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PETROLOGICAL AND ELECTRICAL CONDUCTIVITY CHARACTERS OF COALS, AFFECTED BY IGNEOUS INTRUSIVES AROUND PATHARDIH, IN JHARIA COALFIELD, DHANBAD DISTRICT, INDIA

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ABSTRACT

Three coal seams affected by mica-lamprophyre dikes and sills are studied. Samples from the coal seams at the actual contacts of the intrusives with the coal and at increasing distances from the contact are subjected to proximate chemical analysis and petrological studies including reflectance measurements. It is found that the affected coals undergo a progressive increase in rank as these approach the contact with the igneous intrusives. Electrical conductivity measurements of these samples show that seams intruded by a sill show maximum conductivity with the "most affected coal," nearest to the intrusive, whereas in the case of seams intruded by a dike, the maximum conductivity is found with "partially affected coal," at some distance from the contact with the intrusive. The "unaffected coal" shows minimum conductivity in each case. Electrical conductivity also varies widely, in the affected and partially affected coals, in three directions at right angles to one another. This variation in conductivity in the coals affected is ascribed to greater compaction, in a particular direction, induced by the intrusives on these coals.

INTRODUCTION

THE area investigated is around Pathardih (Lat. 23°35′N–23°45′N:Long. 86°23′E–86°30′E), which lies in the south eastern part of the Jharia Coalfield, Dhanbad district in Bihar. Here the coal measures occurring in Barkar formations have been extensively affected by igneous intrusions. Intrusive bodies here are mica-lamprophyres only. These intrusions have rendered a large quantity of coal worthless or completely useless to mine, as in most cases the coal has been converted to jhama, i.e., natural coke and thus the intrusions are very destructive.

GENERAL CHARACTERS

These intrusions, instead of forming sheet like sills and caking a few feet of coal seam in a regular manner, are commonly in the form of arterial or vein like sills and do not always keep to one horizon in a coal seam. The result is that in places the whole seam is rendered useless by these anastomizing root-like occurrences of mica-peridotites—each with its sheath of caked coal. It is believed that the mica-peridotite was erupted in a molten condition and there is no doubt that the coal was caked by the highly heated injected material. The mica-peridotite has invariably followed faults as channels of escape when occurring as dikes but it keeps steadily to the bedding planes of the strata when present as sills.

Where the intrusive is a dike, the first apparent change in the seam is the development of innumerable fine cleat-like fractures, which make the coal much more tender and friable than normal. Within a short distance, as the intrusive is approached, suddenly the coal becomes massive and compact without retaining any trace of original lamination or jointing, the luster of the normal coal is also totally destroyed. Actually this change from normal coal is somewhat abrupt and presents rather a break. Nearer to a dike the coal becomes harder and tougher, until at the actual contact with the intrusive it is almost a hard rock.

Intrusion of a sill into a seam of coal tends to be very destructive and commonly renders the seam completely worthless. This is probably due to the fact that a sill is in contact with a much larger area of the seam, being concordant.

COLLECTION OF SAMPLES

For the purpose of this study on the effects of igneous intrusive on coal, samples were collected systematically from the actual contact of the coal and the intrusive and then at regular intervals away from the contact. Three coal seams namely Jharia XVI A from Amlabad Colliery, Jharia XVIII from Hurriladih Colliery and 100-foot seam of Rorabandh area from Bright Tarsa Colliery, which have been affected by the mica-lamprophyre intrusions were investigated. Samples thus collected were subjected to proximate (chemical) analysis and petrological analysis. Special attention was given to the measurement of reflectivity and electrical conductivity of these samples. The results and discussions follow hereafter.

PROXIMATE ANALYSIS

The proximate analysis was carried out on carefully controlled conditions as per standard methods (1). The results are given in Tables IA–C.

