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AMITAVA CHAKRABORTY, P.K.TIWARI & A.K.SINGH

## **Coalbed Methane Exploration in A Tertiary Lignite Basin, North Gujarat, India**

### **Extended Abstract**

Coal Bed Methane (CBM) has emerged as clean unconventional energy source to augment the rising demand for conventional hydrocarbons. Over the past few decades tremendous impetuses to exploration of Coal Bed Methane has been given in countries including India endowed with considerable coal reserves.

The term Coal Bed Methane (CBM) refers to a form of natural gas, composed dominantly of methane, which is found in coal beds worldwide. This gas, which generates during coalification i.e. conversion of plant biomass by biological and geological processes into coal, is often categorized as unconventional gas because it is stored within the micropores / matrix of the coal) itself rather than within the inter-granular pores of the host rock (Levine, 1993).

The key parameters for the evaluation of CBM prospects are occurrence of adequate coal in a suitable depth range, coal rank and type, gas content, storage capacity, deliverability and gas composition. These parameters are ascertained by petrophysical, physico-chemical and geochemical analysis of coal cores and the desorbed gas samples. Coalbed Methane reservoirs essentially have dual-porosity where most of the gas is stored in the low permeability coal matrix (primary porosity) by sorption, the flow of gas to wellbore however, occurs through the coal's natural fracture system (secondary porosity), which stores relatively small amount of gas. Thus reservoir characterization plays the most crucial role in CBM exploration.

CBM Exploration in the acreage falling in Barmer-Sanchor Basin, covering an area of about 790 sq. km in Banaskantha Dist. of North Gujarat (Fig.1) was taken up by ONGC as operator. During Exploration Phase- 1, ten wells (8 core holes and two test wells) were drilled for generation of CBM specific data (Table-1) and to evaluate the CBM production potential of the block. The two relatively shallower prospective areas on eastern and western side of regional Sanchor Low (Fig-2) were taken up for drilling. In this area coals are confined to the Middle Tharad Formation of Middle Eocene age (Table-2). Eight core holes and two test wells were drilled to assess the CBM potential.

The Barmer-Sanchor Basin is an elongated N-S trending synclinal depression dipping towards south (Fig.1). The CBM exploration acreage area lies in the Sanchor tectonic Block which is delimited in the north by the Serau fault and the Tharad fault in the south. Geologically, this block lies at the junction of the Cambay basin to the south and Barmer Basin to the north. The area forms the southern part of Sanchor depression. Basalts of Deccan Trap form the Technical Basement in the area. The initial synrift basin fill sediment is of Paleocene age and is equivalent to Olpad Formation of Cambay rift basin. The Lower Tharad Formation overlies the mixed basin floor facies, which is equivalent to Older Cambay Shale. This shale grades upward into Middle Eocene Tharad Formation. The upper and middle members of Tharad Formation show widespread development of coal in and around the block under lower delta plain setting. The coals are overlain by shale sequence of Tharad Formation which is succeeded by Wav Formation of Oligocene sequence. The fluvial Mio Pliocene thickness is of the order of 1000m.

Extensive conventional coring in coal bearing horizons (74 cores with cumulative length of 618 m in 10 wells) were undertaken and a voluminous data pertaining to coal characteristics and their CBM potential like coal rank, type, thermal maturity, calorific value, mechanical, petro-physical properties, gas storage capacity and gas content of the coals were generated to evaluate the CBM Block. Onsite Desorption studies were carried out on 152 coal core segments, 30 cm each. The data so generated are

summarized in Table-1. The desorbed gas samples were subjected to chromatographic and isotopic analysis to know the composition of the desorbed gas and the genetic type of the gas i.e. whether these are of thermogenic, biogenic or of mixed origin. The two test wells were stimulated to delineate the production potential of these coals.

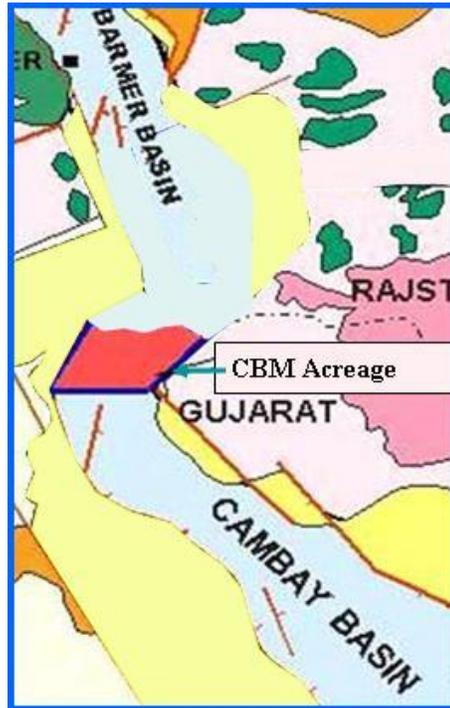


Fig: 1 Location map of CBM acreage area

Electrolog and core data have been utilized to enumerate the thickness and nature of disposition of coal seams. Log correlation profiles (Fig-3) have been prepared for better understanding of the continuity and thickness variation of the coal units in space and time.

