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# Coal Bed Methane and its Future Prospects

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**Abstract—***Energy is the single most important commodity on earth, a commodity which is depleting at a rampant pace. The mankind is striving hard to unearth new sources of energy. Geologists, geophysicists and other researchers are putting up best efforts to not only come up with new sources of energy but also making them cost effective for their effective utilization. There are concerns about the availability of essential non-renewable resources in the near future. Crude oil and natural gas are the primary raw materials for petrol, diesel and other petroleum products. These raw materials are rich sources of hydrocarbons but are limited due to which the world will ultimately run out of these priceless resources. Thus alternate and non-conventional sources are being discovered to meet the ever-increasing energy demand. One of the alternative sources is coal bed methane, which is a gas which occurs naturally in coal seams and consists primarily of methane with lower concentrations of higher hydrocarbons. Coal Bed Methane (CBM) is a natural gas and it occurs in coal as an adsorbed gas. Generally it is used as fuel for power plant, feed stock for fertilizers, petrochemical plants. CBM can be piped for domestic and industrial supplies. Also, It can be used as transportation fuel in the form of CNG. CBM reserves are energy source with huge potential usually found at shallow depths. Coal can contain up to seven times the amount of gas volume of traditional reservoirs. Production of CBM normally involves dewatering the formation to lower the reservoir pressure. Lowering the pressure facilitates the migration of gas into the wellbore. Perforation and hydraulic fracturing are widely used for extracting CBM gas. Connecting the naturally occurring fracture network to the wellbore provides a conduit through which water and gas are produced. With this paper, efforts were made to understand the gas and its implications in geological preparation, extraction, handling and usage.*

## 1. INTRODUCTION

Coal Bed Methane (CBM) is a natural gas and it occurs in coal as an adsorbed gas. Generally it is used as fuel for power plant, feed stock for fertilizers, petrochemical plants and other industries. CBM can be piped for domestic and industrial supplies. It can also be used as transportation fuel in the form of CNG. It is different from conventional gases as it is adsorbed it coal seams while conventional gases are found in traps. Conventional gases are found in random spaced fractures while CBM is found in uniformly spaced cleats. Conventional gases are usually compressed while CBM is adsorbed on coal surface. Conventional gases follow Darcy's law while CBM follows Darcy's law and Fick's law of compressibility. It is seen that the production rate in conventional gas wells is high in beginning and then declines and water production is very less while in CBM wells, production of gas is low in beginning and then increases. Also, only water production is there in beginning in CBM wells. Unlike conventional gas reservoirs, coal is both the reservoir rock and the source rock for methane. Coal is a heterogeneous and anisotropic porous media which is characterized by two distinct porosity (dual-porosity) systems: macro pores and micro pores. The macro pores, also known as cleats, constitute the natural fractures common to all coal seams. Microspores, or the matrix, contain the vast majority of the gas. This unique coal characteristic has resulted in classification of CBM as an "unconventional" gas resource. The open fractures in the coal (cleats) can also contain gas or can be saturated with water.

Cleats are of two types:- Face Cleats- They are horizontal in direction and are continuous and Butt Cleats- They are vertical in direction and are discontinuous. Face cleats and butt cleats are perpendicular to each other as illustrated in Fig. 1.


**Fig. 1: Face and butt cleats**

Methane absorbed into the solid coal matrix is released if the coal seam is depressurized. Coal seam can only be depressurized by drilling wells into the coal seam. The goal is to decrease the water pressure by pumping out water from the well. The decrease in pressure allows methane to desorb from the coal and flow as gas up the well to the surface. Methane is then compressed and piped to market. The objective is to avoid putting methane into the water lie, but allow it to flow up the backside of the well (casing) to the compressor station. If the water level is pumped too low during dewatering, methane may travel up the tubing into the waterline causing the well to become gassy.

