0 : 115.0
5.	" Acadia and Intercolonial	100.0 : 121.0
6.	" " Welsh as delivered in Portland	100.0 : 106.0

Ashes and Clinker.—Mr. Flett, chief engineer of the S.S. *Peruvian*, in his Report of June, 1869, says:—"There is a large quantity of ashes from the Acadia coals, but little clinker, which enables us to clean the fires easily, as nothing sticks to the bars." Mr. Dick, chief engineer of the S.S. *Hibernian*, says:—"The fires are easily cleaned, that is, the clinkers do not stick to the bars, neither do they burn the bars." The other engineers complain of more or less clinker from both Acadia and Intercolonial coal; the Acadia, however, appears to give the less trouble in this respect. This is owing to the fact that the Intercolonial coal is the softest, and if not properly stoked would be inclined to clinker. The fact that some engineers burn these coals without clinker, is sufficient proof that it is possible to do so in every case. As I shall presently show, it is probable that, if these coals are burnt with a fire, thin at the bridge, deep at the fire-door, with proper perforations in the door, (equalling at least 8 or 10 square inches per square foot of door,) there should be no difficulty in keeping good steam, and avoiding the large flat clinkers which are complained of; but attempts to burn these caking coals on a thin flat fire such as is generally made in burning Welsh steam-coals, which are not inclined to cake, will never result in success.

Ash and clinker.

The amount of refuse from these coals in proportion to Welsh, is variously estimated by the different engineers; the average seems to be, in buckets thrown overboard per watch of four hours:—Welsh, from 15 to 18; Pictou, from 35 to 45.

Smoke, etc.—The only mentions made of smoke in these reports occur in the reports of Messrs. Jack, of the *Hibernian*, and McMaster, of the *Nestorian*, both of whom complain that when urging the fires to get all the steam possible, large volumes of smoke and flame are seen coming from the funnel. I need hardly say that this manifestly results from an improper arrangement of the draught, and it would appear from this that no air is supplied above the fire, to assist in burning the volatile matters passing off from the coal in coking, previous to combustion. This must result in a great loss of coal, and can be partially remedied by the same change in

Smoke.

* Welsh, "best Welsh steam-coal, delivered in Liverpool."

† The low result of trial No. 4 is probably due to bad management of the coal. It is so discordant with other results that I think it should be rejected.

management mentioned above, viz.:—proper stoking, and perforated doors. This subject will be further considered under the next heading, paragraph "*Smoke consumption.*"

GENERAL REMARKS ON STEAM-TRIALS.

General remarks on steam trials.

The general result of all the trials above described has been to demonstrate the fitness of the coals used, for steam production, whether under stationary marine or locomotive boilers. As the result of each separate trial can be compared with similar trials of foreign coals, by reference to any work on standard coals or engineering practice, it seems unnecessary to make any such comparison here.

Former prejudices against bituminous coals, as steam producers.

A few remarks on late experiments on the consumption of such coals, however, may not be out of place, but though of very great importance to our coal trade, a full discussion of the subject will not be practicable, without extending this Report far beyond the limits to which it must be necessarily confined. A prejudice existed for a long period against using bituminous coals as steam-producers, especially in the Navy, on account of the large amount of smoke produced in burning them, and their low evaporative power, as compared with anthracites, or the so-called free-burning coals of the Welsh coal-fields. The heavy black smoke emitted from the funnel of a steamer burning these coals rendered them quite unfit for the use of ships of war, and in towns and cities became a serious nuisance. Their evaporative powers, as has already been stated, were supposed to be dependent on their content of fixed carbon, which supposition seemed to be quite justified by practical experiments. The most careful trials with the old style of furnaces failed to give them the value of the Welsh steam-coals, in proof of which I may cite the final results of the British experiments (De la Beche and Playfair's), in evaporative powers:—

Average of	37	samples	from	Wales	9.05	lbs.
"	17	"	"	Newcastle	8.37	"
"	28	"	"	Lancashire	7.94	"
"	8	"	"	Scotland	7.70	"
"	8	"	"	Derbyshire	7.58	"

Resemblance of Pictou and North Country coals.

Of the above list of coals, the coals of the Pictou district approach nearer to the Newcastle Hartley, or North Country coals than to any other class well known, and it will be, therefore, of the greatest interest to show the change of opinion which has taken place with regard to these coals within the last few years; to mark how all the old prejudices have disappeared, and to ascertain with what success these coals are now consumed as steam-producers.

To accomplish this object in the most direct manner, I cannot do better than quote from the "Report of a Committee appointed by the North of England Institute of Mining Engineers, to investigate the smoke question" (dated Oct. 24th., 1860.) After mentioning the causes that led to the appointment of this committee, they state:— Smoke consumption.

