A CRITICAL STUDY OF SOME INDIAN COAL ASHES.

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In coal, the mineral matter, which gives rise to the ash when the coal is burnt, may be generally classified as inherent and extraneous impurities. The former is derived either from the inorganic salts of vegetation from which the coal was formed or from dust or sludge carried and deposited by wind and rain. The latter represents partings, bands or nodules of pyrite, shale and calcite, etc. In consequence, the coal ash consists mainly of silicates, sulphates, phosphates, alumina, lime, magnesia, oxide of iron and alkalies. It also contains traces of Cobalt, Nickel, Silver, Barium, Zinc, Lead, Cadmium and rare elements.[1]

From the commercial and industrial point of view, the quantity, composition and the fusibility of ash in coal are of considerable importance. It is an imperative necessity both for the metallurgist and the fuel-engineers to be well conversant with the characteristics of fuels that are going to be consumed either for metallurgical operations (such as blast-furnace or foundry) or for boilers and gas-producers. When selecting coke for the blast-furnace or the foundry, it is of considerable importance for the metallurgist to consider the ash-content and the composition of the ash of the coke along with other important properties of coke such as porosity, hardness, combustibility and uniformity of the size, etc. The serious disadvantage which is met with in the blast-furnace operation due to the high ash-content in coke is well known. The high ash-content naturally diminishes the calorific value of the coke and further it necessitates the addition of lime to flux the ash and to liquefy it into slag, a certain amount of more fuel is required besides the increased blast, steam and time, etc.

Again the percentage of ash-content is not the only factor involved in the evaluation of the suitability of the coal for fuel purposes. For the efficiency of the boilers and gas-producers, the fusibility of ash plays an important rôle. The lower the fusion-temperature of the coal-ash, the greater is the tendency to form clinkers on the fuel-bed in the case of boilers and gas-producers. The formation of clinkers on the fuel-bed is detrimental for the following reasons:—

(I) Firstly, combustible matter becomes enclosed within the molten 'ash' which excludes air from it and the coal so enclosed passes away into the ash-pan and is thus wasted.

(II) Secondly, inefficient combustion takes place since the clinkers prevent the induction of air through the fuel-bed.

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[1] Goldschmidt, V. M., *Ind. and Eng. Chemistry*, 27, 1100, (1935).

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(III) Thirdly, the coal-ash may attack the refractory materials of the furnace and also cause excessive damage to the fire-bars.

(IV) Fourthly, the clinkers necessitate further labour cost for cleaning the furnace.

From what has been said, it is clear that a thorough study on the composition and fusibility of ash is of vital importance for determining the factors in connection with the question of fuel-economy in the Iron and Steel Industry and in boiler plants.

The object of this paper is to present the results of investigations carried out on the composition of ash on the following lines:—

(I) Firstly, the chemical composition and the fusibility of ash obtained by burning coal at 950°C.

(II) Secondly, the chemical composition of ash obtained by burning coal at different temperatures. (750°C., 850°C. and 950°C.).

Though comprehensive studies have been made on the physical and chemical properties of Indian coals, the work done on the composition of ashes has been very limited. The *Memoirs* and the *Records of the Geological Survey of India*[1] furnish some valuable information regarding the composition of coal-ashes. Recently Mazumder [2] has studied the chemical composition of ashes of 49 different samples of coal from various parts of India but he has not dealt with the fusibility of ash.

THE CHEMICAL COMPOSITION AND THE FUSIBILITY OF ASH.

The ash in coal is considered to be a deleterious ingredient since it is an anti-calorific substance which does not produce heat but actually absorbs heat in attaining the temperature of the fire. The composition of the ash varies widely from seam to seam and the variation in the composition may sometimes occur along a particular seam. 20 samples of coals have been selected for the investigation and the area from which they have been collected are as shown below:—

Jharia field	9
Raneegunge field	9
Salt Range	1
Assam coal	1
	20

1 Fox, C. S., The Natural History of Indian Coal, *Mem. G.S.I.*, Vol. LVII, pp. 148–150, (1931).

Fox, C. S., The Lower Gondwana Coalfields of India, *Mem. G.S.I.*, Vol. LIX, pp. 65–67, 127, 146, (1934).