Based on these data, structure and coal thickness maps for both the upper and lower coals (Fig: 4, 5 & 6) for the exploration area have been prepared. VSP survey data has been utilized for time-depth conversion to trace the top of the different litho-units in general and Middle Tharad coal top in particular in the composite seismic profile. The Structure and coal thickness map and the Electrolog correlation profile clearly shows thickening and deepening of coal seams towards the central low (Sanchar Low). Based on the log motif and nature of disposition, the Middle Tharad Coals have been divided into upper coal and lower coal (Fig-3).

Proximate Analysis data show that these coals are high in moisture (9-23%), very low in ash (2-9%) content with high Volatile Matter (30-55%) with low calorific value and are assigned Lignite Rank as per ASTM Coal Classification. The VRo% values of these coals are observed to vary between 0.28 to just below 0.4 indicating a very low thermal maturity. Desorption studies are performed mostly on coal cores at the drill site to determine the all-important gas content of a particular coal zone. Gas content of a coal and its producibility decide the fate of a CBM project. The gas content of coal has three components, namely Lost Gas, Desorbed gas and Residual gas and these together constitute the Total Gas content.

The gas content of the Lignites in the eastern prospect varies mainly from 2- 4gm/cc in the lower coal unit and 2-3.5gm/cc in the upper coal unit. In the western area gas content varies from 2.5 - 5 cc/gm in the lower coal unit and 3.5-5cc/gm in the upper coal unit. Higher gas content of 8-10 cc/gm has been reported in coal seams encountered at depths beyond 1440m in test well E. (Table-I).

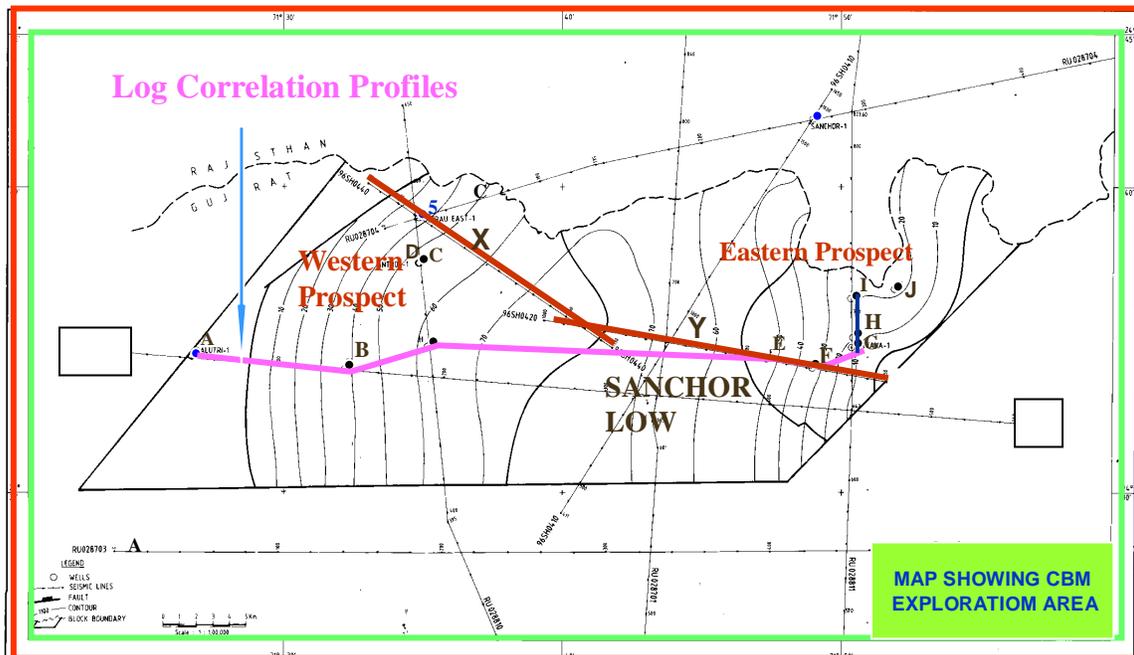


Fig-2: Map showing Eastern and Western Prospective area, Central Sanchor Low and well locations, correlation profile and merged seismic lines X and Y

Adsorption Isotherm generated for these coals show a high degree of under saturation as well as great difference between reservoir pressure and critical desorption pressure (fig-2a) implying prolonged dewatering before gas break-through. These coals are devoid of cleats, micro-cleats and fractures which make up the fairways for the gas to flow. Isotopic studies on desorbed gas indicate this gas to be of biogenic origin.