"They (the Committee) cannot, however, forbear remarking that there is really very little left for them to do. A few years ago, in 1855, there was an impression that North Country steam-coal not only made smoke when burnt, but was of an inferior evaporative power to that of the so-called smokeless Welsh coal. Since then, on two subsequent occasions, this has been proved, most satisfactorily, to be an error. In 1856-7, experiments were made at Elswick, conducted by Sir William Armstrong, Mr. J. A. Longridge and Dr. Richardson, which fully demonstrated that Hartley could give, without smoke, 12.9 lbs., and Welsh 12.35 lbs. of water evaporated from 212°, per pound of coal, in an ordinary marine boiler; and in 1864, Mr. Miller, at the request of the House of Commons, made a series of experiments which proved again most satisfactorily that Hartley could give without smoke 10.68 lbs., and Welsh 10.13 lbs. of water evaporated from 100 per pound of coal. Again, at Wigan, in 1867, Messrs. Fletcher and Dr. Richardson conducted a series of experiments proving most conclusively that a bituminous coal, more difficult even to manipulate in the fire than the coal of this district, can be economically and *smokelessly* consumed. All these results have been accomplished with the smallest possible alteration of the furnace and bars of ordinary marine boilers. Your Committee, therefore, have, from many and various sources, the highest authority for stating that, as far as experiments can do so, the question is practically *solved*, and more particularly in connection with any ordinary quality of round coal, and in Cornish or marine boilers of ordinary construction. It could hardly be expected that any further experiments would produce better or more conclusive results, or be attested by gentlemen of higher reputation and position. Lake experiments.

* * * * * * * * * * *

"Believing, as they do, that the semi-bituminous steam-coal of this district can be burnt without smoke, so as to give as high, if not a higher and more speedy evaporative power, than Welsh (as might be expected from its chemical composition), your Committee can by no means aver that this most important fact is comprehended by the great bulk of consumers; but they are not of opinion that any further experiments in this direction are necessary, as it seems to them that data on this subject are so numerous already, that the public may be properly left to draw their own inferences thereon.

"If your Committee were asked for the reason for so much incredulity on a subject so important to the interests of the Northern coal-owners, they would suggest that it, to a certain extent, arises from the fact that the steamships built in the neighbouring ports are not, as a rule, by any means successful either in their attempts to prevent smoke, or to obtain the highest results from the coal of the district. These steamers, going from port to port, and from country to country, assist in advocating the views of those who refuse to recognise the value of the Northern steam coals, and your Committee regret that the boilers of these ships at least are not constructed so as to bear out the results so laboriously obtained at such great cost."*

Many of the statements in the above extract will apply with almost equal force to our own coals. It is scarcely possible that we shall obtain the very high results in evaporative power above indicated, from the Pictou coals, from the fact that the amount of ash in these coals almost invariably exceeds that in the coals of the North of England; but it is certain that with proper furnaces, the evaporative power of our coals may be materially increased, probably to the extent of from twenty-five to thirty per cent., and there seems no reason to doubt, that, in the matter of smoke, our coals may be as successfully burnt as those of the North Country.

Mr. Bunning's experiments.

In this connection it will be interesting to examine into the success with which the Newcastle coals are burnt without smoke, and to this end, an abstract of the experiments of Mr. T. W. Bunning, of Newcastle-on-Tyne, on the steamer "*Weardale*," will most conclusively show the wonderful improvements made from the results of the old system of burning the coals, by a very slight change in the furnaces and bars. A series of smoke-trials were made on this steamer with the ordinary furnace, fitted with grate-bars five feet long, and the exact amount of smoke produced by Hartley coal was obtained by a method presently to be described. An alteration was then made in the furnaces, which consisted simply in shortening the bars to three feet six inches, and introducing an *air-plate* (of fire-bricks with open spaces between them, hung on iron bars), at the back of the fire. Underneath this air-plate was a flue, or open space, separated from the ash-pit of the furnace by a cast-iron plate, carrying the brick forming the bridge proper of the furnace. This cast-iron plate was pierced with a hole giving communication between the ash-pit and air-plate flue, when open, and thus admitting air between the fire and the chimney, through the spaces between the fire-brick forming the air-plate; or this hole could be closed by a shovel-full of ashes and cinder. Beside these simple alterations the furnace-doors were fitted with perforated flash-plates, through which the air was allowed to pass into the furnace, in front of the fire, but above the grate. After the alteration, another series of experiments was tried with the steamer, and with the most signal success. The results were published in the Transactions of the North of England Institute of Mining Engineers, and accom-

* Transactions North of England Institute of Mining Engineers, vol. xviii, pp. 37–38.

pany a short paper by Mr. Bunning, a portion of which will subsequently be quoted. As it will be impossible to reprint in full, the tabulated results of these trials, it will be necessary to explain the method adopted (and now, I believe, agreed to as the standard by the Imperial Government), for estimating the exact amount of smoke produced by a given coal, consumed in the furnace of any particular steamer. It is this:—Let the smoke issuing from the funnel of a steamer be noted every minute for an hour, upon a blank table, subdivided into minute-columns, similar to the table published with the Acadia coal-trial on the steamer "St. Lawrence" (Trial No. 2, of this Report). Let the figure 1, placed in a minute-space, indicate that the very faintest possible smoke, a mere indication of light-coloured gas was visible; 2, that this was increased, and so on to 6, indicating the densest black smoke. Having obtained these *smoke-marks* for an hour, the addition of them gives the *smoke-equivalent* for that time. This understood, the extract from Mr. Bunning's paper above referred to, will become intelligible to the reader. After referring to the tabulated record showing the smoke-marks for every minute during his experiments, he states:—

Rule for estimating smoke.