Gee, E. R., The Geology and Coal resources of Raniganj Coalfield, *Mem. G.S.I.*, Vol. LXI, pp. 265-266, (1932).

2 Mazumder, J., *Fuel*, Vol. XVII, 8, p. 230, (1938).

The proximate analyses and the colours of the ashes of the respective samples are shown in Table I. The analyses of ashes, which were obtained by burning coals at 950°C. in an electric muffle, have been performed according to the standard methods [1] and the results are recorded in Table II.

From Table I, it will be evident that the colour of the ashes varies from white to buff and it is rather interesting to find out if any relation exists between the colour and the chemical composition of the ashes. The buff and reddish colour in ash is generally due to the presence of iron-pyrites and manganese. Generally speaking, the colour of the ashes of coals from the Jharia field varies from white to grey while that from the Raneegunge field varies from drab-grey to buff. This striking variation in colour of the ashes of the two series of coals cannot be fully explained by the difference of the iron and manganese contents. Hence it is rather difficult to warrant the laying down of any definite relationship between the colour of the ash and its chemical composition.

The chemical composition of ashes (Table II) reveals the fact that in general there exists no marked difference between the mineral contents of the coals of the Jharia field and the Raneegunge field. The chemical composition of two Tertiary coals (one from the Salt Range and the other from Assam) differs markedly from those of the Jharia field or the Raneegunge field. These contain a high percentage of SO_3 while P_2O_5 and MnO are conspicuous by their insignificant amounts. This variation in composition of the ashes of Tertiary coals and of Gondwana coals of Jharia and Raneegunge fields is of considerable importance to stimulate speculations regarding the formation and origin of Tertiary coals.

Having studied the chemical composition of ashes, it is of special importance to make investigations on the fusibility of ashes. It has already been stated that the behaviour of ashes on melting is an important factor for the calculation of efficiency of the boiler plants or gas-producers. Various mehods have been recommended for the determination of the fusion point of ash from time to time, by different investigators. The methods often employed consist in moulding the ash into the form of seger-cones with some suitable material and testing them in furnaces. The temperature at which the tip of the cone touches the base of the supporting material is regarded as the fusion-temperature.

La Chatelier and Chantetre [2] and Cobb [3] found out the fusion-points of ashes by making balls from the ashes and heating them in furnaces. Marks [4] and Rickets [5] determined the fusion-point by using the seger-cone method. Later

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[1] Mellor, J. W.—A Treatise on Quantitative Inorganic Analysis, (1938).
Washington, H. S.—Chemical Analysis of Rocks, (1930).
Hillebrand and Lundell—Applied Inorganic Analysis, (1929).

[2] Bulletin Soc. d'encour., p. 273, (1902).

[3] *J. Soc. Chem. Ind.*, p. 11, (1904).

[4] *J. Am. Soc. Chem. Eng.*, p. 205, (1915).

[5] *Ibid.*, p. 213, (1915).

TABLE I.

