[PS]Geological Controls on Coalbed Methane Reservoir in East Bokaro Coalfield, Jharkhand, India*

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Abstract

Coalbed methane desorption and other reservoir parameters were evaluated for coal seams in East Bokaro coalfield comprising blocks such as Tenughat, Saram, Tulbul, Koiyotanr, Gomia and Kathara of Bokaro district, Jharkhand. The main objectives of the investigations were to decipher the in-situ gas content, sorption time (τ), geochemical properties, sorption capacity (VL), vitrinite reflectance (VRo%), molecular gas composition, petrographic constituents, etc. East Bokaro coalfield belongs to Peninsular Gondwana Basins in India occupies an area of about 237 km^2 between latitudes 23°44′N and 23°49′N and longitudes 85°42′E and 86°04′30″E. The coalfield has 24–27 coal seams worth for CBM exploration with thickness as high as 35m with cumulative thickness of 105–150m and occurring to a maximum depth of 1,300m. Coal core samples were collected from exploratory boreholes in airtight canisters. In-situ gas content of coal core samples ranges from 1.7–22.9m^3/t and decreases laterally from East to West of the coalfield. The molecular gas concentrations of C_1, C_2, C_3, N_2 and CO_2 varies from 34.3–99.4, 0.1–30.0, 0.1–4.0, 0.2–65.7 and 0.4–58.8 respectively. It is observed that methane is the main component of desorbed gas (in average >74.4%). The observed $\delta^{13}C_1$ (0/00) lie in the range of –70.5 to –22.4. The shallower samples (<600m) are lighter with $\delta^{13}C1$ values mostly in the range of –70.5 to –45.0, whereas deeper samples become heavier with depth and $\delta^{13}C_1$ values vary from –42.6 to –22.4. The shallower samples are of mixed origin with substantial biogenic methane and relatively higher amount of N_2. The sorption time (τ), moisture, ash, volatile matter and VRo% obtained as 0.08–10.8days, 0.5–7.4, 11.2–68.0, 16.2–38.7wt.% and 0.83–1.50 respectively, which indicates the coal seams are sufficiently matured. Sorption capacity (VL) varies from 14.8–24.6m^3/t with Langmuir pressure (PL) as 2,865–3,716kPa. The sorption data compared with gas content reveals, near saturation (>65%) of coal seams. Liptinite has been found to constitute up to 12.1% by volume, hydrogen rich liptinite coals are capable of generating higher hydrocarbons at higher maturation level. This may be attributed to mixing with or dominance of biogenic methane generated during interaction of bacteria carried by recharging water in to the coal seams. Desorption and other properties of coal seams are highly encouraging for production and development of CBM reservoir in East Bokaro coalfield.

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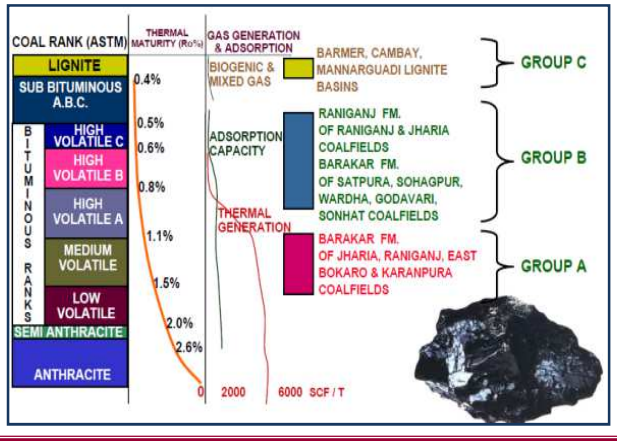
Abstract