Results of Proximate Analysis:

Table IA

SEAM NO. XVI A — AMLABAD COLLIERY

Distances From Contact of Intrusive and Coal	Moisture Percentage (as received basis)	Ash Percentage	Volatile Matter Percentage	Fixed Carbon Percentage	Caking Character
At the contact	0.7	24.9	19.6	54.8	Non-caking
2 ft. from contact	1.0	21.5	23.7	53.8	Non-caking
4 ft. from contact	1.0	19.8	25.9	53.3	Weakly-caking
6 ft. from contact	1.1	17.6	27.9	53.4	Good-caking

Table IB

SEAM NO. XVIII HURRILADIH COLLIERY

Distance From Contact of Intrusive and Coal	Moisture Percentage (as received basis)	Ash Percentage	Volatile Matter Percentage	Fixed Carbon Percentage	Caking Character
At contact	0.7	25.7	19.3	54.3	Non-caking
18 in. from contact	0.9	23.9	22.7	52.5	Non-caking
5 ft. from contact	1.3	20.9	26.6	51.2	Good-caking
7 ft. 6 in. from contact	1.4	17.1	28.8	50.7	Good-caking

Table IC

SEAM NO. 100 FEET SEAM OF RORABANDH AREA BRIGHT TASRA COLLIERY

Distance From Contact of Intrusive and Coal	Moisture Percentage (as received basis)	Ash Percentage	Volatile Matter Percentage	Fixed Carbon Percentage	Caking Character
At the contact	0.8	38.2	13.6	47.4	Non-caking
1 ft. from contact	1.2	37.0	14.9	46.9	Non-caking
2 ft. from contact	0.8	35.3	17.6	46.3	Non-caking
3 ft. from contact	1.0	32.5	19.7	46.8	Weakly-caking
4 ft. from contact	1.2	29.6	22.5	46.7	Moderately caking
5 ft. from contact	1.0	29.0	24.5	45.5	Good-caking

From the proximate analyses it is seen that the proximity to the igneous intrusive brings about a considerable reduction in the volatile matter content, a gradual increase in the fixed carbon content and a consequent increase in rank of the coal. The coal which is normally good caking has also gradually lost its caking properties due to effect of the igneous intrusive.

PETROLOGY

The samples of coal from the contact with the intrusive and away from it were studied under a Leitz coal petrological microscope. Polished blocks of each of the samples were examined under oil-immersion objectives at 250 magnification.

In the "most affected coal" at the contact with the intrusive the maceral vitrinite is not discernible at all. Its place is taken largely by rounded dark areas with bright white patches in between. The latter ingredients have a high reflectivity comparable to fusinite and impure graphite.

The "partially affected coal" (occurring at 1 to 3 feet from contact) the vitrinite bands, which are well developed in "unaffected coal," are much less conspicuous. Vitrinite observed has a higher reflectance. There is a predominance of a streaky white ingredient with higher reflectance than vitrinite and these closely resemble semi-fusinite.

The "unaffected coal" (occurring generally beyond 4 ft. from contact) shows broad and thin bands of vitrinite with intermediate bands of exinite. Vitrinite is the main maceral with subordinate exinite and a little fusinite and semi-fusinite. The vitrinite here shows moderate reflectance.

A quantitative petrological (maceral) analysis on the basis of three main group macerals (3, 4) viz. vitrinite, exinite and inertinite was undertaken and is given in Tables IIA–C. The increase in the values of inertinite with consequent decrease in the values of vitrinite and exinite in coals affected by the intrusive is indicative of thermal metamorphic effect in these coals.

Results of Quantitative Petrological Analysis:

Table IIA

SEAM NO. XVI A — AMLABAD COLLIERY

Distance From Contact of Intrusive and Coal	Vitrinite Percentage	Inertinite Percentage	Exinite Percentage	Visible Mineral Matter Percentage
Contact with sill	12.3	77.5	6.1	4.1
2 ft. from contact	29.7	54.3	10.1	5.9
4 ft. from contact	48.6	39.8	7.2	4.4
6 ft. from contact	66.7	20.0	9.1	4.2

Table IIB

SEAM NO. XVIII — HURRILADIH COLLIERY

Distance From Contact of Intrusive and Coal	Vitrinite Percentage	Inertinite Percentage	Exinite Percentage	Visible Mineral Matter Percentage
Contact with sill	11.3	78.9	5.1	4.7
1 ft. 6 in. from contact	25.7	59.9	9.4	5.0
5 ft. from contact	39.8	40.1	10.2	9.9
7 ft. 6 in. from contact	50.6	24.7	13.8	10.9

Table IIC

SEAM NO. 100 FEET SEAM OF ROHRABANDH AREA — BRIGHT TASRA COLLIERY

Distance From Contact of Intrusive and Coal	Vitrinite Percentage	Inertinite Percentage	Exinite Percentage	Visible Mineral Matter Percentage
Contact with sill	30.9	53.5	9.4	6.2
1 ft. from contact	33.9	45.7	11.2	9.2
2 ft. from contact	38.0	41.2	10.1	10.7
3 ft. from contact	44.5	9.3	12.1	14.1
4 ft. from contact	50.2	25.5	12.3	12.0
5 ft. from contact	53.2	23.1	12.3	11.4