			Seam.	Moisture %.	V.M. %.	Ash %.	F.C. %.	S. %.	C. Index.	Colour of ash.
Bhagatdih ..	Jharia field	Barakar Series	11 seam Sec. B	0·80	24·42	15·08	59·70	0·56	18	Grey.
Ena ..	,,	,,	11 seam bottom.	1·30	24·62	14·42	59·66	0·43	17	,,
Kustore ..	,,	,,	12 and 13 seams	0·82	21·06	15·32	62·80	0·54	16	Cream.
Kustore ..	,,	,,	13 seam ..	0·62	22·80	16·28	60·30	0·68	17	,,
Gopalichak ..	,,	,,	14 ,, ..	0·60	24·32	13·70	61·38	0·54	14	Grey.
Malkera ..	,,	,,	15 ,, ..	0·90	23·60	13·80	61·70	0·57	14	White.
Sijua ..	,,	,,	16 ,, ..	0·80	24·76	18·10	56·34	0·54	18	Grey.
Jamadoba ..	,,	,,	17 ,, ..	1·45	28·30	10·10	60·15	0·44	16	,,
Jamadoba ..	,,	,,	18 ,, ..	1·76	28·56	14·30	55·38	0·47	14	Pinkish white
Victoria West ..	Raneegunge field.	,,	Top Ramnagar	1·40	23·10	12·84	62·66	0·43	16	Salmon buff.
Seetalpur ..	,,	Raneegunge Series.	Dishergarh seam.	2·00	35·40	13·27	49·33	0·23	12	Drab grey.
Aldihi ..	,,	,,	,,	2·00	38·20	11·82	47·98	0·28	11	,,
Dishergarh ..	,,	,,	,,	2·60	36·50	11·15	49·75	0·24	13	Light buff.
Nega ..	,,	,,	,,	2·50	38·63	10·24	48·63	0·28	10	,,
Murulidih ..	,,	,,	Mohuda bottom. ..	2·38	30·20	12·72	54·70	0·32	12	Drab grey.
Saltor ..	,,	,,	Dishergarh seam.	2·30	37·80	14·34	45·56	0·30	11	Light buff.
Shripur ..	,,	,,	Poniati ..	2·00	37·92	10·10	49·98	0·28	11	Pinkish buff.
Charanpur ..	,,	,,	,,	4·60	34·12	7·31	53·97	0·35	10	,,
Makerwal Colliery (Simpson's Mine).	Salt Range	....	Makerwal ..	3·04	43·43	9·24	44·29	5·65	..	Ecru drab.
Assam Coal (Mawbel Karas).	....	....	....	0·98	43·06	4·76	51·20	3·08	..	Pinkish buff.

on, Sinnat and his co-workers [1] developed a method in which coal-ash was pressed through a circular orifice to form ash-rods and the fusion-points of these ash-rods were noted. Fieldner, Hall and Field [2] made classical researches on the various factors that are responsible for the accurate determination of the fusion-point. Of the various factors, the most important is the nature of the atmosphere in which the ash is heated. In expressing the fusion-point, the oxidising or the reducing zone of the furnace used must be definitely stated. The other important factors on which the fusion-point depends are the following:—

(*a*) the rate of temperature-increase in the furnace;
(*b*) fineness of ash.

Recently Bunte and Baum,[3] and King, Blackie and Millot[4] have introduced some modified methods for the determination of fusion-points.

The method employed here is as follows:—

The ash is finely powdered in an agate-mortar—moistened with a solution of dextin and moulded into small triangular pyramids. These are then allowed to dry in air and are then vertically mounted on a refractory base along with the seger-cones. The air and gas entering the furnace are adjusted for regulating the atmosphere as well as the increase in temperature in the furnace. The atmosphere surrounding the ash-cones consists approximately of equal parts of oxidising and reducing gases. The rise of temperature per minute is not allowed to be more than ten degrees centigrade. The temperature is carefully noted when the apex of the cone begins to bend by optical pyrometers and this is then compared with the seger-cones used. Thus an accurate fusion-point is obtained. The fusion-points of ashes along with their chemical composition are recorded in Table II.

From the results it is evident that, generally speaking, two broad generalisations can be drawn:—

(I) Firstly, the fusion-points of ashes from the Jharia field are higher than those from the Raneegunge field and tertiary coals.

(II) Secondly, the fusion-points of the ashes of tertiary coals are comparatively lower than those of Jharia and Raneegunge fields.

The relationship between the fusibility and the chemical composition of ashes seems not to be of a definite character. The main constituents of ash are silica, alumina and iron-oxide with small percentages of other constituents such as lime, magnesia, alkalies, etc. As is well known, of these alumina has got the highest melting point, *i.e.* 1775°C. and silica has a melting point of 1685°C. If alumina and silica are present alone, in the proportion in which