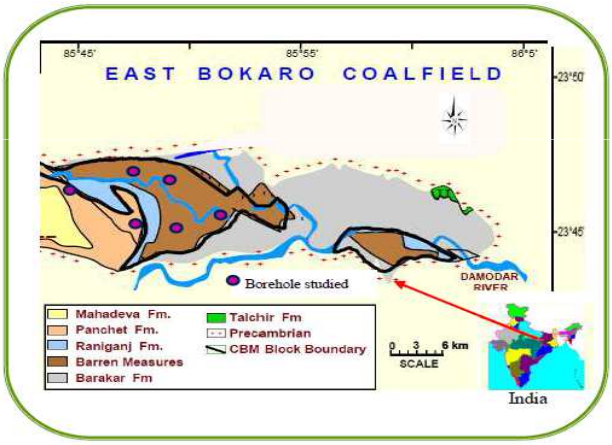
Coalbed methane desorption and other reservoir parameters were evaluated for coal seams in East Bokaro coalfield comprising blocks such as Tenughat, Saram, Tulbul, Koiyotanr, Gomia and Kathara of Bokaro district, Jharkhand. The main objectives of the investigations were to decipher the in-situ gas content, sorption time (τ), geochemical properties, sorption capacity (VL), vitrinite reflectance (VRo%), molecular gas composition, petrographic constituents, etc. East Bokaro coalfield belongs to Peninsular Gondwana Basins in India occupies an area of about 237sq.km. between Latitudes 23°44'N and 23°49'N and Longitudes 85°42'E and 86°04'30"E. The coalfield has 24–27 coal seams worth for CBM exploration with thickness as high as 35m with cumulative thickness of 105–150m and occurring to a maximum depth of 1300m. Coal core samples were collected from exploratory boreholes in air tight canisters. In-situ gas content of coal core samples ranges from 1.7–22.9m^3/t and decreases laterally from East to West of the coalfield. The molecular gas concentrations of C_1, C_2, C_3, N_2 and CO_2 varies from 34.3–99.4, 0.1–30.0, 0.1–4.0, 0.2–65.7 and 0.4–58.8 respectively. It is observed that methane is the main component of desorbed gas (in average >74.4%). The observed δ13C1 (0/00) lie in the range of –70.5 to –22.4. The shallower samples (<600m) are lighter with $\delta^{13}C_1$ values mostly in the range of –70.5 to –45.0, whereas deeper samples become heavier with depth and $\delta^{13}C_1$ values vary from –42.6 to –22.4. The shallower samples are of mixed origin with substantial biogenic methane and relatively higher amount of N_2. The sorption time (τ), moisture, ash, volatile matter and VRo% obtained as 0.08–10.8days, 0.5–7.4, 11.2–68.0, 16.2–38.7wt.% and 0.83-1.50 respectively, which indicates the coal seams are sufficiently matured. Sorption capacity (V_L) varies from 14.8–24.6m^3/t with Langmuir pressure (P_L) as 2865-3716kPa. The sorption data compared with gas content reveals, near saturation (>65%) of coal seams. Liptinite has been found to constitute up to 12.1% by volume, hydrogen rich liptinite coals are capable of generating higher hydrocarbons at higher maturation level. This may be attributed to mixing with or dominance of biogenic methane generated during interaction of bacteria carried by recharging water in to the coal seams. Desorption and other properties of coal seams are highly encouraging for production and development of CBM reservoir in East Bokaro coalfield.

Introduction

India is endowed with a vast coal reserves of about 298 billion tonne and the associated Coalbed Methane (CBM) resources are estimated to be in the range of 0.8 to 1.4 TCM with majority of these resources confining in Gondwana coals of Permian age in Jharia, East & West Bokaro, North & South Karanpura and Raniganj coalfields. Tertiary coals of North-Eastern states and Gujarat have not been proved to be a source of CBM yet. The Indian coal basin are categorized as Group A, B and C on the basis of their resource potential and thermal maturity . CBM industry, in India, is now considered to be technically matured and CBM related activities are expected to increase manifold in near future.

The East Bokaro coalfield is known for thick and multiple coal seams of a high rank and quality. The four coreholes and two exploratory test wells have been drilled in the Block as a part of the exploration program. The exploration results have proven the presence of thick and mature coals and accumulative coal thickness of 105-150 m is expected in major part of the area. Laboratory data indicates that the coals are mature (VRo >0.8) and gas content and saturation are highly encouraging. The east Bokaro coalfield is evaluated for CBM reservoir parameters for better understanding and its commercial development.





