

## Evaluation of coal bed methane potential of Chalkari and Phusro areas of East Bokaro Coalfield

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### Summary

Cleat mapping and integrated laboratory studies of selected coal samples from a corehole/ coal mines in Chalkari and Phusro areas of East Bokaro Coalfield were carried out to find coalbed methane prospectively of the area. A total of 35 coal seams with individual seam thickness in the range of 0.2-16m were observed. The coals in general have low moisture content (0.6-2.8%) and moderate ash content (35.28-8.22%). With increasing depth dry ash-free volatile matter (daf) has been found to decrease but there is no relationship between ash content and depth. The vitrinite reflectance (VRo) (0.85 – 1.7%) and coal rank (High volatile bituminous ‘A’ to low volatile bituminous) have been found to increase with depth. Vitrinite is the dominant coal maceral which varies from 41.93% to 65.83%. Cleat and fracture data were collected from coal mines indicate face cleats orientated in NNE-NS and butt cleats orientated in E-W direction. Cleat spacing varies from 3-15 cm for face cleats and 7-25 cm for butt cleats in coal seams exposed in mines. Gas data indicates that gas content of coal seams vary from 3.17 to 11.74 cc/g and increases with depth. The gas saturation in the range of 32-84% and gas content also follows the same trend. Present studies reveal that the coal seams of Chalkari and Phusro areas of East Bokaro Coalfield are prospective for development of coalbed methane.

### Introduction

The East Bokaro coalfield forms a part of Damodar valley coal fields situated in Bokaro and Hazaribagh districts of Jharkhand state. The East Bokaro coalfield is a spindle shaped basin covering an area of 237 sqkm and forms eastern half of the Bokaro Basin (Figure 1). The study area Chalkari and Phusro encompasses an area of 11 sq.km located in south-eastern most part of East Bokaro Coalfield.

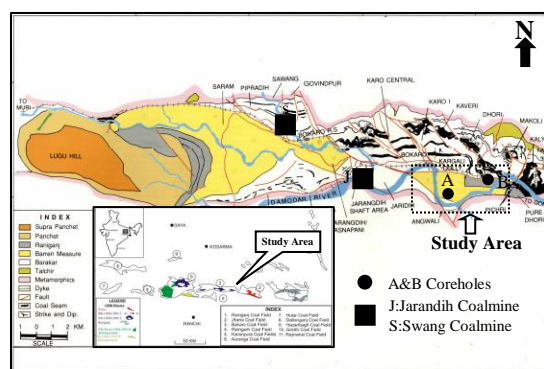


Figure 1: Geological map of East Bokaro coalfield showing location of study area, coreholes and mines (Modified after CIL, 1993)

### Geological Setting

The East Bokaro coal field exhibits complete succession of Gondwana sediments starting from Talchir to Mahadeva Formation, of which Raniganj, Barren Measures, Barakar and Karharbari formations are coal bearing. Major part of the field is occupied by Barakar Formation while the Barren Measures crops out all along the axial region of the field. Raniganj and Panchat strata are exposed mainly along the flanks of Lugu Hills, which is capped by youngest Mahadeva Formation. Structurally, East Bokaro coal field is an elongated westerly plunging syncline with closure at eastern part of the basin. The western part exhibits an ideal graben bounded by two boundary faults in the south and north (Mitra, 1987). Barakar Formation which is the chief contributor of coal contains 21 coal seams with a cumulative thickness of 105 – 150 m. The Barakar coal seams can be grouped as Jarandih, Swang, Kathara, Uchitdih, Kargali, Bemo and Karo. The rank of coal increases with towards east as well as with depth.

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**Methodology**

Following studies have been carried out:

- Study of coal disposition – Field studies, collection of coal samples from corehole and Jarandih and Swang coal mines.
- Integration of CBM specific data available in the form of report (Ghosh and Pandit, 2013)
- Cleat characterization – Measurement of cleats orientation, spacing in outcrops and coal mines. Cleat characterization at micro level by using Scanning Electron Microscope (SEM).
- Proximate Analysis, maceral studies, VRo measurements, desorption and adsorption studies as per standard procedure.

**Results and Discussion**

Selected coal core samples from corehole-A and coal samples collected from Jharandih and Swang coal mines have been investigated to evaluate CBM potential of Chalkari and Phusro areas. A total of 35 coals seams with individual seam thickness in the range of 0.2-16m have been encountered in the corehole; out of which 10 seams are local, 5 seams in Jharandih, 3 seams in Swang, 2 seams in Kathara, 4 seams in Uchitdih, 1 seam in kargali 3 seams in Bermio and 4 seams in Karo. The cumulative thickness of coal seam is up to 110m. In corehole-B drilled in eastern most part of study area, where in no Barakar coal seam was encountered due to faulting. Generally the coals are black, moderately hard, compact and brittle falling in durain –clarain lithotype.