"It will be seen that before the alteration, this smoke-equivalent averaged 107.9 over 25 experiments; that frequently, and for several consecutive minutes, dense black smoke was issuing from the chimney, and that there was rarely any actual cessation from smoke; while after the alteration no smoke of greater intensity than 2, was ever visible, and this only nine times in eighteen hours, for a minute each time; and that during the same eighteen hours the average smoke-equivalent was 7.7, each mark so rarely exceeded 1. This indicates that the very faintest possible smoke was visible only for 7.7 minutes in each hour, no smoke whatever being visible for the other 52.3 minutes. It would be vain to look for, nor indeed can any better results be found, even when the best of the so-called smokeless coals are burnt; for all practical purposes, therefore, good Hartley coal, as consumed in the *Weardale*, may be considered as smokeless as any other known coal. The plate* shows the alteration made to the fire-bars and bridge; the former were reduced from 5 feet to 3 feet 6 inches. The doors were not changed, and those shewn are those used by the Admiralty, admitting air at the bottom.†

Experiments on the Str. "Weardale."

"The secret of burning the North Country steam-coal, and in fact all other good steam-coal, is to put it on as large as possible, as thick as possible, and to have as great a draft as possible, so as to burn off as large an amount per square foot of grate-surface as possible."‡

Rule for burning North Country steam-coal.

* Published with Mr. Bunning's paper.

† That is, the bottom of the door; the air passing into the fire through a perforated flash-plate.

‡ "*On Experiments on the Weardale,*" Trans. N.E. Inst. Mining Engineers, vol. xviii., pp. 105 et seq.

Farther trials and alterations.

Since these trials, which were carried out in the winter of 1868-9, farther experiments have been made by Mr. Bunning on the Weardale, and some slight alterations made, among which may be mentioned the placing of a door at the hole piercing the plate between the ash-pan and air-plate flue, which being moved by a bar extending to the front of the furnace, permits the admission of air, *at will*, behind the fire. Under date of 14th April, 1870, Mr. Bunning (to whom I am indebted for much information on this subject, which I would here gratefully acknowledge, writes me :—

Success.

"We consider the Weardale, now perfect; she makes absolutely no smoke, and keeps her steam well."

A proper discussion of the rationale of these experiments, and of their importance to our coal-trade, must be postponed to some future occasion. Much more might be said in favour of the use of steam-coals of the class under consideration, and it can be clearly proved, that, if properly burnt, they are at least as economical, as smokeless, and as easily stoked as any other class of coals.

Use of Newcastle coal in the Navy.

The experiments above quoted, in connection with Government trials made at Devonport, already mentioned, have produced a material change of opinion with regard to Newcastle coal, and it has now taken a position second to none, among coals for the Navy, where it is chiefly used in admixture with Welsh coal, and the testimony of the very highest authority, is that a very large saving has already been effected by its use.

Necessity for steam and smoke-trials of our coals.

It is hoped that enough has already been said to call the attention of our coal-owners and consumers to the urgent necessity of practical trials of a similar character to those above mentioned. Such experiments could be carried out at a very trifling cost, on any steamers, without interfering with their regular voyages; and though the great results of the North Country experiments might not be obtained, still, a great addition would be made to our knowledge of the coals, and that a very material improvement in the matter of steam and smoke would be made, cannot be doubted.

I shall close these remarks, which have already exceeded the length originally assigned to them, by an extract from a circular of the Coal Trade Association of Newcastle-on-Tyne, just received from Mr. Bunning. It is of interest as showing the results of the very latest trials.

RESULT OF EXPERIMENTS AT PORTSMOUTH, 1869-70.

Experiments at Portsmouth 1869-70.

"A very comprehensive series of experimental trials have been carried out during the past twelve months on board Her Majesty's steamers "Urgent" and "Lucifer," at Portsmouth, with Welsh and North-

Country coal mixed, and burnt in two forms of furnace, for the purpose of ascertaining the best proportions in mixed coal, and form of furnace for the consumption of smoke. The trials have been carried out under the direction of Captain E. Rice, A.D.C. to the Queen, commanding the Steam Reserve at Portsmouth, and the superintendence of Mr. G. Murdock, Chief Inspector of Machinery to the Reserve; and the results are considered to be so important, that orders have been issued from the Admiralty for the furnaces in the boiler-rooms of her Majesty's ships to be altered according to the plan finally adopted in the trials as the best for the consumption of smoke. When the comparative trials between the ordinary and the new form of furnace commenced, the proportions of the mixed coal burnt were one-third North-Country and two-thirds Welsh; but in all the later trials the coals have been burnt in equal proportions, and under these latter conditions less smoke has been emitted from the smoke-consuming furnace funnel than has been emitted from the funnel over the ordinary form of furnace, when the latter was burning the very best description of Welsh coal. The last three trials made on board the "Urgent" afford conclusive evidence of the success of the new form of furnace over the old. In the trial made on the 27th ult., both sets of furnaces were used, the coal burnt being Ferndale and Cowpen's Hartley, in equal proportions. The report of this trial gave the following results:—

Change of furnaces in the navy.

