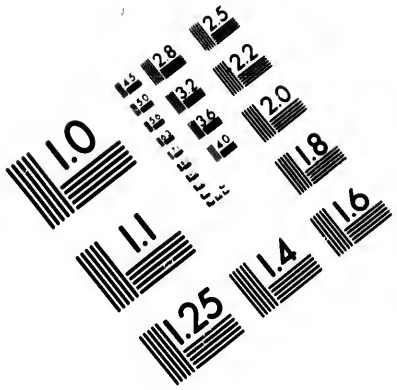

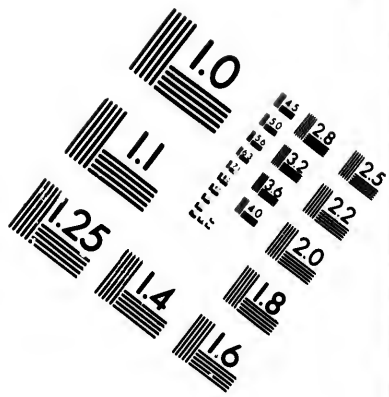

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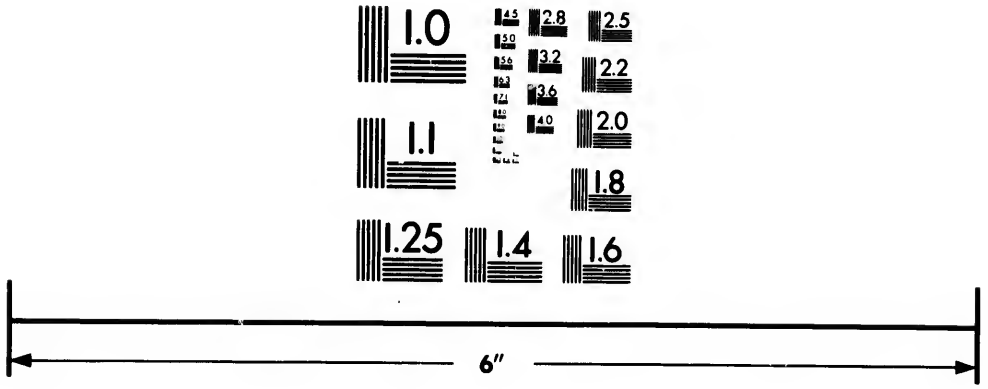

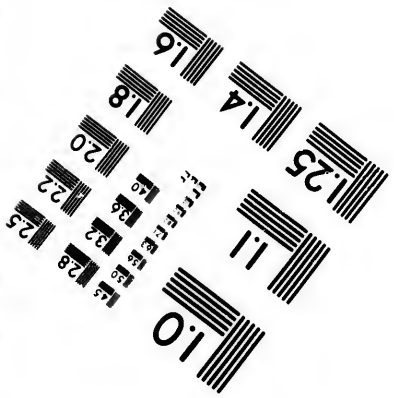

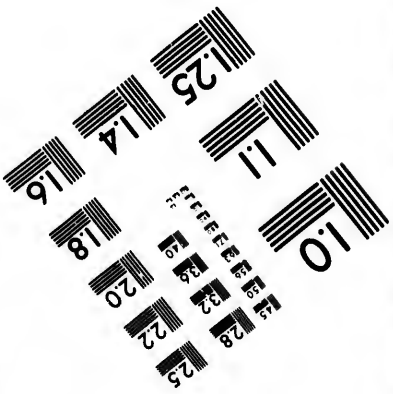

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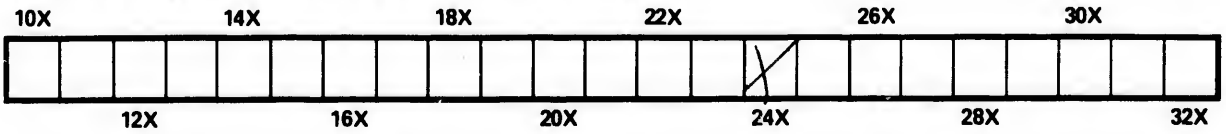