REFLECTIVITY

The reflectance measurements were carried out by Berek Slit Microphotometer fitted to a Leitz MOP microscope, using a Leitz green filter with a maximum transmission at 5,300 Å. The observations and calculations for reflectance values were done under standard methods of Seyler, described by

Results of reflectivity measurements:

Table IIIA

SEAM NO. XVI A — AMLABAD COLLIERY

Distance From Contact of Intrusive and Coal	Average Reflectivity of Major Ingredient in Oil (R_o)			Approximate to Seyler's Component (N_R)		
				a	b	c
Contact with sill	a. 4.27	b. 4.10	c. 3.50	9	9	8
9″ from contact	a. 3.22	b. 3.20		8	8	
1 ft. 6 in. from contact	a. 3.10	b. 2.56		8	7	
2 ft. 7 in. from contact	a. 1.65	b. 1.66	c. 1.20	6	6	5
4 ft. from contact	a. 1.20	b. 1.20		5	5	

Table IIIB

SEAM NO. XVIII — HURRILADIH COLLIERY

Distance From Contact of Intrusive and Coal	Average Reflectivity of Major Ingredient in Oil (R_o)			Approximate to Seyler's Component (N_R)		
				a	b	c
Contact with dike	a. 4.20	b. 4.16	c. 3.19	9	9	8
1 ft. from dike	a. 3.20	b. 3.21	c. 2.26	8	8	7
2 ft. from dike	a. 2.30	b. 2.28	c. 1.65	7	7	6
3 ft. from dike	a. 1.28	b. 1.26		5	5	
4 ft. from dike	a. 1.26	b. 1.25	c. 0.92	5	5	4

Table IIIC

SEAM NO. 100 FEET SEAM OF ROHRABANDH AREA — BRIGHT TASRA COLLIERY

Distance From Contact of Intrusive and Coal	Average Reflectivity of Major Ingredient in Oil (R_o)			Approximate to Seyler's Component (N_R)		
				a	b	c
Contact with sill	a. 4.21	b. 3.18	c. 3.20	9	8	8
1 ft. from contact	a. 3.15	b. 3.14	c. 2.60	8	8	7
2 ft. from contact	a. 2.27	b. 1.65		7	6	
3 ft. from contact	a. 1.65	b. 1.25	c. 0.94	6	5	4
4 ft. from contact	a. 1.31	b. 1.27		5	5	
5 ft. from contact	a. 1.31	b. 0.92		5	4	

Mukherjee (2). Some of the samples exhibited anisotropism and therefore the maximum value of reflectance for each component only was taken. Results of reflectivity measurements on major ingredients of the samples examined are given in Tables IIIA–C.

The major ingredients in the "most affected coal" give mainly reflectance values that closely agree with Seyler's N_R 9 and N_R 8 (5, 6, 2). The "partially affected coal" is characterized by components that give values of reflectance very near to Seyler's N_R 7 with subordinate components giving reflectivity of N_R 6. In the "unaffected coal" the components give reflectivity values of Seyler's N_R 5 and in a few cases that of N_R 4. These values of reflectance in "most affected," "partially affected" and "unaffected" coals indicate clearly that the intrusive induces thermal metamorphic effect with consequent carbonization and increase in rank of the affected coals.

ELECTRICAL CONDUCTIVITY

For the purpose of the electrical conductivity measurements rectangular blocks ($2 \times 1 \times 0.5$ cm) were prepared from the samples of "most affected," "partially affected" and "unaffected" portions of the coal. The resistivity of each of the samples so prepared was measured in three directions—at right angles to one another—indicated by AA, BB and CC, by a resistance bridge using two plates connecting the samples between two ends of the block. For each sample the electrodes were held to the block at a constant pressure and the conductivity was calculated from the resistivity, using the usual formula. The results of these measurements are in Tables IVA–C.