H. M. S. "Urgent."

	New Furnace.	Old Furnace.
Smoke	1.55	4.55
Coal burnt per hour	2,940 lbs.	3,294 lbs.
Producing		
Ash	23.14	32.75
Soot	2.82	5.16
Clinker	35.08	25.00

"The last two trials made were on the 2nd and 11th insts., the new furnaces only being used on the former, and the old furnaces only on the latter trial, the coal burnt in each instance being equal quantities of Powell's Duffryn and Cowpen Hartley, with the following results:—

	New Furnace.	Old Furnace.
Coal burnt per hour	2,912	3,397.3
Producing		
Ash	17.73	24.34
Soot	1.94	4.06
Clinker	31.0	40.6

"In these two trials, the new furnaces exhibited a saving upon the old, of 14.28 per cent. in fuel, an increase of 7.56 per cent. in horse-power, and a positive gain in the consumption of smoke, of 21.84 per cent."

PRACTICAL TRIALS IN GAS MAKING.

Requisites of a gas-coal.

The most important requisites of a gas coal are :—1st. That it contains a large amount of volatile combustible matter (gas);—2d. That this volatile matter be of good illuminating power, and as free as possible from sulphur, and—3d. That the coke furnished by the carbonization of the coal be bulky, and at the same time firm, (*i. e.* not inclined to be granular.)

The importance of the first requisite, will be evident to all. The percentage of volatile matter in true coals usually employed in gas-making, is from 25 to 40 per cent., and in cannels it rises to 60 or 70 per cent.

Gas-content.

The true bituminous coals of this district which are now being worked, average, according to the latest analyses, as given in the first Section of this Report, about 28 or 29 per cent. of volatile matter ; the content of the hardest being 20.46 per cent., and of the softest being 38.84 per cent. The oil-coals, oil shales, and a single cannel range higher in gas-content, the stellarite reaching 68.38 per cent., and Lawson's cannel 41.18 per cent., which last figure is not, however, a high percentage of volatile matter for a cannel. That the percentage of volatile matter, given by analysis in the small way, is not always a true index of the value of a gas-coal, will be seen by a reference to the analyses of the Foord-pit coal, which stands nearly at the head of the list of Pictou (true) coals, as a gas-producer. The percentage of volatile matter appears rather low in this case, in fact so much below what would be expected from so good a gas-coal, that I am inclined to suspect that the samples analysed in the small way, were not fair averages of the produce of this colliery.

Quality of gas.

That the gas produced from the coal be of good illuminating power, is most important, will also be seen, though from the fact that the standard of illuminating power can easily be raised by the addition of a few per cent. of some rich cannel, or substance of the character of the stellarite, many coals, which produce gas of a low standard, but in large quantity, (if they coke well,) are often used as gas coals. The stellarite has been used to raise the standard of illuminating power of gas from other coals ; as are also, torbanite, albertite, cannels, and many oil shales. To instance a case of this kind, I may state that Mr. Thompson, of the Pictou Gas-works informs me that when using a coal giving *per se* 15-candle gas, he adds 10 per cent. of Leshmahagow cannel, in order to raise the gas to the standard of 18 candles.*

* The standard candle in testing gases, is of spermaceti, burning at the rate of 120 grains to the hour. To compare the illuminating powers of gases, the light given by a standard burner burning five (5) cubic feet per hour of the gas under examination, is compared with the light of one of these standard candles, the result giving the *candle-*

Coke.

The majority of the coals of the Pictou region furnish an excellent coke in the gas-retorts, if properly carbonised, as will be abundantly proven by the statements to be given below from some of the first gas-chemists of this continent. Statements have recently been published to the effect that coke from these coals is worthless. In a single case this may be warranted; in the majority of cases it is not, as from a number of the coals I have seen most excellent coke made in the gas-retorts of the Pictou works. It is true that if the heat is not properly applied, the coke cannot be properly formed, and a few of these coals will never be successfully coked, but the testimony of our first gas-chemists, such as Buist of Halifax, and the engineer of the Boston Gas works, who have used many thousand tons of the coals, is that some of them furnish good merchantable coke.

Sulphur.

The greater number of the coals of this district will, I believe, compare favourably with those of any district of the world in regard to sulphur. A number of analyses in the first section show the sulphur-content of the different coals, which in most cases is considerably below 1.00 per cent. These determinations of sulphur may be compared with the following table, giving averages of determinations of sulphur in a large number of the coals of Great Britain, from the analyses given in the reports of the British Admiralty Trials: —

					Per cent.
Average of	37	samples from	Wales.	gave of sulphur	....1.42
"	17	"	Newcastle,	"	.... .94
"	28	"	Lancashire,	"	....1.42
"	8	"	Scotland,	"	....1.45
"	8	"	Derbyshire.	"	....1.01

Further statements concerning the small amount of sulphur in Pictou coals, will be found in the extracts of letters from Messrs. Buist and Greenough, given below.

GAS TRIALS AT THE PICTOU GAS-WORKS.

Gas trials at Pictou.