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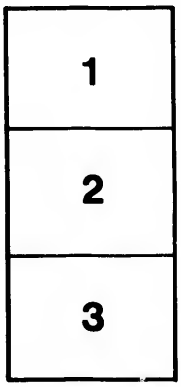

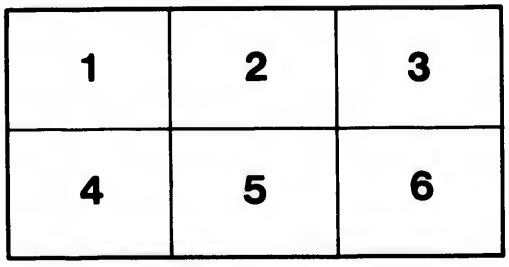

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How

[*Reprinted from the Journal of the Chemical Society, April*, 1874.]

ON TWO COALS FROM CAPE BRETON, THEIR COKES AND ASHES, WITH SOME COMPARATIVE ANALYSES.

By HENRY HOW, D.C.L., Professor of Chemistry, University of King's College, Windsor, Nova Scotia.

SINCE the publication of my report to the Provincial Government on the Mineralogy of Nova Scotia, in 1868, a good many examinations of mineral deposits have been made, and in connection with these, analyses of various sorts have been executed, so that there has been a considerable addition to our knowledge of the minerals of the province. Some results of these inquiries have been published in the "Transactions of the Nova Scotia Institute;" in the Official Reports of the Provincial Inspector of Mines; in late reports of the Geological Survey of Canada; some in "The Coal Fields of Nova Scotia," a comprehensive paper contributed to the Transactions of the North of England Institute of Mining and Mechanical Engineers, by Mr. John Rutherford, in 1870, while Inspector of Mines here; and some in "The Coal Fields and Coal Trade of Cape Breton," by Mr. R. Brown, for many years manager of the Sydney Coal Mines, Cape Breton. It is more particularly in reference to some analyses of mine given in this last valuable historical, scientific, and commercial account of the chief mineral wealth of the Island of Cape Breton, published in London in 1871, that I propose writing upon the present occasion. The results quoted by the author are a summary of the facts of most importance in showing the commercial value of two coals, but there are some details, naturally not dwelt upon in such a connection, which I think are not without

interest both from a scientific and from a practical point of view. The analyses in question were made on the whole thickness of the main seam coal at Sydney Mines, and on that of the Lingan Mine coal. In the latter case, an examination of the coal in sections of the seam, with reference to a known variation in qualities, gave an opportunity of observing—for the first time, I believe, taken advantage of—the difference in the composition of the ash in parts of the same seam of coal.

Cokes.—As regards the Sydney coal, it is a fuel which for more than forty years has enjoyed a very high reputation as a house-coal, while its value as a steam-producer has also been deservedly high since it was first used as such in 1838. A full account of its composition, qualities, and consumption is given by Mr. Brown,* from which I take some of the details of my analysis, viz., these results.

On Coking average Samples of Whole Main Seam of Sydney Coal.

	Medium.	Fast.	Slow.
Total volatile matters.....	34·18	37·48	29·70
Coke (ash 4·32).....	65·82	62·52	70·30
	100·00	100·00	100·00

In all these cases a coherent coke was left, about double the bulk of the coal taken, and they are referred to for the purpose of showing how the amount of coke varies in quantity with the mode of producing it.

Corresponding results were obtained on the Lingan coal. Taking for example, the middle coal, forming about one-third of the whole seam, there were found—

On Coking average Samples of Middle Lingan Coal.

	Medium.	Fast.	Slow.
Total volatile matters.....	30·42	35·16	26·09
Coke (ash 3·47)	69·58	64·84	73·91
	100·00	100·00	100·00

Here, again, in each instance, a firm coherent coke was found, of about twice the volume of the coal; in the last case there was a bituminous odour remaining. When heat was very gradually applied, and finally only very low redness attained, all gases seemed to be expelled, but there was no coke formed, the residue was pulverulent, and the quantitative results were—

* *Coal Fields and Coal Trade of Cape Breton*, p. 78 *et seq.*

By extremely slow heating of Middle Lingan coal—

Volatile.....	21·78
Powdery residue	78·22
	100·00

and no further change, of course, was produced in the appearance of the residue by application of a good heat to the closed crucible.

