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Effects of chemical composition and petrography of coal for coalbed methane evaluation with special reference to in-situ gas content

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Summary

Coalbed methane (CBM) or Coalbed gas has gained considerable ground as an unconventional source of energy in the recent past. Due to incremental demand for conventional fossil fuel both in industrial and domestic sector, coupled with dwindling reserves of oil and gas, hunt for unconventional sources of energy has gained momentum world over. In the present study the coal samples were collected from Jharia coalfield, Jharkhand. Chemical and petrograpgic analysis of the samples were determined and rank of coal in the studied coal samples have been evaluated. The present paper established the correlation between in-situ gas content data with chemical and petrographic data in the study area and it is found that with increasing fixed carbon, carbon and vitrinite reflectance of coal samples, the gas content also increases. From the result it is established that with increasing depth of coal, the gas content capacity increases.

***Keywords**: CBM, Rank, Fixed carbon, Carbon, Vitrinite reflectance*

Introduction

With the nation requiring more energy sources to sustain its rapid pace of development, CBM will play an important role as one of the prime energy sources in India. Coalbed methane is generated during coalification process which gets adsorbed on coal at higher pressure. Presence of CBM in underground mine not only makes mining works difficult and risky, but also makes it costly. Even, its ventilation in atmosphere adds green house gas and therefore contributes to global warming. On the other way, CBM is a remarkably clean fuel when burnt. CBM constitutes clean gases having heating value of approximately 8500 KCal/kg compared to 9000 KCal/kg of natural gas.

Petrographic and chemical analysis of coal is important for determination of coal rank and evaluation of gas content. The percentage of vitrinite reflectance, fixed carbon, volatile matter, moisture content and ash determine the rank of coal. Maximum volume of methane obtained from coalbeds are formed by thermogenic process, where interns are controlled by burial history, maceral composition and basin hydrodynamics (Berbesi et al., 2009, Scott and Kaiser, 1996). A part of the generated gas is retained into the coal in adsorbed condition and remaining escaped from coalbeds. The petrographic composition, coal rank and the type of organic matter are some of the main factors controlling the quality and quantity of gaseous hydrocarbons retained by coal (Quick and Brill, 2002; Mastalerz et al., 2008). Coal rank indicates the level of maturation of coal, potential of methane generation, the storage capacity and development of cleat network in coal/coaly bed. Out of all four ranks of coal (peat, lignite, sub-bituminous, bituminous and anthracite), bituminous shows the maximum capacity to adsorb coalbed methane. The methane retention capacity becomes econiomical in high volatile bituminous coals and peaks at medium volatile bituminous coals. Gas holding capacity of coal is related to carbon percentage, moisture content, ash percentage and volatile matter into the coal. In most of the cases, moisture content decreases with increasing depth and increasing rank of coal (Sivek et al.,2010). Theoretically, lower moisture and ash content in coal can provide more sites for methane adsorption (Crosdale et al., 2008; Ozdemir and Schroeder, 2009) hence gas holding capacity in high rank of coal is more than the lower one. Petrological aspect is important for evaluation of rank of coal and it depends upon the volume of maceral group,

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i.e., vitrinite, semi-vitrinite, liptinite, inertinite, mineral matter and the mean vitrinite reflectance into the coalbed. The vitrinite maceral is related to CBM potentiality because of its storage capacity, higher proportion of micropores resulting in more surface area and high adsorption capacity. Commercial CBM generating coals have values of reflectance between 0.7-2.0 % (Chandra, 1997). So, studies of coal quality parameters which include grade, chemical composition, maceral composition, rank and physico- mechanical properties are important for characterizing CBM reservoir and gas flow potential of coal (Levine, 1993; Paul and Chatterjee, 2011a).

Materials and method

The coal samples have been collected from different depth intervals of one well of Jharia coalfield, Jharkhand. The rank, gas content and CBM potential of the collected samples was evaluated on the basis of chemical and petrographic results.

Proximate analysis

Proximate analysis is the study of physico-chemical parameters of coal and can be used to establish the grade and rank of coals. Chemical characteristics of coal are an important parameter that dictates the sorption potential of coal. For the present study Indian Standard procedures (BIS Standard: 1350, Part-1, 2003) were carried to determine moisture, ash and volatile matter content of coals.