Mr. Alex. Thompson, of the Pictou Gas-works, has used all the coals which have been worked to any considerable extent in this region, and he has been kind enough to supply me with notes of his experience, from which the following tabulation has been compiled.

power of the gas. Thus if we suppose a gas burnt in a five-foot burner to give fifteen (15) times the amount of light furnished by one standard candle, the gas is said to have 15-candle power or to be 15-candle gas. The standard of gas in our large cities ranges from 13 to 18-candle power.

PRODUCTION OF GAS, AND QUALITY OF GAS AND COKE, FROM VARIOUS COALS AT THE PICTOU GAS-WORKS.

(FROM NOTES OF MR. ALEX. THOMPSON, MANAGER.)

Results of trials at Pictou.

Company shipped by, and name of mine.	Cubic feet of gas (per ton of 2240 lbs.)	Illuminating power (candles.)	Bushels of coke per ton.	Character of coke.	Remarks.
GENERAL MINING ASSOCIATION.					
Foord Pits, (1869 shipments.)	8,000	18	35	Good.	
Albion (Old) Mines........	7,700	16	34	"	
Forster Pit..................	6,000	13	32	Not good.	Coke unsaleable.
Dalhousie Pit..............	7,500	15	32	Good.	
Cage Pit, (old shipments)....	7,800	17	34	Good.	
ACADIA COAL COMPANY.					
McGregor workings........	7,600	14	34	Fair.	Coke firm, but sulphurous.
Fraser Mine, stellar coal....	11,000	36	....	....	Coke worthless.
" oil-shale......	8,000	30	....	....	" "
Acadia Colliery, west slope.	7,000	13	32	Not good.	Coke granular.
INTERCOLONIAL COAL COMPANY.					
Drummond Colliery........	7,700	15	34	Good.	
NOVA SCOTIA COAL COMPANY.					
Nova Scotia slope...........	7,000	14	32	Fair.	Coke saleable.
MONTREAL AND PICTOU COAL CO.					
Montreal and Pictou pit....	6,000	13½	28	Not good.	
PICTOU COAL MINING COMPANY.					
Marsh Colliery.............	6,000	14	28	"	

Of the coals named in the above list, that from the Foord pits appears to give the best result in gas-making, from its large gas-content, the high illuminating power of the gas, and the superior coke produced in its carbonization.

Value different coals.

The Drummond coal, and the coals of the Old mines, Dalhousie and Cage pits, appear to stand next, the value of the other coals for gas purposes falling slightly below these. The stellarite and oil-shale of the Acadia mines are most valuable for mixing with the coals, to increase their illuminating power, but would not be of great value if used alone, for two reasons: because their cokes are worthless, (being merely a cinder, with but a few per cent. of fixed carbon, and therefore useless in heating the retorts); and because the gases produced in carbonizing them are too carbonaceous for use with ordinary burners. Good coke is not only valuable to the gas-manufacturer as a merchantable product, but also is used for heating the retorts, and therefore cannels, and substances like torbanite, stellarite, and albertite, though producing a large amount of highly carburetted gas, are seldom used in gas-manufacture, except in mixture with coals furnishing a good coke.

I shall now proceed to give such facts as it has been possible to procure concerning the value of the different coals of this district in gas-manufacture, some of which facts have already been published, while others have been obtained by correspondence, and in one case a special trial has been made at the Pictou Gas-Works.

COALS OF THE ALBION MINES.

The following extracts are from letters by Mr. George Buist, Manager and Chemist of the Halifax Gas Company, and Mr. W. W. Greenough, Manager of the Boston (Mass.) Gas Company, in answer to letters from myself, soliciting information for this Report. The companies represented by these gentlemen, have been for years large consumers of the Albion Mines coal. Albion-Mines coal.

LETTER OF MR. GEORGE BUIST.

(*Copy.*)

GAS OFFICE, HALIFAX, N.S., Feb. 24th, 1870.

Edward Hartley, Esq.,

DEAR SIR,—

I beg to acknowledge receipt of yours of 8th instant, making enquiries regarding Pictou coal.

I think the following statement may be taken as giving the correct quantities of the gas, coke and tar produced from one (1) ton of 2,240 lbs. Mr. Buist's letter.

The quantity of gas will average about..............	7,300 cubic feet.
Illuminating power, about	15½ to 16 candles.
Weight of coke, about...............................	1,450 lbs.
Quantity of coal-tar, about..........................	9½ to 10 gallons.

The sulphur in the Pictou coal is very much less than in any of the other Nova Scotia coals. The quality of the coke is very good indeed. * * * *

I remain,

Yours truly,

(*Signed*,) GEORGE BUIST.

LETTER OF MR. W. W. GREENOUGH.

(*Copy.*)

OFFICE OF BOSTON GAS LIGHT COMPANY,
No. 20 West Street, Boston, Feb. 7th, 1870.

Edward Hartley, Esq.,

DEAR SIR,—

Your letter of inquiry of the 4th instant reached me * * * * * * * *

We use the caking coals of Pictou and Cape Breton, in combination with richer coals. The proportions of these combinations are based upon experimental trials of each coal separately. Mr. Greenough's letter.