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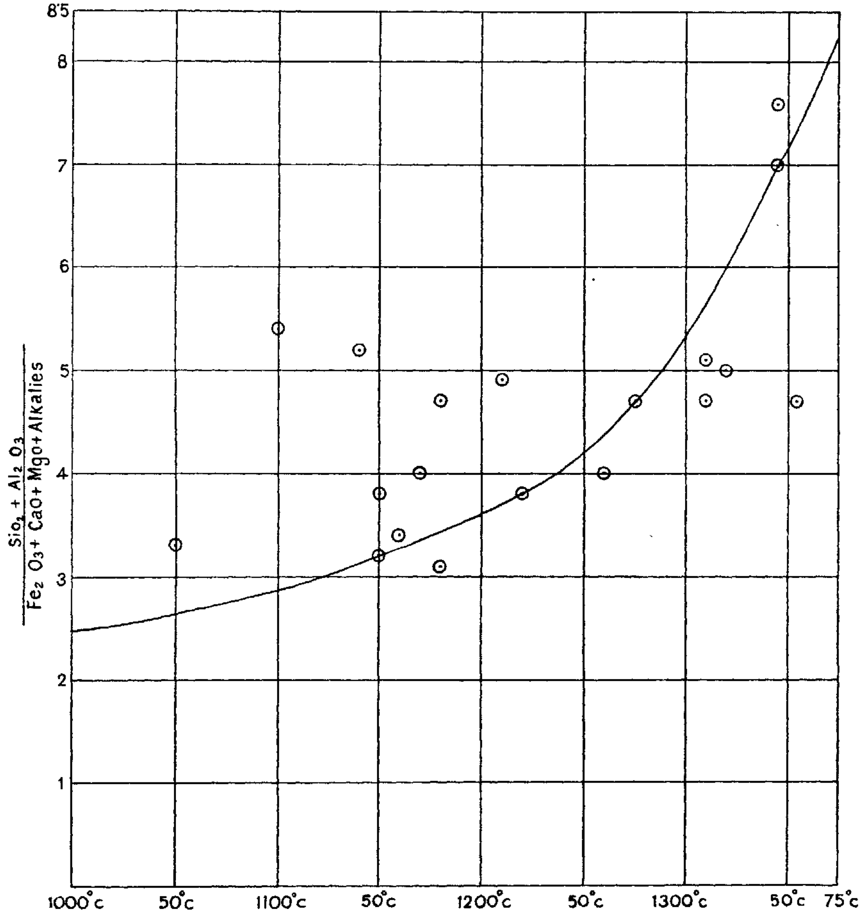
[1] *J. Soc. Chem. Ind.*, 42, p. 267T–272T, (1923).
[2] *U.S. Bur. of Mines Bull.*, 129, (1918).
[3] *Gas und Wasserfach.*, 97, p. 125, (1928).
[4] *Fuel Research Technical paper* 23.

TABLE II.

