THEORETICAL CONSIDERATIONS ON THE VALUE OF COAL PETROGRAPHY IN COKE STUDIES OF CHIRMIRI COAL (M.P.), INDIA

S. K. BABU* AND A. R. CAMERON**

INTRODUCTION

THIS short communication describes a simplified application of coal petrography, whereby the reflectance measurements can be used to estimate and evaluate the coke strength. Several theoretically calculated stabilities of the coals of Chirmiri with blends of American coals are presented as examples of the value of petrography in estimating coke strength. Also, in combination with chemical analysis, the reflectance can be used to determine the degree of coalification and coal blend proportion. This simple technique of reflectance measurements, where applicable, is quite rapid and inexpensive, and provides a practical quality control to the coke-oven operator.

It is not intended to present a review of the developments and recent trends in the science of coal petrography. A chronological development and the present status of coal petrography has been summarized and reviewed in the articles by Harrison[1] and Marshall.[2]

The petrographic evaluation of coal by reflectance studies is based on the knowledge that coal is a heterogeneous substance composed of macerals, each of which has distinct physical properties for a specific rank of coal.

The various types of macerals composing the coal can be grouped into two major categories, namely, (*i*) the reactives and (*ii*) the non-reactives or inerts. The reactive components, which always contain most of the volatiles, are the vitrinoids, exinoids, resinoids and semi-fusinoids. Of these, the vitrinoids are present in greatest abundance in most coals. These reactives, during carbonization, pass through a fluid or plastic phase, and ultimately solidify to form the main mass of the coke cell-walls. Each type of vitrinoid material yields a carbonization product possessing a different strength. The non-reactives or inerts are comprised of fusinoids, micrinoids and mineral matter. The micrinoids and fusinoids are always low in volatiles and higher in carbon than the reactive components. They remain largely inert or unchanged during carbonization, and are incorporated by the reactives into the coke mass.

* Department of Geology and Geophysics, Organic Sediments Laboratory, The Pennsylvania State University.

** Coal Research Section, Geological Survey of Canada.

The studies of Ammosov,[3] Schapiro and Gray,[4] Harrison,[5] and Gin and Dahl[6] are based on the basic assumption that for each rank of coal, there is an optimum ratio of the reactive to inert macerals that will yield the strongest coke. Hence the petrographic work consists in determining this ratio for various ranks of coal, and devising a method of proportionately combining the data of individual coals to arrive at the weighted value for any coal blend.

The various types of vitrinoid materials are identified petrographically, by measuring the amount of vertical incident light reflected from polished surfaces. For this a Leitz Ortholux microscope is used, that is equipped with the necessary accessories for reflected light observations, and a Photovolt model 520 M photometer of which the sensing element is attached to the monocular tube of the microscope. The determination can be done quickly and with great precision and lends itself to the possibility of automating the analytical procedure. The various types of vitrinoids can be provisionally differentiated into types by assigning a reflectance range of 0·1% to each type. For example, if a vitrinoid material exhibits a reflectance of 0·60–0·69% it is classed as V_6 and if a vitrinoid material exhibits a reflectance of 0·70–0·79% it is classed as V_7, etc. Thus the types of vitrinoids based on reflectance values range from V_1 to V_{18} (Schapiro and Gray[4]). Low volatile coals usually contain concentrations of V_{13} up to V_{19}, while the medium volatile ones generally have concentrations of V_{10}, V_{11}, V_{12}. High volatile coals are characterized by an abundance of V_7, V_8, V_9. The reflectivity of the vitrinoid material is closely correlated to its volatile matter content.