Similar results are noticed in Hartley's report on the coals and iron ores of Pictou Co., Nova Scotia,* for instance, as regards the coal of the Acadia Seam at the Acadia Colliery, while from 65·12 to 68·70 per cent. of firm coke was obtained by rapid and slow coking respectively, by slow heating a pulverulent mass only remained. Further on, in the same report (page 385) is a statement which does not agree with the foregoing; in describing the coals from different benches of the same (Acadia) seam at another colliery, it is said that the cokes of some "were all strong and light, whether by slow or rapid heating, though of course more compact with a slow carbonisation." On this point, he states, "a still more important consequence of a long-sustained and high heat is the condensation and contraction of the coke into a smaller volume."—(*Dictionary of Arts, &c.*, Am. Ed., 1854, p. 429.)

Ashes.—There are not many published quantitative analyses of coal ashes, although general enumerations of some of their constituents are by no means uncommon. Such analyses as are to be found are not all made on the same plan, and there are some curious discrepancies to which it may be useful to draw attention. The most complete series of quantitative analyses of the ashes of bituminous coals was made by Mr. J. A. Phillips during the Admiralty Coal Inquiry, and they are given in the Appendix to the First Report on Coals suited to the Steam Navy, and in Mr. Phillips's Metallurgy, second edition, p. 136. There is a paper giving a number of analyses of coals from Silesia and Westphalia, by M. Becker (*Revue Scientifique et Industrielle*, 1854, p. 161), at the end of which it is said, "Les cendres n'ont pas été analysées quantitativement; celles des houilles se ressemblent du reste en tout; elles ne renferment pas d'alcalis, mais elles contiennent du sesquioxyde de fer, de l'alumine, de la chaux, de la silice, du soufre et de l'acide sulfurique, du chlore et de la magnésie, et des traces d'acide phosphorique." These constituents agree pretty closely with those recorded by Phillips, and those found by myself in all the cases I have examined; but in Muspratt's Chemistry (vol. II, p. 79), is a table giving the composition of the ashes of six American anthracites, and of one bituminous coal from Quin's Run, Pennsylvania, where there is no mention made of chlorine, sulphuric, or phosphoric acid; the constituents given

* *Geology of Canada, Report of Progress*, 1863–69, pp. 375, 381, 382.

are the rest of those just enumerated from M. Becker's account, and they make up the 100 parts either without "loss," or with a loss never exceeding 1·085.

With respect to sulphuric acid, it has been so generally received as a somewhat abundant constituent of coal-ash, that its absence in the American coals, and especially the bituminous coal, is remarkable. So certain has its presence been considered to be, that in the Coal Inquiry above alluded to, it was, I remember, the practice, in estimating the sulphur in the coal, always to make an allowance according to the accepted average of sulphur as sulphuric acid in the ash, and this I have continued in cases where a determination of the latter has not been made. The variation in amount is sufficiently large to make an experiment desirable in all cases where great accuracy is sought; thus, in Phillips's analyses, the quantity of sulphuric acid in the ashes of seven coals varies from 2·22 to 8·38 per cent., and in the analyses referred to on this occasion in three of ash from coal of parts of one seam, I have found from 3·08 to 6·13, and in the other ash 6·46 per cent. It may be remembered that the fact of the ash containing no more than traces of sulphuric acid was held to be an important fact in support of the non-coal nature of the Torbanehill mineral; and at the Edinburgh trial* on the subject, Professor Anderson stated the amount of this acid he had found in ash of West Wemyss coal as 2·73 per cent., and that in the Methyl coal to be "abundant;" while he himself had detected none in the Torbanite ash. This last was my own experience when a piece from the centre of a lump was selected.

