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Classification of coal seams for coal bed methane exploitation in central part of Jharia coalfield, India – A statistical approach

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HIGHLIGHTS

- A methodology is proposed for coal seam classification for CBM exploration.
- HCA has been performed based on the log-derived coal seam parameters.
- The classification according to CBM potentiality is known as first attempt in India.
- The coal seam classification can be improved with measured gas content studies.
- Well test permeability data can further modify the proposed classification.

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ABSTRACT

Laboratory analyses data of coal core samples and coal seam characteristics, derived from well logs, have been used for quantitative analysis of proximate and petrophysical parameters of coals to assess the potential of coal bed methane (CBM) reservoir as clean energy source in central part of Jharia coalfield, India. Coal core samples and well log data of 27 exploratory wells have been used for this analysis. Coal seam permeability data for 14 major coal seams, obtained from shallow resistivity log, varies from 0.60 md to 1.25 md. Gas content values, calculated from available empirical equation varies from 11.11 cc/g to 11.91 cc/g. Hierarchical Cluster Analysis (HCA) has been applied to group the 14 coal seams of the study area based on these above mentioned parameters for quantitative assessment of CBM potentiality of coal seams. Based on this HCA, the total 14 numbers of coal seams/objects occurring within the depth intervals of 214.58–1345.05 m have been classified into three categories in order of potentiality as CBM reservoir depending upon average coal seam permeability and average gas content. The data set, generated from the experimental work and assessment of CBM potentiality, may further be used in the investigations for enhanced CBM (ECBM) recovery with CO_2 sequestration into coal beds in the Jharia coalfield.

1. Introduction

The requirement of clean, economically viable fossil fuel energy is essential for energy security of India with due safeguards for environment. The Jharia coalfield, the sole repository of prime coking coals of Barakar Formation, is the leading contributor to India's coal production. Coal quality including petrographic composition, coal rank and the type of organic matter are some of the main factors controlling the type and quantity of gaseous hydrocarbons generated by coal seams and also potential of the seams as CBM reservoir [1]. Gas content of the recovered coal samples were determined by carrying out canister desorption tests at reservoir temperature at well sites by following modified United States of Bureau of Mines (USBM) direct method [2]. The other available techniques of estimating gas content from well log mainly use the density log for determination of ash content and other proximate parameters for the estimation of gas content.

CBM reservoir parameters such as gas content, coal seam permeability, coal seam thickness, critical desorption pressure, reservoir pressure generally affect the CBM production, among which the permeability is the key factor controlling the migration and flow of gas in CBM reservoir and thus controls CBM production [3–5]. Recent studies involving field measured cleat orientation patterns and fracture style suggest that new investigations of even these well studied parameters can yield insight into coal permeability and CBM production [5]. Prior information about opening mode fracture/face cleat orientation pattern in a coal field is another requirement to plan well locations or horizontal drilling for any CBM project development including CO_2 sequestration. Previously authors had established an overall NNE–SSW and NW-SE ori-

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ented face cleat or maximum horizontal compressive stress (S_H) direction from cleat and joint orientation mapping in 21 opencast as well as two underground mines of Jharia [6,7].

This paper presents quantitative technique for assessment of CBM potentiality of Barakar Formation coal seams of central part of Jharia coal field. A methodology has been proposed for classification of coal seams according to potentiality as CBM reservoir, based on parameters such as thickness, gas content and permeability for Hierarchical Cluster Analysis (HCA). The statistical HCA approach of classifying the coal seams for assessment of CBM potential has not been made till date for Jharia coalfield.

The objectives of this paper are (a) to establish statistical relationships between coal quality parameter (proximate analysis) with well log value, (b) to estimate coal seam permeability from well log, (c) to estimate gas content from an empirical equation, established for Jharia coalfield and finally, (d) to perform multivariate statistical analysis for the generation of HCA and classification of coal seams depending on depth, thickness, permeability and gas content. Findings of this work shall help in locating the sweet spots with high CBM content and high permeability. Recent development of CO_2 sequestration offers an approach to redirect CO_2 emissions into unmineable coal seams at a depth of around 800–1500 m with enhanced CBM recovery [8]. These zones can be targeted for sequestration of CO_2 with simultaneous recovery of CBM.

2. Study area

The Jharia coalfield located in the eastern part of India is roughly sickle shaped, its longer axis running northwest–southeast (Fig. 1). The dip of the Formation in general is southerly (10°). The general stratigraphic succession of Jharia coalfield is given in Table 1 [9]. The stratigraphic units of the Jharia coalfield are marked by the presence of two coal-bearing horizons: the Barakar Formation and the Raniganj Formation. Barakar Formation coals of Damodar valley Gondwana coalfields are of Permian age deposited in fluvio/deltaic condition having maturity from sub-bituminous to low volatile bituminous coal and are considered as potential reservoir for CBM [10].