All commercial coals contain several vitrinoid types, and each of these require an optimum amount of inert material in order to produce coke of maximum strength. Hence, it is important to know the effect of various amounts of inert on each vitrinoid type before coke strength can be calculated from coal composition. From the data provided by petrographic analyses of any coking coal sample, it is possible to calculate the strength of the coke that may be produced from it. The procedures for calculating the coke strength or stability, using the strength index and composition balance

TABLE I

	Entity Composition Vol. Pct.														Stability Factor		
	Reactive Entities									Inert Entities							
	V_4	V_5	V_6	V_7	V_8	E	R	S.F.	Total	F	M	M.M	S.F.	Total	Strength index	Composition balance Index	Calculated stability
Seam No. 4, (India)	0·62	6·12	11·44	5·56	1·25	22·16	0·80	5·33	53·28	23·36	8·60	4·10	10·66	46·72	0·77	3·52	0·00
Seam No. 2, (India)	1·73	13·08	25·77	11·75	1·06	18·28	1·20	2·63	75·50	10·87	4·09	4·28	5·26	24·50	1·86	1·37	0·00

COMPOSITION OF THE COALS TRIED FOR BLENDS
(Taken from Schapico *et al.*[6])

	V_8	V_9	V_{10}	V_{11}	V_{12}	V_{13}	E	R	S.F.	Total	F	M	M.M.	S.F.	Total			
Sewell, (M.V.) (U.S.A.)	0·00	0·00	2·80	40·80	24·8	0·70	6·00	0·10	1·20	76·40	9·80	10·20	11·30	2·30	23·60	4·41	1·07	61
Pittsburgh (H.V.) (U.S.A.)	0·70	35·90	32·40	1·40	0·0	0·00	5·90	0·90	0·80	78·00	4·10	11·90	4·30	1·70	22·00	3·66	0·72	48

Theoretically calculated stability of seams Nos. 4 and 2 with Sewell and Pittsburgh

BLENDS:

Seam No. 4 : Sewell (M. V.) (½ : 1)	3·60	1·64	40
Seam No. 2 : Sewell (M. V.) (½ : 1)	3·50	1·21	43
Seam No. 4 : Pittsburgh (H. V,) (½ : 1)	3·10	1·20	37
Seam No. 2 : Pittsburgh (H. V.) (½ : 1)	3·10	0·90	46

Abbreviation for entities : V_4–V_{13} Vitrinoids ; E—Exinoid; R—Resinoid; S.F—Semifusinoid ; F—Fusinoid; M—Micrinoid ; M.M.—Mineral Matter; M.V.—Medium Volatile; H.V—High Volatile.

index are fully described by Schapiro, Gray and Eusner.[6]

The petrography of seams Nos. 4 and 2 collected from Chirmiri colliery has been described by Babu and Dutcher,[7] in an earlier publication. The two seams were investigated in accordance with the technique previously described and with the purpose of determining their most suitable utilization.

PROCEDURE

Representative samples from seam No. 4 and seam No. 2 of Chirmiri were crushed to — 20 mesh, mixed with an epoxy resin binder, briquetted into 1 inch diameter samples, and polished to a relatively scratch-free surface. They were examined at 600 magnification using an oil immersion objective. The maximum reflectance value of 75 (scratch-free and contaminant-free) vitrinoid grains was measured and averaged. The average value is considered as the "reflectance" rank of the coal. Coal maceral determinations were made on the same pellets, and along with reflectance data are the only petrographic information required for the calculation of the optimum ratio index, the strength index and the stability. This information is presented in Table I.

The above investigations are singnificant because of the nature of these coals, which are classed as "selected grade" (11–13% ash ; and 6,800–7,000 cals./gm.) according to the coal grade classification employed in India. They explain why these high rank bituminous coals are non-coking by themselves and provide information on how a good quality coke may be obtained by their proper blending.

The reflectance studies have shown that both coals are non-coking, because they do not have the required V_9, V_{10}, etc., types of vitrinoid to induce fluidity during the coking process. Besides, the inert ratio of seam No. 4 which is calculated from the reflectance types and maceral data, exceeds the optimum ratio by 2·5 times. Seam No. 2 in this respect, is satisfactory because it has the permissible amount or inerts. However, it is suggested that the excess of inerts in No. 4 seam can probably be reduced by screening and mechanical size reduction.