	Seam.	SiO_2 %.	Al_2O_3 %.	Fe_2O_3 %.	TiO_2 %.	P_2O_5 %.	MnO %.	CaO %.	MgO %.	SO_3 %.	K_2O %.	Na_2O %.	Total	Ratio $\frac{SiO_2+Al_2O_3}{Fe_2O_3+CaO+MgO+Alkalies}$.	Fusion-point of ash.
Jharia field.															
Bhagatdih ..	11 sec. B ..	50·64	20·73	9·88	1·52	1·87	0·23	2·36	1·16	1·03	0·46	0·30	100·18	5·04	1320°C.
Ena ..	11 bottom 9′ Sec.	49·74	30·71	8·43	1·42	1·32	0·32	4·56	2·02	0·80	0·43	0·20	99·95	5·14	1310°C.
Kustore ..	12 & 13 seams	62·64	22·15	9·20	1·42	1·20	0·02	2·10	0·34	0·30	0·54	0·49	100·40	7·00	1340°C.
Kustore ..	13	48·34	28·12	13·80	1·50	2·36	0·32	3·20	1·08	0·66	0·46	0·60	100·54	4·00	1260°C.
Gopalichak ..	14	53·02	26·68	11·88	1·60	1·30	0·20	3·06	1·38	0·68	0·48	0·34	100·62	4·70	1355°C.
Malkera ..	15	57·60	29·20	7·20	1·32	0·53	0·12	0·82	2·50	0·48	0·58	0·30	100·65	7·60	1345°C.
Sijua ..	16	57·61	22·54	10·10	1·52	1·20	0·64	2·58	2·68	0·25	1·48	0·30	100·90	4·70	1310°C.
Jamadoba ..	17	48·24	28·22	9·73	1·42	2·30	0·15	6·30	3·10	0·42	0·42	0·34	100·64	3·84	1220°C.
Jamadoba ..	18	56·72	30·42	5·65	1·44	1·86	0·20	1·83	1·04	0·52	0·32	0·30	100·10	9·50	1380°C.
Victoria West ..	Top Ramnagar	49·40	31·48	9·20	1·20	2·30	0·13	4·22	1·60	1·10	0·80	0·60	100·03	4·93	1210°C.
Raneegunge field.															
Charanpur ..	Poniati	55·72	27·50	9·18	1·14	0·23	Trace	2·51	2·53	0·97	0·78	0·40	100·96	5·40	1100°C.
Seetalpur ..	Dishergarh	51·36	23·24	11·18	1·30	1·68	0·04	6·00	4·30	0·48	0·40	0·30	100·28	3·40	1160°C.
Aldihi ..	,,	48·12	30·68	7·80	0·68	1·28	0·64	8·40	2·36	0·32	0·46	0·23	100·97	4·04	1170°C.
Dishergarh ..	,,	49·00	27·63	8·26	0·60	1·52	0·40	8·62	3·45	0·48	0·48	0·30	100·74	3·80	1150°C.
Shripur ..	,,	51·84	28·98	7·42	1·12	1·08	0·38	5·72	2·46	0·62	0·64	0·39	100·65	4·70	1180°C.
Saltor ..	,,	54·18	27·42	7·20	0·70	1·68	Trace	6·32	1·42	0·52	0·42	0·26	100·12	5·22	1140°C.
Nega ..	....	46·74	27·38	10·43	1·20	1·24	0·20	8·45	2·86	0·54	0·63	0·42	100·09	3·26	1150°C.
Muruldih ..	Mohuda bottom	52·18	27·84	7·80	1·15	0·73	0·48	5·20	2·30	0·50	1·06	0·68	99·92	4·69	1290°C.
Salt Range.															
Simpson ..	Makerwal ..	48·00	20·72	15·58	Trace	Trace	Trace	4·26	1·45	9·10	0·42	0·77	100·30	3·05	1180°C.
Assam.															
Mawbelkaras ..	....	43·04	31·40	17·89	1·38	,,	,,	1·50	1·60	2·52	1·01	0·25	100·59	3·33	1050°C.

they occur, there is practically no chance of their melting at the fuel-bed of the boilers or the gas-producers. The other components such as iron-oxide, lime, magnesia and alkalies have the effect of a flux upon alumina and silica present and thus reduce the fusion-point of ash. The fusion point generally varies according to the ratio between the acidic components and the bases

$$\frac{SiO_2+Al_2O_3}{Fe_2O_3+CaO+MgO+Alkalies}.$$



Fusion Temperature.

Mean Curve showing the relation between $\frac{SiO_2+Al_2O_3}{Fe_2O_3+CaO+MgO+Alkalies}$ and the Fusion temperature.

From Table II it will be observed that this ratio varies from 9·50 to 3·05. Broadly speaking, the greater the ratio, the higher is the fusion-point.

The mean curve plotted against the ratio of $SiO_2+Al_2O_3$ to $Fe_2O_3+CaO+MgO+$Alkalies and the fusion temperature of the ashes affords consistency to the above generalisations but still the departure from the mean curve cannot be overlooked. Although it is not possible to draw some definite relation between the fusibility and the chemical composition of the ashes due to their complexities, the results however permit some reliable duductions to be drawn.

(I) Ferric oxide, which varies from 7 to 18%, has a fluxing effect which increases almost directly to the percentage composition.

(II) Lime, which varies from 0·8 to 8%, has a similar fluxing effect but the combined fluxing effect of iron-oxides and lime has a complex relation to the percentages of the two fluxes present.

(III) Magnesia, which varies from 0·3 to 4% has a greater fluxing effect than lime.

(IV) The alkalies are present in small amounts but their fluxing effect, in presence of comparatively high percentage of lime, is quite appreciable.

(V) The ratio of silica to alumina ranges from 2·82 to 1·38 and the fusion-point generally increases with this ratio but below 1·4 it has a marked effect in decreasing the fusion-point.

The function of temperature on the composition of ash.

The methods, prevalent for the determination of ash-content in coal, generally consist in burning the coal at temperatures between 750°C. and 1000°C.

TABLE III.