East Bokaro Coalfield : The Barakar formation is the chief coal-bearing unit in East Bokaro coalfield. The East Bokaro coalfield has about 24-27 coal seams, which are grouped into Jarangdih, Sawang, Kathara, Uchitdih, Kargali, Bermo and Karo group of seams. Of these Kargali and Karo group is most important. Generally the coal is black, moderately hard, compct and brittle, and brittle and falls in Durain-Clarain lithotype. The coal rank is High Volatile 'A' to Medium Volatile bituminous . Litho stratigraphy is given below:

SYSTEM	FORMATION	LITHOLOGY	THICKNESS
UPPER GONDWANA	MAHADEVA		0-10m Present in western boundary
LOWER GONDWANA PERMO CARBONIFEROUS	PANCHET		>40m Present only in western part
	RANIGANJ		>100m Thin coal seams
	BARREN MEASURES		>150m
	BARAKAR		600-1000m Having 24-27 coal seams with cumulative thickness 105-150m
	TALCHIR		>60m
	ARCHEAN		----

Methods and Experimentals

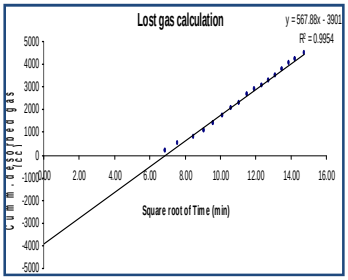
In-situ Gas Content and Sorption Time

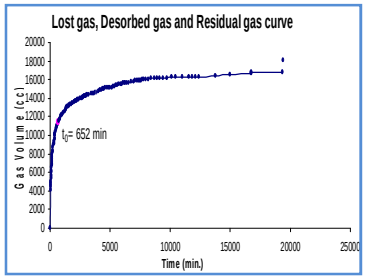
The basic equipment used for performing gas content measurement consists of specially fabricated gas tight cylindrical desorption canisters fitted with pressure gauge and a needle valve and a manometer type of apparatus for measuring gas volume. The desorption canisters are maintained at reservoir temperature by the aid of a heating unit and a temperature controller. A rotary grinding machine is used to crush the coal samples to below 200 mesh BSS for measurement of residual gas.

There are several steps involved :

- Core recovery
- Sample collection
- Sealing of coal core samples in desorption canisters
- Short term gas desorption for estimation of lost gas (Q_1)
- Long term gas desorption for determination of desorbed gas (Q_2)
- Determination of residual gas (Q_3)

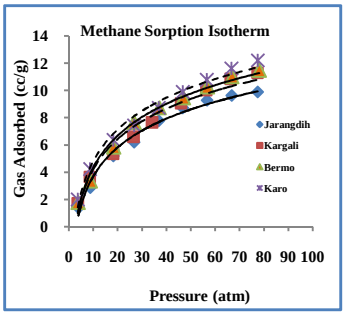
$$Q = \frac{Q_1 + Q_2 + Q_3}{W} \, m^3 / t$$





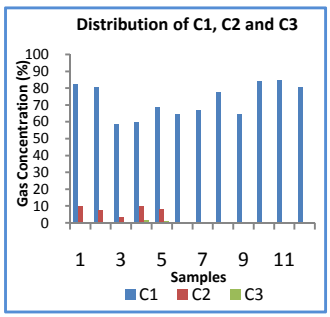
Methane Sorption Isotherms

One of the unique characteristics of the coal is that it contains extensive pore network with extremely large surface area. Methane adsorption by coal is a physical process and is completely reversible. Apparently, not all of the surface area is suitable for methane adsorption. Water vapour appears to be preferentially adsorbed onto oxygen-bearing sites along the surface, reducing the moist coal adsorptive capacity for methane. The peak gas flow rate, cumulative gas recovery and efficiency of recovery are highly influenced by the gas saturation level of coal. The most effective method of investigating sorption of methane by coal and gas saturation level is the determination of adsorption isotherms, which shows the manner in which the amount of gas adsorbed varies with pressure at a constant temperature.



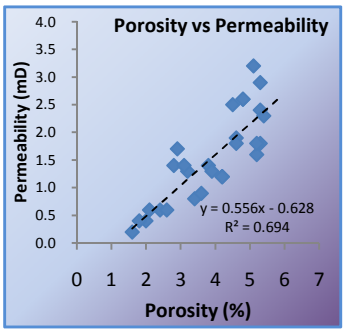
Gas Composition

Desorbed gas concentration of different gases with time interval from canisters has equal importance in coalbed methane assessment. Gases desorbed from coal core samples contain mainly methane, carbon dioxide, nitrogen and higher hydrocarbons. The concentration of gases in coal may vary with depositional and degree of metamorphism conditions. Low rank coal may have high percentage of carbon dioxide and nitrogen gas and it may decreases with increasing the rank of the coal.