In Table I it is shown that it is petrographically possible to produce suitable cokes from the No. 2 and No. 4 coals by proper blending with medium volatile coals. Calculations show that a ½ to 1 blend of No. 4 or 2 coal with "Sewell" or "Pittsburgh" coal of the U.S.A. can produce a coke with a stability of 37–46. Since reflectance data along the lines described in this paper are at present not available on Indian coals, it was not possible to make calculations on blends using Indian medium volatile coals. Hence calculations were tried with some American coals, like the "Sewell" and "Pittsburgh" coals.

In conclusion it is suggested that detailed petrographic studies of Indian coals along the lines described above, and followed in the U.S.A. and U.S.S.R., may prove an invaluable criterion in evaluating the coking characteristics of the various Indian coals.

The authors thank Dr. Russell R. Dutcher of the Penn. State University for his valuable suggestions during the course of the work, and Dr. P. Hacquebard, Head of the Coal Section of the Geological Survey of Canada, for going through the manuscript and constructive criticisms.

1. Harrison, J. A., "Coal petrography applied to coking problems," *Proc. Illinois Min. Inst.*, 1961, p. 17.
2. Marshall, E. C., "Coal petrography," *Economic Geol.*, 50th Anniversary Vol., Pt. II, 1955, p. 757.
3. Ammosov, I. L. and Ermin, I. V. *et al.*, "Calculation of coking charges on the basis of petrographic characteristics of coke," *Koks i Khimiya*, 1957, No. 12, p. 9.
4. Schapiro, N. and Cray, R. J., "Petrographic classification applicable to coals of all ranks," *Proc. Illinois Min. Inst.*, 1960, p. 83.
5. Gin, T. T. and Dahl, C. L. *et al.*, *Petrographic Evaluation of Coking Coals*, Regional Tech. Meeting of American Iron and Steel Inst., 1963, p. 1.
6. Schapiro, N., Gray, R. J. and Eusner, G., "Recent developments in coal petrography," *AIME Blast Furnace, Coke Oven and Raw Materials Proc.*, 1961, p. 89.
7. Babu, S. K. and Dutcher, R. R., "Petrological investigations of the two Gondwana coal seams from Madhya Pradesh, India," *Curr. Sci.*, 1964, 33 (15), 457.

ANOTHER NEW PARTICLE?

THE experimental observation on the 2π decay of the K meson reported by Fitch *et al.* of Princeton (*Physical Review Letters*, 1964, No. 13) contradicts the *CP* rule for particle reaction and has led to the postulate of a fifth natural force (see *Curr. Sci.*, 1965, 34, 133). In a recent communication to *Physics Letters* [1965, 14, (2), 131], H. J. Lipkin and A. Abashian of Illinois suggest a possible explanation for the $K \rightarrow 2\pi$ decay which does not violate the *CP* rule. The explanation assumes the existence of a new particle, another K° meson which is degenerate in mass with the ordinary K°.

The experimental observations involved are the following: According to an earlier observation of Leipuner *et al.* (*Physical Review*, 1963, 132, 2285), Decay rate $K^\circ \rightarrow 2\pi$/(Decay rate charged K° 2) $= 0 \cdot 06$, for 1 GeV/c. K° at 8 ft. from target, while according to the Princeton group this branching ratio is $0 \cdot 002$, for 1 GeV/c. K° at 60 ft. from target. The large difference between the two decay rates is not easily interpreted if both results are due to *CP* violation or a new external field.

A natural explanation attributes the observed 2π decay to a neutral particle different from K°_1 and K°_2 and having a different lifetime from either of the two. Lipkin and Abashian estimate this lifetime as 7×10^{-9} sec., and account for the observed difference above to the exponential decay between 8 ft. and 60 ft.

An alternative assumption, the authors point out, is that this neutral particle is almost exactly degenerate with K° and anti-K°, and mixes with them in the decay process. The best test of this hypothesis seems to be further measurements of the long-lived $K \rightarrow 2\pi$ decay at different distances from the target.—[*Physics Letters*, 1965, 14 (2), 151.]