Petrographic analysis of coal in laboratory

Coal petrographic analysis for collected coal samples from different depths were carried out at the Central Institute for Mining and Fuel Research, Dhanbad. Analysis was carried out as per Bureau of Indian Standards (BIS No 9127 part 2 for preparation, grinding and polishing of pellet, part 3 for maceral and mineral identification and part 5 for VRo measurement).

Results and discussion

The CBM potential of the collected samples was evaluated on the basis of in-situ gas content and correlated with chemical and petrographic data.

Proximate analysis

Coal proximate analysis of the collected samples reveal that the moisture content varies from 0.13% to 2.81%, ash content varies from 12.00% to 26.63%, volatile matter varies from 6.93% to 28.40% and fixed carbon percentage varies from 79.64 to 91.52%.

Petrographic analysis

Coal petrographic analysis of collected coal samples from well 1 of Jharia coalfield shows the value of vitrinite ranges from 32.04% to 74.90%, semi-vitrinite ranges from 0.60% to 4.10%, inertinite ranges from 15.02% to 51.40%, liptinite ranges from 0.02% to 10.40%, mineral matter ranges from 4.6% to 23.00% and vitrinite reflectance ranges from 1.23% to 2.03%. Based on proximate analysis and petrographic analysis results, the rank of most of the coals recovered from well 1 of Jharia coalfield are inferred to be medium volatile bituminous (mvb) to low-volatile-bituminous (lvb) rank and these rank of coals are also important for prospect of coal bed methane.

In-situ gas content

In-situ gas content values of most of the desorbed coal core samples from Well 1 of Jharia coalfield are found to vary from 4.55 cc/g to 13.47 cc/g (as received basis) and from 5.25 cc/g to 15.88 cc/g (dry ash free basis). The measured gas content data indicate that the study areas have good CBM potential, since the average gas content of the seams are mostly greater than the commercial value of 8.5 cc/g of methane (Mukherjee et al., 1999). However, in the present study, this thumb rule is not strictly followed. From the data of the upper seams (zone 1) and lower seams it was observed a linear increase in the gas content with depth as conventionally observed (Figure 1). This is mostly because of reduction in moisture content and volatile matters in the coal, resulting in more sites available for gas adsorption.

Relation of gas content with fixed carbon content

The coal samples recovered from well 1 of Jharia coalfield are inferred to be medium-volatile bituminous (mvb) to low-volatile-bituminous (lvb) rank. Medium volatile bituminous to low volatile bituminous coals are important for prospect of CBM than anthracite or lower rank coals because of amount of methane retention and development of cleat network as mentioned earlier. In this study, a linear relationship has been established between gas content and fixed carbon content of the samples (Figure 2) and 2 zones have been identified and both the zones shows the linear relationship with increasing fixed carbon but gas content of coals of the upper seams of zone 1 is relatively higher as compared to the coals of lower seams although the fixed carbon content of the lower seam is high. This abnormal behavior of lower seams may be attributed due to presence of week zone (fault and fracture) in the vicinity of the coal seams where gas can escaped from the coal reservoir.

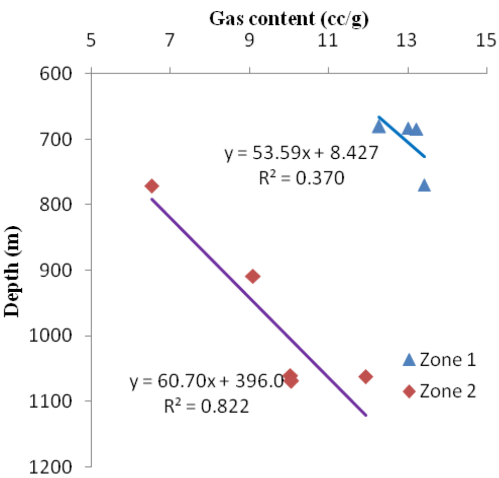

Figure 1: plot gas content and depth

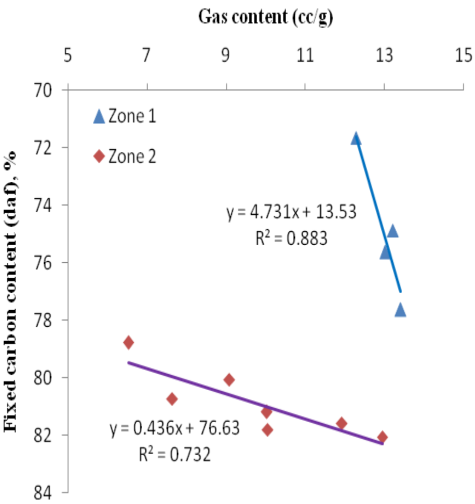

Figure 2: plot between gas content and fixed carbon content (daf)