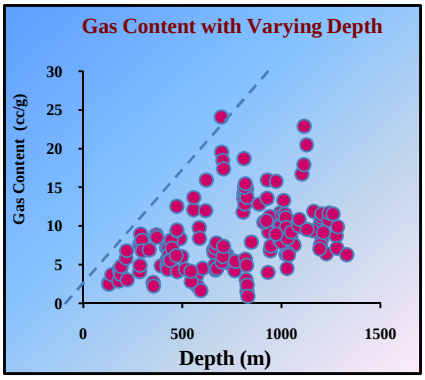


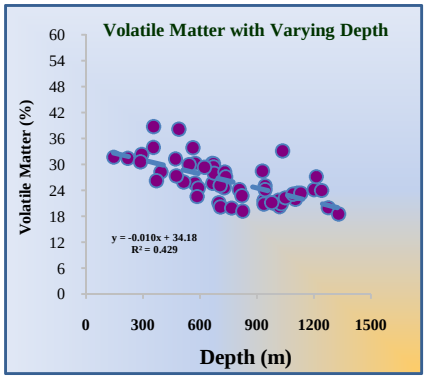
Permeability and Porosity under Confining Pressure

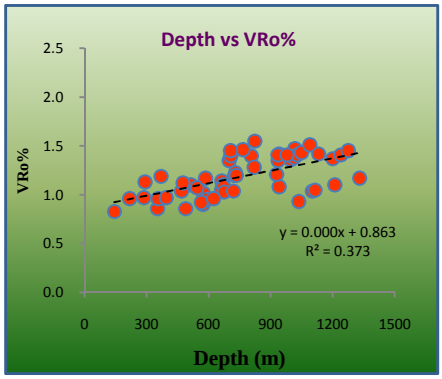
Permeameter and porosimeter system is highly rapid, accurate and non-destructive measurement of permeability and effective porosity of core samples. A computer data acquisition system automatically calculates the permeability and porosity, and records the data saved in a spreadsheet file. Test core of varying diameters can be easily accommodated by switching core holder internal parts. Cores are easily and quickly inserted and removed by screwing the end plugs. Maximum confining (overburden) pressure is 10,000 psig (68.9 Mpa) at room temperature and maximum flowing (pore) pressure through the core sample is 2500 psig (17.2 Mpa) at room temperature.