If we turn to lime as a constituent of coal-ash, we find it given in by no means small quantity in all the analyses by Phillips, viz., from 3·7 to 12 per cent., and to the extent of from 0·85 to 5·76 per cent. in the American anthracites before mentioned, but none is stated to have been found in the Quin Run bituminous coal. On looking over the evidence in the Torbanite trial, I find some most curious statements, to which it is worth while to allude. On both sides it was admitted that the amount of lime in the ash of the disputed mineral was quite small, varying from nothing up to 1·3 per cent. in the four analyses given, but it was shown by Professor Anderson, that in the ash of the West Wemyss coal, the amount was 8·46 per cent., and that it was "abundant" in that of the Methil coal; yet one chemist stated that the ash of the mineral (in dispute) resembled the ash of other coals, being a subsilicate of alumina, with peroxide of iron and traces of potash and lime; and another distinguished chemist said he thought there was about as much lime in the ash of the mineral as in that of coals generally, and stated that the quantity of lime in coal is seldom large,

* Gillespie *versus* Russel, Report of Trial, Edinburgh, 1853.

seldom larger than this (in ash of mineral), and repeated that lime is a very trifling ingredient in the ash of all coal.

The following are my results. The Sydney main coal left on complete incineration a residue consisting of red and white portions; the latter were heavier than the former, and were evidently the clay of shale; the former was ferric oxide in part. There was a trace of sulphuretted hydrogen, evolved on addition of hydrochloric acid, and on continued action with aqua regia, a considerable coarsely gritty, reddish residue remained. The filtrate from this gave a little soluble silica. The percentages stand as under:—

Ash of Sydney Main Coal (bituminous).

Sand and clay, ferruginous, and a little soluble silica	29·57
Peroxide of iron	51·33
Alumina	4·84
Lime	7·57
Sulphuric acid	6·46
Magnesia, undetermined Phosphoric acid, decided traces Chlorine, traces Manganese, traces }	0·23
	100·00

The top or roof, middle, and bottom portions of the Lingan seam were examined separately; the ash of the roof was nearly white, the residue left by acid consisting of clay and fine sand; that of the middle was still whiter, and that of the bottom was red, with white specks throughout, the residue left by acids being reddish clay and sand. Having found in the former case that the amount of soluble silica was but small, it was disregarded, and it is, if present below, included in the alumina, as separated by strong alkali from peroxide of iron. The results were these:—

Ash of Lingan Coal (bituminous).

	Top.	Middle.	Bottom.	Whole coal average.
Sand and clay	43·07	79·46	48·62	57·05
Peroxide of iron	35·66	1·57	27·75	21·66
Alumina (and soluble silica?) ..	9·07	6·08	4·91	6·69
Lime	6·13	8·84	11·83	8·93
Sulphuric acid	5·73	3·08	6·52	5·11
Magnesia, undetermined..... Phosphoric acid, decided traces Chlorine, traces ..... }	0·34	0·97	0·37	0·56
	100·00	100·00	100·00	100·00

As regards the coal itself, the following, quoted from Mr. Brown (*loc. cit.*, p. 88), who describes it as a fine gas-coal, are the results corresponding with those given for the Sydney coal.

Average whole Lingan Coal on Coking.

	Medium.	Fast.	Slow.
Total volatile matters	30·03	33·70	25·43
Coke (ash 3·06)	69·97	66·30	74·57
	100·00	100·00	100·00

The only other Nova Scotian coal-ash of which a quantitative analysis has been made, and this is but partially complete, is that of the coal of the deep seam from Cage Pit, Albion Mines, Pictou Co. Qualitatively I found in 1869, a good deal of insoluble siliceous matter, while acid dissolved peroxide of iron, alumina, sulphuric acid, and not a large amount of lime. Mr. Broome observed (*Geology of Canada*, 1863—69, p. 375) 75 per cent. insoluble in hydrochloric acid, and in solution an amount of iron equal to 3·94 per cent. ferric oxide. The coal of the main seam at the same mine, from the Foord Pit, gave me in 1869 much sandy, insoluble matter, and in solution much ferric oxide, and decided quantities of lime and sulphuric acid. The analyses of the coals themselves I made are quoted in Hartley's report before mentioned (*loc. cit.*, 372, 373, 375).