The best results in gas-making with the Pictou coals, are obtained by working the retorts at a cherry-red heat. One then gets from each ton of 2240 lbs., 7280 feet of gas—of *strong* 15-candle illuminating power, with a yield of 1325 lbs. of coke of fair quality. Higher heats will give more gas of an inferior grade, and with a diminished value of coke. This coal contains but a small proportion of sulphur compounds, is easily purified, and may be safely stored without danger from spontaneous combustion.*

* * * * * * * * * *

Yours truly,

(*Signed*,) W. W. GREENOUGH.

* The rest of this letter refers to Cape Breton coals, and need not be quoted here.

I would take this opportunity to thank Messrs. Buist and Greenough for the above facts, and for other valuable information they have kindly given me.

The statements in the following memorandum, sent me by Mr. Jas. Hudson, Chief Manager of the General Mining Association, are partially a repetition of the above facts :—

" Extract from letter of W. W. Greenough, Esq., Treasurer of Boston Gas Light Company, December, 1869.

" ' We have made no recent analysis of gas made from Pictou coal, but the experience of several years working shews a uniform result :—with cherry-red heats, of 3¾ cubic feet to the pound, of 15-candle gas ; with a condensation by bromine of 6.75 ; a specific gravity of 4.75 ; and the *smallest per centage of sulphuretted compounds of any coal called caking*. Coke fair. Higher heats will give more gas, at the expense of the illuminating power of the gas, and the quality of the coke.' "

McGREGOR COAL (ACADIA MINES).

McGregor coal. The following statements are from the published report of Mr. Jesse Hoyt, Manager of the Acadia Coal Company, 1866 :—

" On the 9th. of February, 1865, one ton of this coal, a mixture of both benches, was tested in the works of the Manhattan Gas Company, New York, with the following results :—

Trial at New York, U. S. " ' One ton of 2,240 lbs. yielded 9,500 feet of 13.03-candle gas, and 41 bushels of coke, weighing 1,640 lbs. The coke is good ; it contains rather much ash, and makes some clinker, but it burns well, keeping up a good strong fire. The coal seems to deserve a trial on a larger scale, as it is very readily carbonized, yielding a good volume of gas and coke.' "

Analysis of the coal.

Volatile matter	32.0
Fixed carbon	59.3
Ash	8.7
	100.0

" A subsequent trial was made by the same company, but the result was not so favourable, as will appear by the following report :—

Second trial. " ' One ton of 2,240 lbs. yielded 9,500 feet of 13.34-candle gas, and 38 bushels of coke, weighing 1,744 lbs. The coke is poor ; it clinkers badly, and does not keep up the fire under the retorts. It requires 4 bushels of lime to purify a ton.' "

Analysis of the coal.

Volatile matter	26.8
Fixed carbon	57.9
Ash	15.3
	100.0

Mr. Hoyt remarks that he believes the unfavourable result in the latter trial, to have been caused wholly by the admixture with the coal, of foreign matter from the *shale-band* or fire-clay parting, between the first and second benches of the McGregor seam.*

DRUMMOND COAL.

Drummond coal.

Through the kindness of Mr. Dunn, Manager of the Intercolonial Coal Company, I procured a special gas-trial of three coals, from the three upper divisions of the Acadia seam, as worked at the Drummond colliery.

Special gas-trials.

This trial was made under the superintendence of Mr. Alexander Thompson, Engineer and Manager of the Pictou Gas Company, at their works. The samples were of two barrels each, and believed to be fair averages of the different benches. They were marked and numbered as follows:—

Sample No. 1,—Top of seam, (2 feet 6 inches thick) left in the workings.
" No. 2,—From the fireclay *holing*, 2 feet up to the smooth parting. (Fall coal.)
" No. 3,—First bench. Below the *holing*, and 4 feet thick.

The numbers of these samples correspond to the numbers of the divisions and analyses of this seam at the Drummond colliery, in Section I. of this Report.

The following is a copy of Mr. Thompson's Report:—

(*Copy.*)

Mr. Thompson's Report.

GAS WORKS, PICTOU, N.S.
December 4th, 1869.

Edward Hartley, Esq.,
Geological Survey,

SIR,—

At your request I have carefully examined the contents of six (6) barrels of coal from the Drummond colliery, marked respectively Nos., 1, 2, and 3, with the following results:—

No. 1,—Yields at the rate of 7,000 cubic feet of gas and 32 bushels of coke to the ton.
No. 2,— " " " 7,500 " " " 32 " " "
No. 3,— " " " 8,500 " " " 36 " " "

The gas has an illuminating power of 15 candles. The volatile combustible matter is such in amount and character as to promise well in gas-making. The coke is firm and of good quality, well adapted for heating the retorts in gas-making, and can thus take the place of coal for that purpose.

I am, Sir,
Your obedient servant,
(*Signed,*) ALEX. THOMPSON,
Engineer and Manager.