Present study area, consisting of Singra, Kapuria, Barki, Dumarda and Parbatpur blocks, is located in the central part of Jharia coalfield (Fig. 1). There are 18 major regional coal seams of Barakar Formation, which are designated as: seam A (bottom seam) through seam R (top seam). Due to the presence of thin partings between seams E and F and seams F and G throughout the study area, the seams E, F and G are always marked as a single seam (E/F/G combined seam) for this study area. So, for this present work, 15 major coal seams of Barakar Formation (except seam A and considering E/F/G as a single seam) occurring within the depth interval 214.58–1345.04 m have been studied. The coal seam thickness ranges from 0.40 m for seam Q to 31.40 m for combined seam E/F/G. Well logs, litho logs and available coal analysis data of 27 exploratory wells, distributed in five blocks, have been used for coal seam correlation. Data of total 27 wells, distributed in five blocks – Singara, Kapuria, Barki, Dumarda and Parbatpur, have been used for the present work (Fig. 1).

Representative sequence of the seams, as identified from well logs of well K4, is shown in Fig. 2. It displays the signatures of gamma ray, short normal resistivity and caliper corrected density log corresponding to the identified major coal seams. For proper correlation of the coal seams, geophysical logs of all 27 wells have been used in combination with litho-logs of those wells. A vertical stratigraphic section showing major coal seams for section line covering boreholes K8–S8 is in Fig. 3. The cross-section includes extrapolated seams, beyond the drilled depth limit of some boreholes, based on expected geological continuity. For most of these wells, it was easy to identify the litho-units such as coal, shaly coal, carbonaceous shale, shale, shaly sand and sandstone from the density versus gamma ray cross-plots [11]. Data pertaining to organic petrology and thermal maturity of Barakar and Raniganj Formations are of considerable importance in determining the CBM po-

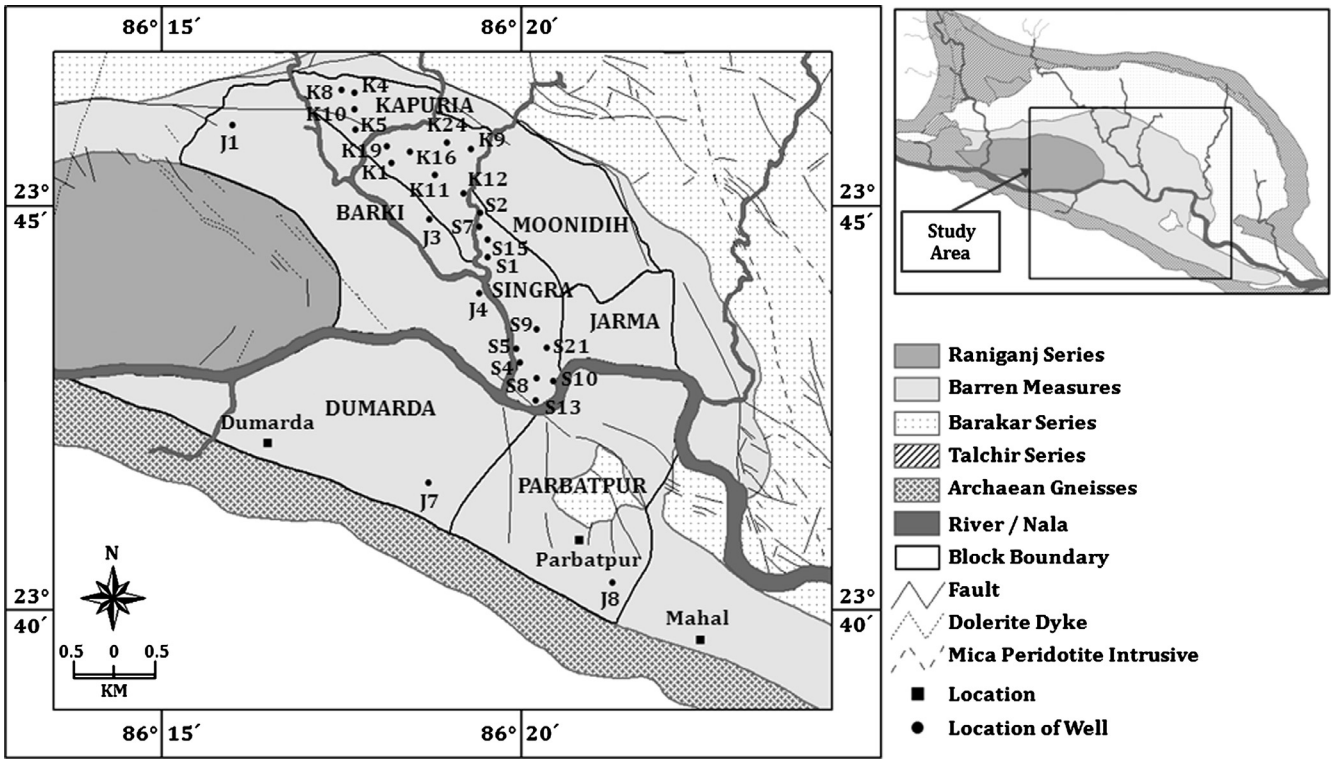

Fig. 1. Inset shows the location map of Jharia coalfield. 27 numbers of wells are distributed in Singra, Kapuria, Barki, Dumarda and Parbatpur blocks. Moonidih and Jarma (extension Moonidih) blocks are adjacent to the study area.