Coal cleats develop as a result of coalification processes. Cleat and fracture orientations are indicative of tectonic stress regime present during coal deposition (Olson and Pollard, 1989 and Kulander and Dean, 1993). In this study cleats are described at macro (cm) meso (mm) and micro (mm) scales. The macro scale cleat measurements, cleat spacing, distribution, and azimuth direction of coal seams were carried out in outcrops, Jharandih and Swang coal mines. The measurements are given in Table -1 and rose diagram in Figure 3: c- d. The spacing of face cleats ranges between 3 cm and 15

cm in coal seams. Butt cleats tend to be less well developed and exhibit a less regular spacing

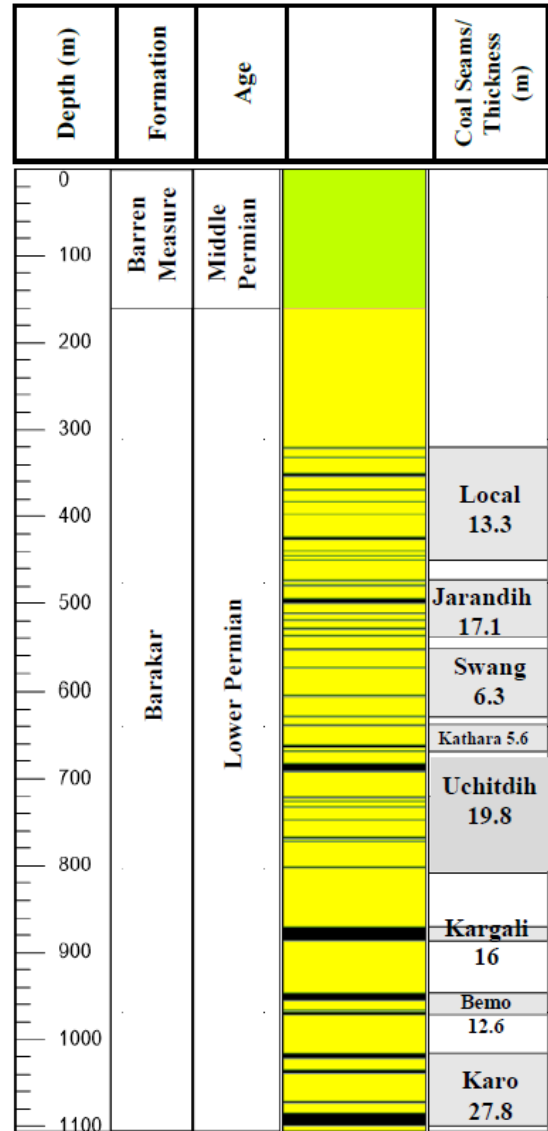


Figure 2: Lithostratigraphic column of corehole-A

(7-25 cm). The average azimuth direction of face cleats is 5° and the average azimuth direction for butt cleats is 95°.

At meso scale, face cleat spacing is in the range of 0.2-0.5 cm and butt cleats spacing 0.3-0.6cm have been observed in individual lithotype in cores (Figure 3b). For microcleat analysis, vitrinite-rich layers in

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coal were selected from coal seams because cleats tend to be developed more prominently along vitrinite intercalations. The vitrinite rich coal samples from Jharandih, Swang, Kathara, Uchitdih and Kargali coal seams were studied under SEM for micro-cleat disposition, aperture type, mineral in-filling etc. Coal samples of seams showed face cleats with spacing of 0.5-2mm with mostly open aperture varying from 5-21 $\mu$ m. Butt cleats aperture varies from 3-5 $\mu$ m and occasionally tight (Figure 4). No secondary mineral fillings were observed in all studied samples.

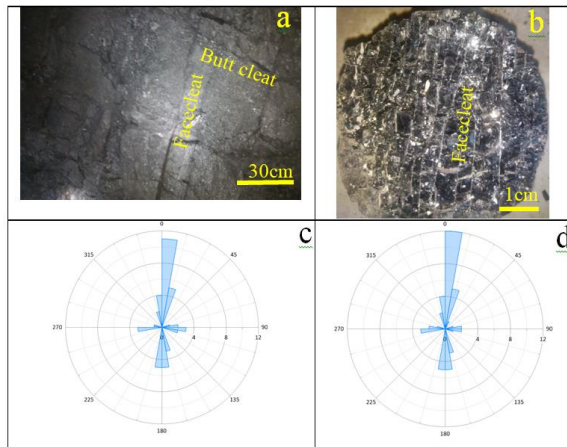


Figure 3a: Face cleats traversing the entire thickness of a Jarandih coal seam in Jarandih coal mine. b: Core from Swang coal seam shows well developed face and butt cleats with face cleat spacing 0.2-0.5cm. c: Rose diagram showing face and butt cleat orientation in Jarandih mine. d: R Rose diagram showing face and butt cleat orientation in Swang mine

With increasing depth face cleats appear to be tight possibly as a result increase in overburden and thermal maturation.