**Benefits of CBM**

It reduces energy dependency over conventional fuels and green house gases emission. It is a cleaner fuel as compared to conventional fuels. It causes less damage to environment because of less surface degradation. There is an enhanced coal productivity because of less frequent downtime or production slowdowns caused by gas. There is a decrease in fan operating costs because of reduced air requirements for methane dilution as there will be a reduction in number of shafts and other development openings connecting the coal seam to the surface. This can at times result in significant level of economic saving. Also there is a significant improvement in mine safety resulting from lower methane contents in coal seams. An improvement in worker comfort and safety during mining is there. Benefits such as reduced dust concentration, improved safety, or improved worker comfort are difficult to estimate but they constitute a real and significant benefit.

## 2. INDIAN SCENARIO OF CBM

India is potentially rich in CBM. The major coal fields and CBM blocks in Indian are shown in Fig. 1. The Directorate General of Hydrocarbons of India estimates that deposits in major coal fields (in twelve states of India covering an area of 35,400 km2 ) contain approximately 4.6 TCM of CBM. Coal in these basins ranges from high volatile to low-volatile bituminous with high ash content (10 to 40 percent), and its gas content is between 3-16 m3 /ton (Singh, 2002) depending on the rank of the coal, depth of burial, and geotectonic settings of the basins as estimated by the CMPDI. In the Jharia Coalfield which is considered to be the most prospective area, the gas content is estimated to be between 7.3 and 23.8 m3 per ton of coal within the depth range of 150m to 1200 m. Analysis indicates every 100-m increase in depth is associated with a 1.3 m3 increase of methane content. In India, commercial CBM production is yet to be started in full pace. Few E&P companies like ONGC Ltd., GEECL and Essar Oil have started production, but field development is yet to be completed.

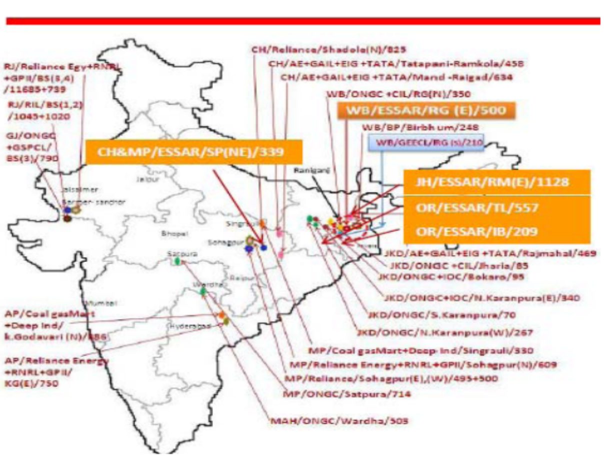



**Fig. 1: Distribution of CBM reserves in India**

**Global scenario of CBM**

The largest CBM resource bases lie in the former Soviet Union, Canada, China, Australia and the United States. However, much of the world's CBM recovery potential remains untapped. In 2006 it was estimated that of global resources totaling 143 trillion cubic meters, only 1 trillion cubic metres was actually recovered from reserves. This is due to a lack of incentive in some countries to fully exploit the resource base, particularly in parts of the former Soviet Union where conventional natural gas is abundant.

The United States has demonstrated a strong drive to utilize its resource base. Exploitation in Canada has been somewhat slower than in the US, but is expected to increase with the development of new exploration and extraction technologies. The global CBM activities are shown in Fig.2. The potential for supplementing significant proportions ofnatural gas supply with CBM is also growing in China, where demand for natural gas was set to outstrip domestic production by 2010.

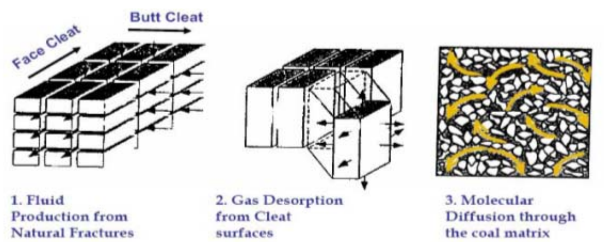

## 3. METHODOLOGY OF EXTRACTION

**Gas Transportation mechanism in reservoir:**

Production of gas is controlled by a three step process (i) desorption of gas from the coal matrix, (ii) diffusion to the cleat system, and (iii)flow through fractures as shown in Fig. 3.. Many coal reservoirs are water saturated, and water provides the reservoir pressure that holds gas in the adsorbed state.