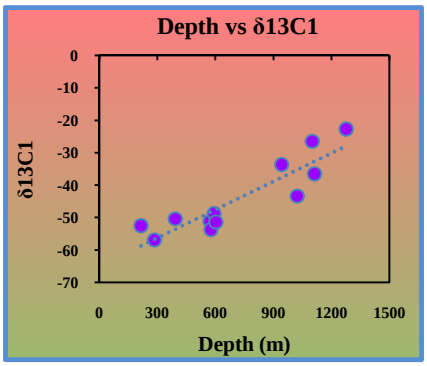


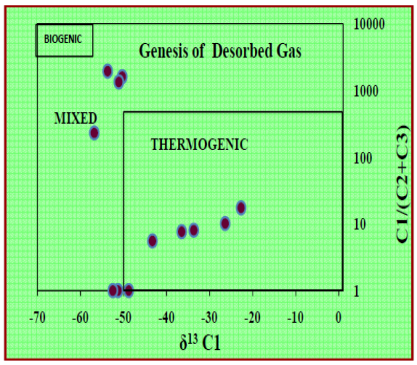
Results and Discussion

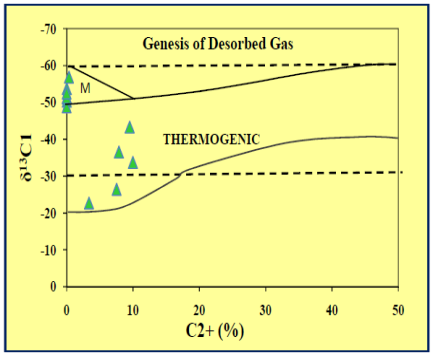


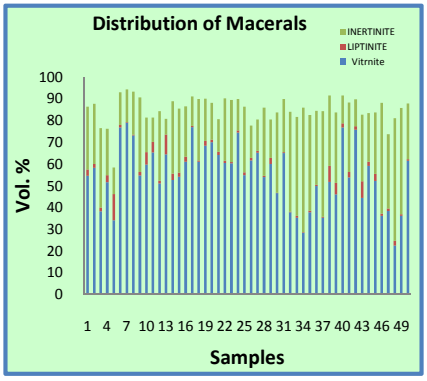


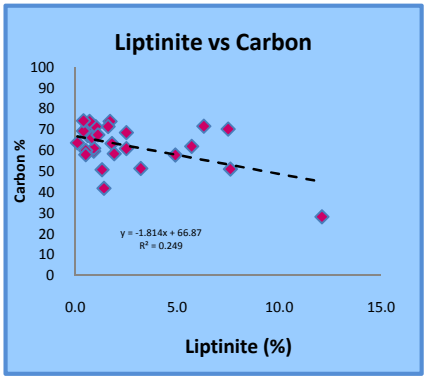


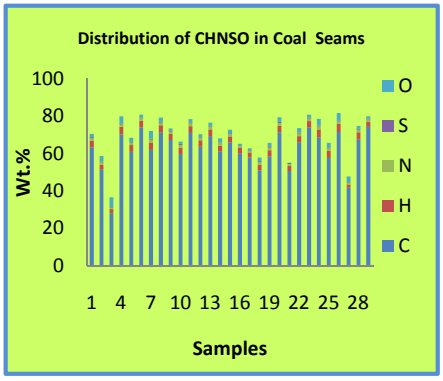






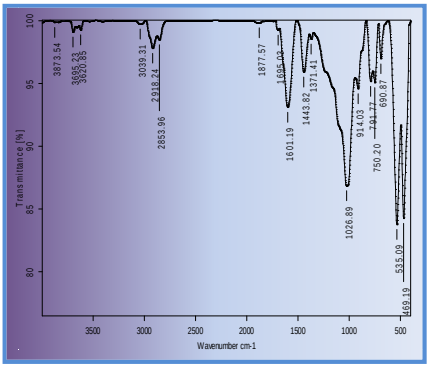


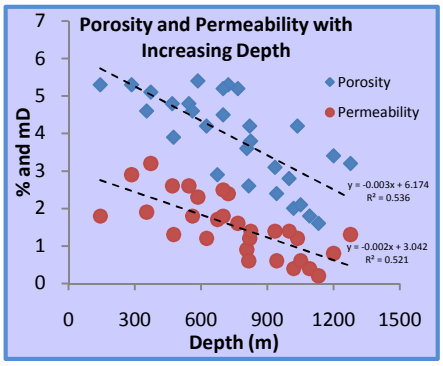




Summary and Conclusion

- In-situ gas content (1.7 – 22.9 m^3/t) is very encouraging and when compared with sorption capacity found most of the coal seams are moderately to fully saturated.
- In-situ gas content is distributed more or less uniformly in most of the coal seams.
- Desorbed gas and Sorption time (0.08 – 10.8 days) indicating ideal gas reservoir.
- Langmuir volume (V_L) varies from 14.8 – 24.6 m^3/t showing sufficient surface area for storage of gas in coal micropores.
- CHNSO and proximate results shown matured coal of bituminous rank.
- Isotope values ($\delta^{13}C_1$) indicating hydrocarbons of East Bokaro Coalfield are of mixed as well as of thermogenic origins. This may be due to some biogenic activities occurred during interaction of Damodar river water in the coal seams.





- Methane is the major component of coalbed gases in East Bokaro. No unusually high concentrations of CO_2 and N_2 have been found. Gases at greater depths (>600m) are predominantly thermogenic, whereas those at shallower depths are of mixed origin with substantial contributions from biogenic methane and relatively higher concentration of N_2.
- Effective Porosity and permeability measured under reservoir simulated confining pressure shown inverse relationship with increasing depth.
- From FTIR, it is observed that aromatic compounds like phenols/ alcohols and alkanes/alkenes functional groups indicating significant source material for genesis of hydrocarbons.
- Coalbed gases of both the blocks, therefore, are expected to have normal heating values and can be commercially exploited