Proximate analysis data are given in Table-2. From the study it was seen that moisture content varies from 0.5 to 2.03%, decreasing with depth. Volatile matter on daf basis varies from 16.20 to 37.74%, decreasing with depth of seam burial. Ash content varies from 14.60 to 35.28%. The ash content of coals follows no regular trend, but appears to depend in part on the local geology of the particular coal seam.

The maceral composition data on mineral matter free (mmf) basis of coal seams is given in Table 2. The

study reveal that coals seems in shallow depth is rich in vitrinite macerals (60.6-65.83%) but with increasing depth the vitrinite macerals (41.93-43.20%) decreases with increase in inertinite (55.90-57.17%) content. The measured vitrinite reflectance (VRo%) is in the range of 0.85-1.7% and increases with burial depth of coal seams (Figure 5). The VRo value indicates high volatile bituminous-A to low volatile bituminous rank.

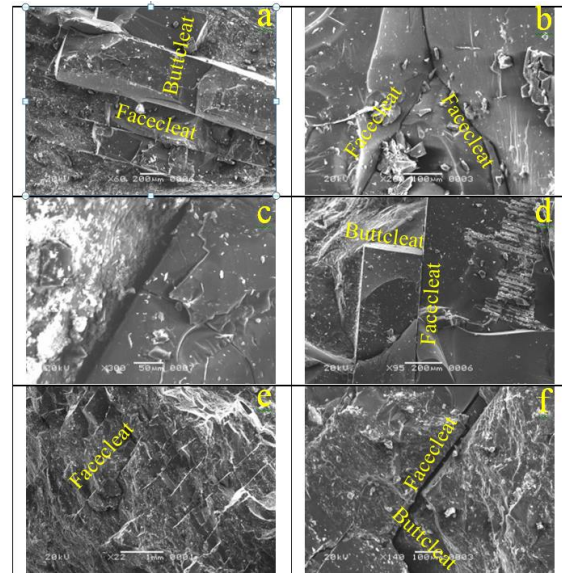


Figure 4a: Well developed face cleat in Jarandih seam with cleat spacing of 0.4-0.7 mm in Jarandih seam. b: Face cleats abutting against each other and face cleat aperture 7-11 $\mu$ m in Jarandih seam. c: Swang seam showing face cleat with aperture of of 17 $\mu$ m. d: Uchitdih seam showing well developed face and butt cleats. Face cleat aperture 8-12 $\mu$ m. e: Well developed face cleats with cleat spacing 0.4-0.8mm and poorly developed butt cleats in Kargali seam. f: Kargali seam showing face cleat with open aperture 5-7 $\mu$ m.

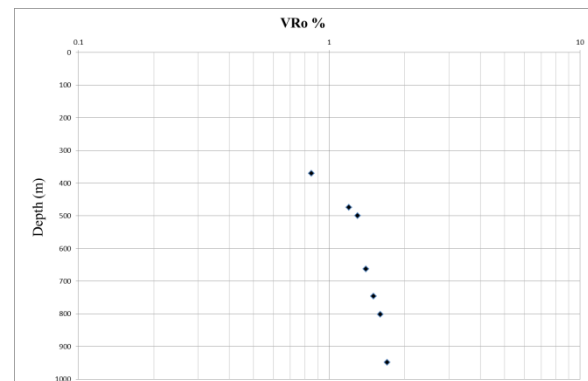


Figure 5: Variation of vitrinite reflectance (VRo) with depth

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Coal Mine	Face cleats			Butt cleats		
	No of measurements	Cleat Spacing (cm)	Azimuth (deg)	No of measurements	Cleat Spacing (cm)	Azimuth (deg)
Jarandih	35	3-12	350-20 165-190	13	8-22	80-110 270-290
Swang	38	3-15	350-30 165-190	11	7-25	80-110 260-290

Table 1: Measured face and butt cleats spacing and directions Jarandih and Swang mines