Coal.		Temperature at which coal burnt off.		
		750°C. Ash%.	850°C. Ash%.	950°C. Ash%.
1. Bhagatdih ..	Jharia field ..	15·48	15·32	15·08
2. Ena ..	,, ..	14·68	14·57	14·42
3. Kustore	,, ..	16·71	16·62	16·28
4. Gopalichak ..	,, ..	13·98	13·78	13·70
5. Kustore	,, ..	15·42	15·18	15·32
6. Malkera	,, ..	14·08	13·78	13·80
7. Sijua	,, ..	18·40	18·20	18·10
8. Jamadoba ..	,, ..	10·40	10·28	10·10
9. Jamadoba ..	,, ..	14·72	14·58	14·30
10. Victoria West ..	,, ..	12·91	12·80	12·84
11. Charanpur ..	Raneegunge field	7·80	7·62	7·31
12. Seetalpur ..	,, ..	13·60	13·40	13·27
13. Aldihi	,, ..	12·00	11·92	11·82
14. Shripur	,, ..	10·42	10·32	10·10
15. Dishergarh ..	,, ..	11·28	11·00	11·15
16. Nega	,, ..	10·40	10·32	10·24
17. Saltor	,, ..	14·60	14·30	14·34
18. Muruldih ..	,, ..	12·93	12·58	12·72
19. Makerwal seam (Simpson Mine).	Salt Range ..	9·98	9·61	9·24
20. Assam Coal ..	....	5·01	4·88	4·76

While expressing the results of the ash-content, the particular temperature at which the coal is burnt is not usually mentioned. Therefore it seems worth while to study the function of temperature on the ash-content as well as its subsequent effect on the composition of the ash.

For this purpose, three definite temperatures have been selected and the respective ashes of coals are obtained at these selected temperatures. The results are shown in the Table III.

From the results it will be seen that the ash-content generally diminishes with rise in temperature and the variation in ash-contents at the selective temperatures, *i.e.* (750°C., 850°C. and 950°C.), ranges from 0·40 to 0·18% in the case of coals from the Jharia and Raneegunge fields while in the case of two tertiary coals (Salt Range and Assam coals) the range lies between 0·74 and 0·25. In view of these results, it will be well to attach due consideration to the effect of temperature to the ash-content. The decrease in the ash-content with the rise of temperature may be attributed to the loss sustained by the volatilisation of sulphur and alkalies.

For co-ordinating the effect of temperature on the ash-content on the one hand and on the composition of ash on the other hand, a special study has been made of the chemical composition of ashes obtained at different temperatures and the results are recorded in Table IV.

From the results the following conclusions may be drawn:—

(I) The variation of silica and alumina contents lies within a very narrow limit.

(II) Phosphorus, Titanium and Manganese contents remain practically constant.

(III) Ferric oxide and lime contents increase with the higher temperature.

(IV) Sulphates and alkalies generally diminish at the higher temperatures.

Summary and Conclusion.

1. Twenty coals from important areas have been investigated as to the composition, distribution and fusibility of ash.

2. No definite relation between the chemical composition and the fusibility of ash could be found. From the ratio of

$$\frac{SiO_2+Al_2O_3}{Fe_2O_3+CaO+MgO+\text{Alkalies}}$$

it was found that, generally speaking, the higher the ratio the higher was the fusion temperature.

3. From a study of the fusion-point of ash, it is possible to predict the suitability of coals for use in boilers and gas-producers without the formation of clinkers on the fuel-bed.

4. The function of temperature in the determination of ash-content as well as its effect on the chemical composition has been studied.

TABLE IV.