Beside their use as steam and gas-producers, several Pictou coals are sold extensively for various other purposes, among which may be mentioned, re-heating iron, blacksmithing and domestic purposes. The cokes of one

* See Geological Report, Section 4, pp. 67 et seq., beds 71—73, See also page 96 of the same Report, and the first Section of this Report.

or two of the coals have also been, to a certain extent, successfully used in iron-smelting and founding. I am not at present able to furnish any exact data concerning the success with which they are used in rolling-mills etc., and no iron-smelting is at present carried on at any point near the Pictou district; but I am aware that in the Eastern United States, the coals are used in various forges and rolling, mills, with very good success, and I am assured by Mr. E. A. Jones, Manager of the Acadian Iron Works at Londonderry, Nova Scotia, that he has used Albion Mines coke in iron-smelting, and finds it better suited to this work than any other Provincial coal he has used.

For domestic purposes these coals are well and favourably known ; they light easily in the grate and burn well and long with very little attention, except in the few cases where the content of ash is very large.

III.

IRON ORES OF PICTOU COUNTY.

Localities of iron ore.

A number of localities are known in the vicinity of the Pictou coal-field, where ores of iron have been found. None of these have ever been developed to any extent; and the few trial-pits upon the deposits, afford very unsatisfactory evidence as to their size and value. The ores of iron which have been recognized in this vicinity are ; specular iron, limonite or brown hematite, and spathose ores (crystalline carbonates of iron) ; besides the clay-ironstone, or argillaceous carbonate of iron of the coal measures.

In the following paragraphs, mention is made of those localities only which I have personally examined, though a large number of others exist, of greater or less value. My field-work in this district was confined to the productive coal-field, except in the few cases where examinations beyond its boundaries were made at special request. The samples analysed, where no statements to the contrary are made, were taken by myself from the deposits, and are believed to be the averages of the ores. The analyses have been made in the laboratory of this Survey, by Mr. Broome.

SPECULAR IRON.

Specular iron

Several deposits of specular iron were examined ; these all occurred in a range of metamorphic rocks lying ten or twelve miles to the south of the coal field. The ore of the variety known as micaceous iron ore, was noted at Battery Hill, near Glengarry station, and proceeding east from this point at a number of localities near the line of the Provincial Railway, the range of rocks including it finally crossing this railway and the East River of Pictou, several miles above Springville. Of the age of this formation, I cannot speak with certainty, but it is probably Upper Silurian ; the rocks consist of quartzites, of light and dark green, purplish, brown and black colours, and slates highly altered, generally of a black colour and giving a white streak. The quartzites are sometimes coarsely granular, but as a rule, compact and fine grained. This formation appears quite distinct in lithological character from the series which has been described in the Reports of Sir William E. Logan and myself, as occuring near the Pictou coal field, at McLellan's and McGregor's Mountains, and at Waters' Hill, and which are believed by Dr. Dawson to be of Devonian age.

Age of including rocks.

I have made no attempt to obtain fossils in these rocks, nor has any bed been observed likely to contain them, at the few localities examined ; but it seems probable that the fossiliferous beds mentioned by Dr. Dawson in his Acadian Geology, (pages 568-570), as occurring near Springville, are included in this series. These beds, from which a large number of fossils have been collected by Mr. D. Frazer of Springville, are of undoubted Upper Silurian age.

Fossiliferous beds.

The specular iron appears to exist in true fissure-veins, but of no considerable size, at any locality which I have seen. In many cases the rocks holding it appear to be much shattered, and the specular iron, with a compact granular quartz as a veinstone, appears to fill the fissures, which are often confined to a particular bed of rock, and sometimes so numerous that the entire bed contains a large per centage of the ore, and may be considered as a single deposit. The most important deposit of this class which I have observed, occurs on the west side of the East Branch of the East River about three and a-half miles above Springville, on the lots of John McDonald and Archibald Thompson. Here the specular iron seems to exist over a considerable area, some portions being quite pure, but as the deposit is opened by two shallow pits only, it is impossible to state its size, or exact relations to the including rocks. The minor veins are often of several inches in thickness, and are included in a light greenish-drab granular quartzite, which they traverse in the most irregular manner. A sample of this ore was taken by me, which appeared to represent an average of what might be mined, provided all the larger lumps of quartzite taken out in mining were rejected. This sample gave on analysis :—

Character of the deposits.

Analysis.

Sesquioxide of iron		65.14
Silica		32.50
Hygroscopic moisture		.91
		98.50
Total amount of metallic iron	per cent.	45.60
Specific gravity		4.607

From the amount of silica present this ore would require a considerable amount of limestone as a flux, or it could be advantageously smelted with a calcareous sparry iron ore like that used for mixture with hematites at the Acadian Iron Works at Londonderry. The locality is well worth a careful exploration, as the deposit seems continuous, and of a considerable width. It is, in common with many other of these deposits, easily traced upon the ground, from the bright rust colour of the soil, and the presence on the surface of a large amount of partially decomposed ore, or *gozzan*, which is easily recognised. The appearance of this substance is very deceptive to the inexperienced eye, and I have frequently had specimens of it brought to me, by parties who, from its uniform rust-red appearance, had been led to imagine it a very rich iron ore. Attention to its low specific gravity will often show how small an amount of iron it contains. The following is the result of a partial analysis of a sample of one of the best of these *gozzans* which I have seen. It was sent me from Rockland fulling-mills, on Middle River, by Mr. Robert Frazer, and in appearance was quite equal to some of the pure ochrey *gozzans* which are found in some other localities, but analysis shows it to be merely a porous mass of granular quartzite, deeply stained with iron-oxyd.