Flow of coalbed methane involves movement of methane molecules along a pressure gradient. The diffusion through the matrix pore structure, and steps include desorption from the micropores, finally fluid flows (Darcy) through the coal fracture (cleat) system. Coal seams have two sets of mode; breaking in tension joints or fractures that run perpendicular to one another.

The predominant set, face cleats, is continuous, while the butt cleat often terminates into the face cleats. Cleat systems usually become better developed with increasing rank, and they are typically consistent with local and regional stress fields. The size, spacing, and continuity of the cleat system control the rate of fluid flow once the methane molecules have diffused through the matrix pore structure. These properties of the coal seams vary widely during production as the pressure declines. Coal, being brittle in nature, cannot resist the overburden pressure with reduction in pore pressure during dewatering; and fractures are developed. In addition, hydraulic fracturing is done to increase the permeability of coal. Because, permeability and porosity of coal is extremely low for which production rate is also low.




The basic petrophysical properties of coal responsible for production of methane, e.g. porosity, permeability vary widely with change in the pore pressure during dewatering as well as gas production period. Hence, efficient production of methane from coal bed needs continuous monitoring of variation in porosity, permeability and compressibility of coal. The unique features of the coal are that coals are extremely friable; i.e., they crumble and break easily. Therefore, it is nearly impossible to recover a “whole” core. Direct measurement of intrusive properties like permeability, porosity, compressibility, relative permeability measurements are very difficult and must rely on indirect measurement. In India, ONGC Ltd. has implemented multi-lateral well technology to increase the drainage area and enhance the production in the Jharia block. But, brittle characteristic of coal restricts the production at the expected rate. Moreover, coal is highly compressible (~as high as 2x10-3psi-1). Variation of permeability and bottom hole properties during production requires accurate well test analysis using correct model. CBM reservoirs are of dual porosity system, which demands for special models of well test analysis. So, only static adsorption-desorption study can not suffice the analysis of coal bed methane production. As these properties will continuously vary during production, efficient & economic production of methane from coal bed requires constant monitoring and analysis of the system by experienced and proficient persons.

**Enhanced recovery techniques:**

The main hurdle associated with the production of CBM is the requirement of long dewatering of coal bed before production. This difficulty may be resolved to some extent with implementing the CO2 sequestration technology. Due to higher adsorption affinity of CO2 to coal surface, methane will be forced to desorb from the coal surface at comparatively high pressure and can reduce the dewatering time and hence the total project period. Also the problem associated with variation in coal properties related to pressure depletion may be alleviated. China, Australia, USA have been started to implement this technology for enhanced recovery of CBM gases.

## 4. CONCLUSIONS

CBM technology is proceeding with good space to prove itself as a cleaner energy security to India as well as the world. However, production strategy of methane from CBM is very much different from conventional gas reservoir. The study revealed that the coal type, rank, volatile matter and fixed carbon are strongly influence the adsorption capacity of methane into the coal bed. With increasing depth maturation of coal increases and generation of methane gas also increases. Gondwana basin as the most prospective CBM field is being developed now. From the studies, it is observed that Singareni coal field under Gandowana basin contains low gas Hence, presently it is not considered for CBM exctraction. However, in future this field may be considered for methane extraction using advanced technology and in emergency condition. Sequestration of CO2 helps in mitigation of global warming, at the same time helps in recovery of methane gas from coal bed unveiled otherwise. However, detailed and intensive studies are required for efficient and economic production of coal bed methane. India with ~4.6 TCM of methane reserves in coal bed can enrich its per capita energy demand by successful exploitation of CBM.

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