Sl.	Coal Seams Disposition			Proximate Analysis					Maceral Studies				Gas Content daf (cc/g)	Gas saturation (%)
	Coal Seam	Interval (m)	Coal Thickness (m)	No of Analysis	Moisture (wt %)	Ash (wt %)	Volatile Matter daf (wt %)	Coal Rank	Vitrinite mmf (vol %)	Inertinite mmf (vol %)	Lipnite mmf (vol %)	VRo %		
1	Local	320.4-450	13.3	8	0.6-2.08	16.10-35.28	24.20-35.74	HVBA-MVB	64.17	35	0.83	0.85	3.17-4.76	32-61
2	Jarandih	473-538	17.1	11	0.5-1.57	16.10-32.41	22.7-29.20	MVB	61.49	37.76	0.75	1.2	4.01-9.97	32-77
3	Swang	552-629	6.3	6	0.9-2	8.36-14.39	22.3-27.34	MVB	65.83	33.44	0.73	1.3	6.09	42
4	Kathara	638-669	5.6	3	0.9-1.2	14.60-24.98	19.4-24.36	MVB-LVB	60.6	38.66	0.74	1.4	5.72-11.74	41-84
5	Uchitdih	720.5-808.8	19.8	4	0.8-1.69	8.22-20.10	19.0-23.85	MVB-LVB	62.05	37.23	0.72	1.5	6.78-10.83	48-77
6	Kargali	870-886	16	1	0.85	19.10	20.84	LVB	43.2	55.9	0.9	1.6	Nd	Nd
7	Bemo	947-971.8	12.6	5	0.98-0.7	17.38-34.00	16.20-18.50	LVB	41.93	57.17	0.9	1.7	11.40	59-80

Table 2: Geochemical data of coal seams in Chalkari and Phusro areas of East Bokaro Coalfield  
HVBA High volatile bituminous -A; MVB: Medium volatile bituminous; LVB: Low volatile bituminous; daf: Dry ash free; mmf: mineral matter free; Nd: No data

### Evaluation of coal bed methane potential of Chalkari and Phusro areas of East Bokaro Coalfield

The volume of gas retained in coal is dependent on the rank, temperature, and pressure or depth of the coal seam. The gas content of coal seams is in the range of 4.8 to 9.9 cc/g on daf basis (Table 2). The variation of gas content with depth is shown Figure 6.

The gas content increases with depth, coal rank and VRo. The highest gas content 11.74 cc/g is observed in Kathara seam and lowest gas content 3.17 cc/g in shallow local seams (Figure 6).

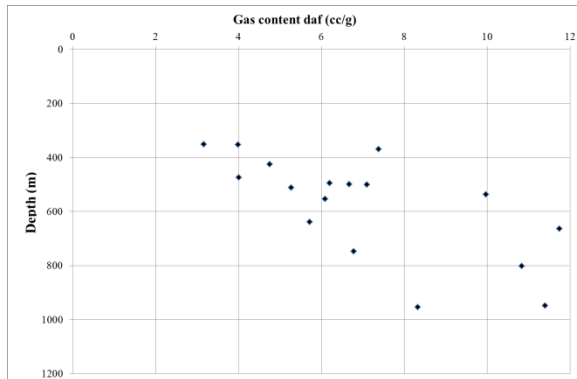


Figure 6: The variation of gas content with depth

Gas saturation of coal seams is estimated from methane adsorption isotherm at the appropriate hydrostatic pressure to the seam depths. The coals are saturated with gas in the range of 32 – 84% with maximum gas saturation of 41-84% for Kathara seam and minimum for shallower local seams (32-61%) (Figure 7). Based on the studies it can be inferred that the perceptivity of coal seams in general increases with depth.

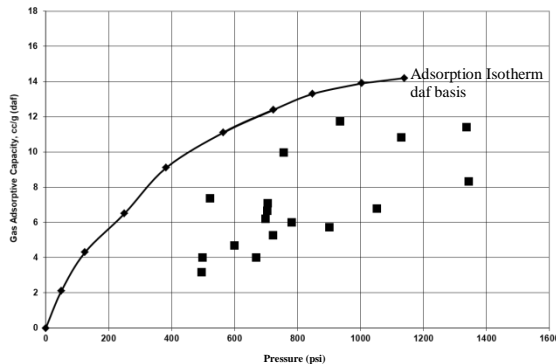


Figure 7: Gas content (daf basis) of coal seams plotted in methane adsorption isotherm (daf basis) plot to show the degree of methane saturation.

### Conclusions

- The rank parameters proximate and vitrinite reflectance (VRo) data indicate the coals range in rank from high volatile bituminous A to low volatile bituminous. The coal rank and VRo increases with depth.
- Petrographically, the coal seams are dominated by vitrinite group macerals (41.93-65.83% mmf basis). The high vitrinite content shows that these coals could act as suitable CBM reservoir.
- Coal seams consists of well-developed cleats in macro (cm) meso (mm) and micro ( $\mu$ m) scales in coal seams, lithotyps in cores and vitrine bands respectively. Cleat orientation data from this study indicate that face cleat direction is NNE-NS. The data of cleats may be used as proxy for knowing in-situ stress, flow paths and estimating permeability.
- Gas content of coal seams showed a linear increase in gas content with depth.
- CBM prospectively of coal seams are in the order of Kathara, Uchitdih, Kargali, Bemo Jarandih and Swang.

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