Gozzans from these deposits.

Analysis of a *gozzan*.

Sesquioxide of iron		25.48
Silica		62.61
Hygroscopic moisture		.81
Volatile at a red heat		4.43
		93.33
Amount of metallic iron	per cent.	17.84

The remaining constituents were lime, magnesia and manganese, which were not determined.

LIMONITE OR BROWN HEMATITE.

Limonite.

Numerous boulders of a very pure variety of limonite, have been found in the vicinity of Springville, on the East River, but so far as I can learn, the ore had not been found in place until Oct. 15th, 1868, when a bed was discovered, on James Frazer's land, about 1¾ miles above Springville, (on the east side of the East Branch of the East River), by Mr. A. P. Ross, of Pictou, and myself, while visiting the locality. The only exploration we were enabled to make, was a shallow pit, sunk in a few hours by one man, but this was sufficient to expose a mass eight feet in thickness, of a pure limonite of the mammillary, stalactitic, and fibrous varities. It was overlaid by a close grained altered sandstone or granular quartzite of a light greenish-gray colour, and appeared to be conformable to the stratification. The bottom of the bed was not exposed; it was hidden by a high drift bank; neither was the deposit traced for any distance on the strike. Should it prove to be a persistent bed, it would be a most valuable deposit, as the ore is one of the purest known. No substance save the pure mineral was discovered in the bed, the roof appearing well defined.

The following analysis is of an average specimen taken by myself. It will be observed that the silicious residue does not equal half of one per cent:— Analysis.

Sesquioxide of iron	84.94
Combined water	15.43
Hygroscopic moisture	.92
Silica, (insoluble residue)	.41
	101.70
Amount of metallic iron per cent.	59.46

The rocks including this deposit appeared to belong to the same series as those further south, holding the specular iron deposits above described.

SPATHOSE ORES.

On the land of Neil McLaurin, about one and three-quarter miles south-west of Sutherland's bridge on Sutherland's river, a peculiar deposit of iron ore occurs, included in Indian-red and greenish-drab sandstones, apparently of the Millstone-Grit series. This ore, which I designate as spathose iron ore, appears to be a mixture of spathic iron, or crystalline carbonate of iron, and red hæmatite, or anhydrous peroxyd of iron, with but little impurity. The ore is seen in place, on the south bank of Sutherland's brook, where it is exposed by a number of costeening-pits, and it has also been traced for about 100 feet west of the point where it was first opened, the strike appearing to be very nearly E. and W., and the attitude nearly vertical. Spathose ore near Merigomish.

Whether this deposit should be considered a bed or a vein, is still a matter of uncertainty, but it appears to be comformable with the stratification. Its thickness, where exposed, varies from eleven to fourteen feet. Several attempts had been made to trace it farther westward at the time of my visit, but the pits sunk had failed to penetrate the drift. That this deposit, if found to be persistent, would be of considerable value, may be judged from the following analyses. No. 1 is of a specimen from the outcrop, on Sutherland's Brook, and No. 2, from a costeening pit, about 75 feet farther westward. Size of deposit

	I.	II.
Sesquioxide of iron	16.98	20.52
Carbonate of iron	65.61	57.40
Carbonate of manganese	7.98	8.29
Carbonate of lime	2.67	4.02
Carbonate of magnesia	3.23	5 66
Silica	3.76	2.38
Hygroscopic moisture	.76	1.43
Sulphur	none.	undet.
Phosphorus	.013	"
Organic matter	trace.	none.
	101.003	99.70
Amount of metallic iron	43.56	42.07

Dr. T. Sterry Hunt has kindly furnished me with the following note on these specimens:—

Dr Hunt's opinion on the Spathose ore.

"The iron ores from Merigomish, Nova Scotia, consist of an admixture of red hæmatite and sparry carbonate of iron, with considerable manganese and but little lime, magnesia and silicious matter, and they appear, moreover, from the results of their analysis, to be remarkably free from sulphur and phosphorus. Their composition is such as to make them very readily reducible with a small amount of fuel in the blast furnace, while the presence of manganese, and their comparative freedom from sulphur and phosphorus, should make them peculiarly well fitted for the production of steel, either by puddling or by cementation."

CLAY-IRONSTONE.

Clay-ironstone.

A large number of bands of clay-ironstone were noted during my examination of the Pictou coal-field, but none of a size generally considered workable. Some thirty years ago, however, a cross-cut was driven by the General Mining Association upon the measures underlying the Main seam at the Albion mines, and several beds of ironstone were intersected. No reliable record remains of their size and quality, and the attempts which were then made to smelt them are known to have failed, but whether from mismanagement, or from the poor quality of the ore, is not certain.

At the present day these ores are better understood, and it would seem probable that some of these beds could be worked in connection with one of the seams, and smelted with some of the richer ores of the upper East River.

E. H.

MONTREAL, P.Q., 22nd June, 1870.

II.
20.52
57.40
8.29
4.02
5 66
2.38
1.43
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42.07

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E. H.