Relation of gas content with carbon content of coal

The carbon content of coal is determined from the elemental analysis of coal. With increasing rank of coal, carbon content of coal increases and vitrinite reflectance also increases, so the gas content of coal increases (Figure 3). From the study area 2 zones have been identified and both the zones show the increasing trend but zone 1 show steeper than zone 1 this is may be due to the escape of gas from the coal seams.

Relation of gas content with vitrinite reflectance of coal

The mean vitrinite reflectance from the laboratory studies of coal samples from well 1 of Jharia coalfield varies from 1.23% to 2.03%. The vitrinite reflectance increases with maturation because of the aromatization of the molecular structure of coal as aliphatic groups are dissipated as volatiles, or converted to aromatics, especially in the bituminous range (C.R. Ward, ed., 1984). The vitrinite maceral is more favorable for CBM potentiality because of development of higher proportion of micropores due to increasing rank of coal which can enhance the gas storage capacity. In the plot (Figure 4) show the relation between gas content and vitrinite reflectance and here follow the increasing trend. 2 zones have been identified in this area where zone 1 show the with small variation of vitrinite reflectance gas content is high and on the other hand zone 2 show the gentle slope and this is may be due to escape of gas from the coal seams.

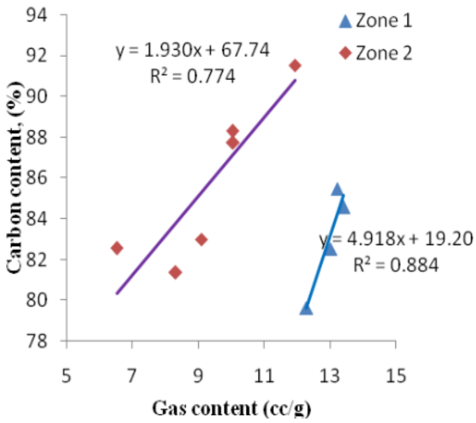

Figure 3: Relation between gas content and carbon content of coal

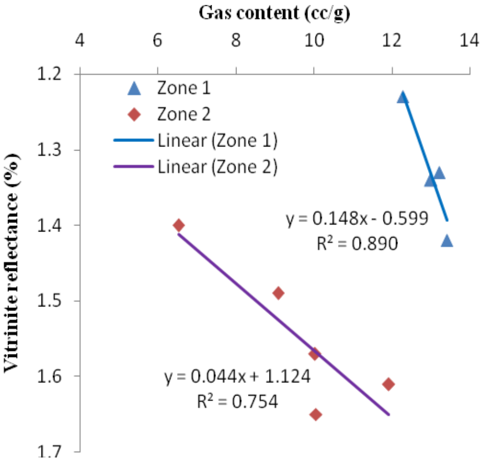

Figure 4: Plot between gas content and vitrinite reflectance

Conclusions

The proximate and petrographic analysis of the studied coal samples reveals that the rank is to be medium-volatile- bituminous (mvb) to low-volatile-bituminous (lvb) rank. From the study, it is observed that all the samples from well 1of Jharia coalfield has the potential of producing coalbed methane. The average methane contents in this wells indicating moderate to high gas content of the coal seams. Initially for the samples of shallower depth, the gas content of coal samples increase and after certain depth gas content decreases compared to the samples from shallow depth. From the studies, it has been found that the in-situ gas content of the studied coal samples show the linear relationship with depth, fixed carbon content, carbon content and vitrinite reflectance.

Acknowledgement

The authors gratefully acknowledge the financial assistance provided by Ministry of Coal, New Delhi to the Department of Petroleum Engineering, Indian School of Mines, Dhanbad, India. Thanks are also extended to all individuals associated with the project.

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