It is evident from the above results that the conductivity of the "unaffected coal" is the least in each case. In the case of a seam intruded by a sill the maximum conductivity is shown by the "most affected coal" whereas the "partially affected coal" shows much less conductivity. Where a seam is intruded by a dike the "partially affected coal" gives a higher conductivity value than that of the "most affected coal." It is however found that coals affected by sill intrusion give a very high conductivity value for the "most affected coal" than those of the "partially affected coal" and the "unaffected coal." But this difference in the conductivity values for the three categories of samples is much less evident when a coal seam is intruded by a dike.

It follows therefore that the "unaffected coal," which is furthest from the igneous intrusive and had the least or no effect from it, behaves almost as a non-conductor, which is the usual characteristic of a normal bituminous coal. Increase in the electrical conductivity in the samples, other than the "unaffected coals" may be due to two factors—compaction and natural carbonization—to which the coals have been exposed due to the pressure exerted by the intrusion of the mica-lamprophyre and its attendant high temperature at the time of intrusion. The higher value of conductivity of the "most affected coal" than the "partially affected coal" can be explained if it is assumed that the compaction due to pressure was the dominating factor rather than the natural carbonization in the case of coal seams intruded by a sill. Whereas the

Results of Electrical Conductivity Measurements :

Table IVA.

SEAM NO. XVI A — AMLABAD COLLIERY

Sample Collected From	AA (Ohm-CM)	AA (Mho/Metre)	BB (Ohm-CM)	BB (Mho/Metre)	CC (Ohm-CM)	CC (Mho/Metre)
Contact with sill	16.8	5.953	29.7	3.3	11.35	8.7
1' ft. from the sill	6.4×10^3	.01563	6.7×10^3	.014	2.38×10^3	0.042
2' ft. from the sill	52×10^3	.001923	20×10^3	.005	7.75×10^3	0.01
3' ft. from the sill	2000×10^3	.00005	700×10^3	.0001	225×10^3	.00045
4' ft. from the sill	20×10^6	.000005	5.6×10^6	.00002	3.5×10^6	.00003

Table IVB

SEAM NO. XVIII — HURRILADIH COLLIERY

Sample Collected From	AA (Ohm-CM)	AA (Mho/Metre)	BB (Ohm-CM)	BB (Mho/Metre)	CC (Ohm-CM)	CC (Mho/Metre)
Contact with dyke	880×10^3	.00011	1×10^6	.0001	$.425 \times 10^6$	.0023
1' ft. from the dyke	920	.1086	445	.22	$.25 \times 10^3$	.4
2' ft. from the dyke	1200×10^3	.000083	610×10^3	.0002	247.5×10^3	.0004
3' ft. from the dyke	2640×10^3	.000037	1×10^6	.0001	$.25 \times 10^6$	.0004
4' ft. from the dyke	4×10^6	.000025	1×10^6	.0001	$.475 \times 10^6$	.0002

Table IVC

SEAM NO. 100' FEET SEAM OF ROHRABANDH — BRIGHT TASRA COLLIERY

Sample Collected From	AA (Ohm-CM)	AA (Mho/Metre)	BB (Ohm-CM)	BB (Mho/Metre)	CC (Ohm-CM)	CC (Mho/Metre)
Contact with sill	17.6	5.681	4.6	21.7	1.8	55.5
1' ft. from the sill	40×10^3	.0025	70×10^3	.0014	62.5×10^3	.002
2' ft. from the sill	800×10^3	.000125	300×10^3	.0003	100×10^3	.001
3' ft. from the sill	1.6×10^6	.0000625	5×10^6	.00002	1.5×10^6	.00007

greater conductivity of the "partially affected coal" in a seam intruded by a dike can be ascribed to the natural process of carbonization. Due to the greater proximity of the "most affected coal" to the actual intrusive, it develops fine cracks and a semi-porous character. The porosity and the presence of fine cracks in the "most affected coal," in this case, have made it less conductive than the "partially affected coal." These postulations also follow from the fact that the room problem for the intruding mica-lamprophyre is greater where it intrudes as a sill than where it appears as a dike. From the field studies it is seen that the dikes invariably follow fault planes (the zones of weakness) whereas the sills have a comparatively harder passage along the bedding planes. Consequently the coals must have been subjected to greater compaction while the mica lamprophyre intruded as a sill.

The above facts are also borne out well from the results of conductivity when measured in three directions at right angles to one another viz. AA, BB, and CC, which vary widely in the coals showing profound effect of the igneous intrusive, due to greater compaction in a particular direction induced by the intrusive.

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