		Temperature at which ash was made.	SiO_2 %.	Al_2O_3 %.	Fe_2O_3 %.	FeO %.	TiO_2 %.	P_2O_5 %.	MnO %.	CaO %.	MgO %.	SO_3 %.	K_2O %.	Na_2O %.	Total.
Kustore ..	12 and 13 seams	750°C.	62·52	22·12	8·64	0·21	1·40	1·06	0·02	1·91	0·35	0·53	0·58	0·68	100·02
		850°C.	62·68	22·13	8·82	0·16	1·40	1·10	0·02	1·78	0·34	0·32	0·56	0·59	100·10
		950°C.	62·64	22·15	9·20	..	1·42	1·20	0·02	2·10	0·34	0·30	0·54	0·49	100·40
Malkera ..	15 seam ..	750°C.	57·52	28·86	7·00	0·28	1·30	0·50	0·12	0·82	2·20	0·52	0·58	0·32	100·02
		850°C.	57·44	29·00	7·20	0·10	1·30	0·53	0·12	0·82	2·50	0·50	0·56	0·30	100·37
		950°C.	57·60	29·20	7·20	..	1·32	0·53	0·12	0·82	2·50	0·48	0·58	0·30	100·65
Sijua ..	16 seam ..	750°C.	57·20	22·72	9·10	0·28	1·52	1·16	0·65	2·20	2·58	0·45	1·60	0·50	99·96
		850°C.	57·52	22·74	9·60	0·14	1·55	1·15	0·65	2·43	2·68	0·28	1·58	0·42	100·74
		950°C.	57·61	22·54	10·10	..	1·52	1·20	0·64	2·58	2·68	0·25	1·48	0·30	100·90
Jamadoba ..	17 seam ..	750°C.	47·60	28·00	9·08	0·42	1·32	2·30	0·14	6·50	3·10	0·52	0·44	0·36	99·78
		850°C.	48·02	27·89	9·45	0·18	1·40	2·28	0·15	6·30	3·10	0·50	0·40	0·36	100·03
		950°C.	48·24	28·22	9·73	..	1·42	2·30	0·15	6·30	3·10	0·42	0·42	0·34	100·64
Victoria West Top Ramnagar	....	750°C.	49·00	30·80	8·70	0·21	1·20	2·10	0·13	3·96	1·60	1·76	0·80	0·60	99·86
		850°C.	49·10	30·76	8·83	0·12	1·20	2·30	0·13	4·20	1·53	1·72	0·78	0·60	100·31
		950°C.	49·40	31·48	9·20	..	1·20	2·30	0·13	4·22	1·60	1·10	0·80	0·60	100·03
Charanpur ..	Poniati seam ..	750°C.	55·16	27·41	8·80	0·26	1·16	0·22	Trace	2·20	2·63	1·12	0·80	0·44	100·20
		850°C.	55·46	27·01	9·00	0·18	1·14	0·22	,,	2·43	2·43	1·08	0·82	0·42	100·19
		950°C.	55·72	27·50	9·18	..	1·14	0·23	,,	2·51	2·53	0·97	0·78	0·40	100·96
Seetalpur ..	Dishergarh ,, ..	750°C.	51·00	23·16	10·80	0·26	1·30	1·52	0·04	5·89	4·30	0·56	0·56	0·32	99·71
		850°C.	51·18	23·20	11·00	0·12	1·30	1·58	0·04	5·92	4·20	0·52	0·52	0·32	99·90
		950°C.	51·36	23·24	11·18	..	1·30	1·68	0·04	6·00	4·30	0·48	0·40	0·30	100·28
Aldihi ..	,,	750°C.	47·66	30·10	7·51	0·24	0·62	1·26	0·58	8·01	2·34	0·66	0·56	0·30	99·84
		850°C.	47·83	30·65	7·24	0·18	0·64	1·27	0·62	8·20	2·36	0·41	0·56	0·26	100·22
		950°C.	48·12	30·68	7·80	..	0·68	1·28	0·64	8·40	2·36	0·32	0·46	0·23	100·97
Simpson Mine ..	Makerwal seam (Salt Range).	750°C.	47·48	19·70	14·80	0·46	Trace	Trace	Trace	4·00	1·46	10·82	0·43	0·82	99·97
		850°C.	47·62	20·10	15·10	0·21	,,	,,	,,	4·18	1·44	10·20	0·40	0·76	100·01
		950°C.	48·00	20·72	15·58	..	,,	,,	,,	4·26	1·45	9·10	0·42	0·77	100·30
Assam Coal ..	Mawbelkaras ..	750°C.	42·88	30·73	17·01	0·28	1·38	,,	,,	1·48	1·62	3·06	1·12	0·28	99·84
		850°C.	42·95	31·03	17·62	0·21	1·40	,,	,,	1·44	1·64	2·85	1·20	0·30	100·64
		950°C.	43·04	31·40	17·89	..	1·38	,,	,,	1·50	1·60	2·52	1·01	0·25	100·59