Perhaps it will not be without interest if I give here some other quantitative results on ashes collected from the famous trial before referred to (see *ante*, p. *b*), and another source.

Thus Dr. Maclagan found in

Cannel coal from Balbardie	70	per cent. silica.
„ „ Lesmahagow..	48	„ „
„ „ Capeldrae	53	„ „

The nature of the other constituents is not given.

The ash of torbanite afforded—

SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	MgO.	K_2O.	Na_2O.	SO_3.		
56·09	40·04	3·24	0·34	0·46	none	none	none	=100	T. Anderson.
58·51	34·75	7·00	undet.	undet.	0·84	0·50	—	=101·60	T. Stenhouse.
56·70	36·20	3·20	1·30	0·40	1·20	1·00	traces	=100·00	A. W. Hofmann.
55·15	39·18	FeO 3·90, alum 0·55, CO_2 1·15, moisture 0·07, and traces of SO_3, PO_4, and a little K_2O and Na_2O						=100·00	G. Wilson.

The following interesting analyses are from Wurtz (*Dictionnaire de Chimie*, 1870, Article "Gaz"):—

"Boghead.—On désigne sous ce nom une sorte de schiste bitumineuse qui est employée dans la fabrication du gaz et des huiles d'éclairage. Payen donne pour la composition du Boghead, l'analyse suivante :

Matières bitumineuses et traces de matières azotées..	77·00
Silicate d'alumine.....	20·50
Chaux, magnésie et traces de sulfure de fer.....	1·67
Eau.....	0·83
	100·00

D'après O. Mather, le Boghead renferme:

C.	H.	N.	S.	H_2O.	SiO_2.	Al_2O_3.	Fe_2O_3.	CaO.	
60·85	9·185	0·780	0·320	0·395	13·19	9·50	1·22	0·270	= 100·05 "

and, finally, the residue of distillation of the same for oil for 12 hours contains, according to Wurtz (*Dict.*, p. 639):—

C.	SiO_2.	Al_2O_3.	MgO and CaO.	Fe_2O_3.	
33·00	39·70	26·75	0·15	0·40	= 100·00

It will be observed that there is a decided contrast between the relative amounts of the constituents, and those of undisputed coals, and it may be conveniently noted here, that "almost all the more eminent chemists on the Continent are agreed, that the Torbanhill mineral is a shale" (*Chemical News*, iii, 129).

The substance most analogous in character to Torbanite is, perhaps, the stellarite of New Glasgow, in this province, which I originally described (*Edin. N. Phil. Jnl.*, July, 1860) in 1860, and which has been frequently referred to since (*Mineralogy of Nova Scotia*, p. 24, *et seq.*; also *Trans. N. S. Inst.*, 1868—69), sometimes (*Geology of Canada*, 1863—69, p. 377, *et seq.*) in connection with "oil-coals" resembling it, found in the same district. The ash of the first quality of mineral consists essentially of insoluble sandy clay; acid dissolves a little iron and alumina, little or no lime, traces of sulphuric acid, and some little magnesia. The ash of the second quality is much more abundant, and consists chiefly of sandy clay, but it gives to acid a notable amount of ferric oxide; sulphuric acid and lime are also present in decided quantity. The substance is called by Dawson (*Acadian Geology*, 2nd edition, p. 339) "a fossil swamp-muck or mud," and this he speaks of in another place (*Jour. Geol. Soc.*, xxii, p. 95) as being the nature of earthy bitumens and highly bituminous shales of the coal-formation generally.

An examination of some fire-clays from the neighbourhood of the New Glasgow locality of stellarite, afforded me results quite similar to those from the ash of the mineral; that is to say, besides the sandy clay itself, the soluble portion contained ferrous carbonate, ferric oxide, and alumina, scarcely a trace of lime, a little sulphuric acid, and apparently more magnesia, and this I have very little doubt would be found to be the case with the ash of the "oil coals" of the district generally, except, of course, as to the ferrous carbonate.

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