The two test wells C & E, in the western and eastern part respectively did not produce coalbed gas even after a dewatering for about one year. However, during dewatering, very little accumulation of gas was observed. Analysis of this gas showed their resemblance to the reservoir gas composition. The initial dewatering rate of about 10 M<sup>3</sup>/D was gradually reduced to about < 1 M<sup>3</sup>/D indicating very poor permeability of these coals. Thus, due to very low rank and thermal maturity, lack of cleats and fractures, high degree of under saturation, great difference between reservoir pressure and critical desorption pressure, coupled with great depth and poor permeability, these coals failed to produce coalbed gas.

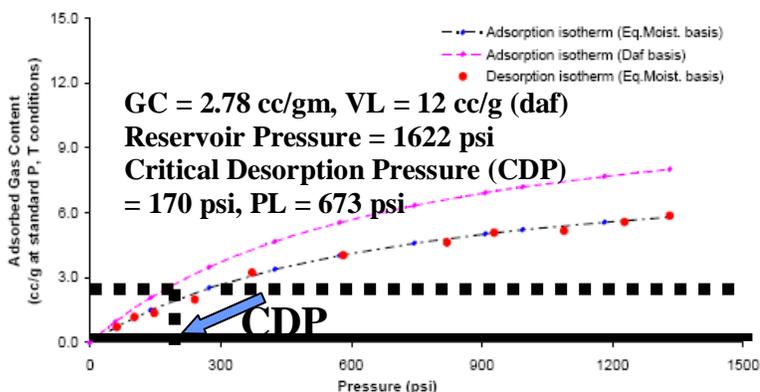


Fig-2a): Adsorption Isotherm from coal core of well-B

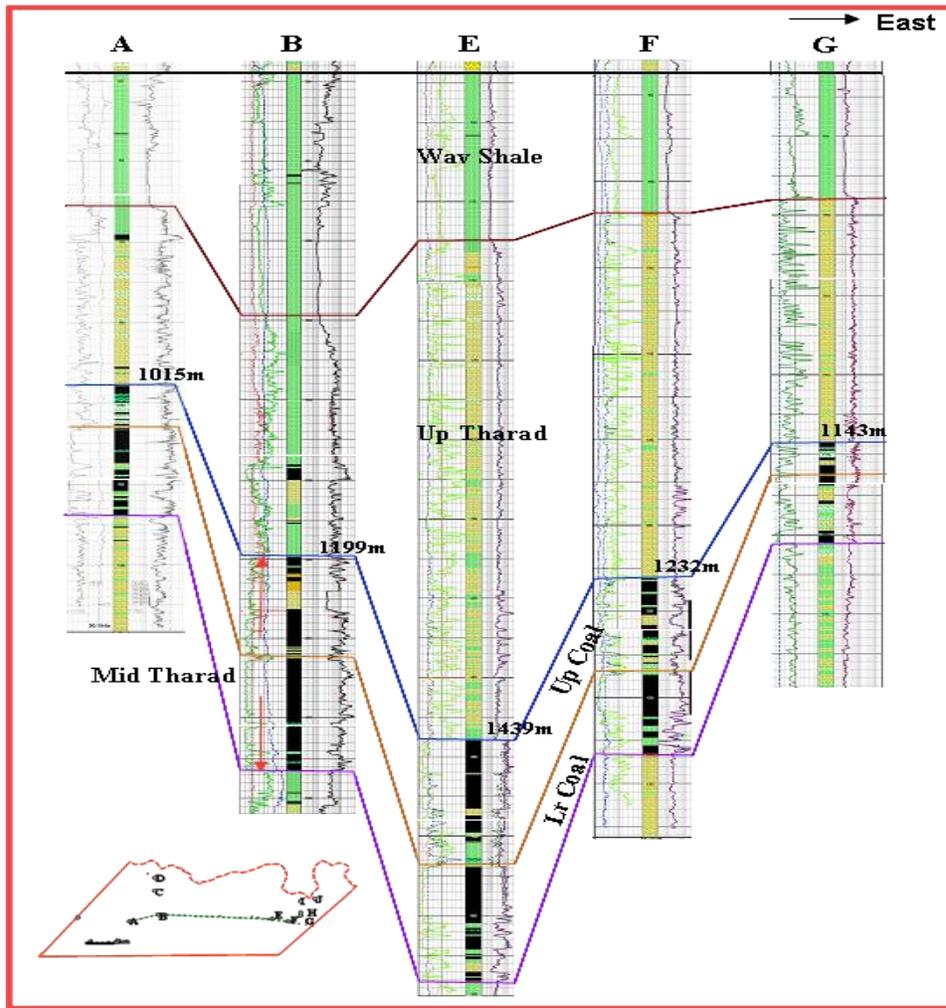


Fig -3 Electrolog correlation across Sanchor block showing Coal seams

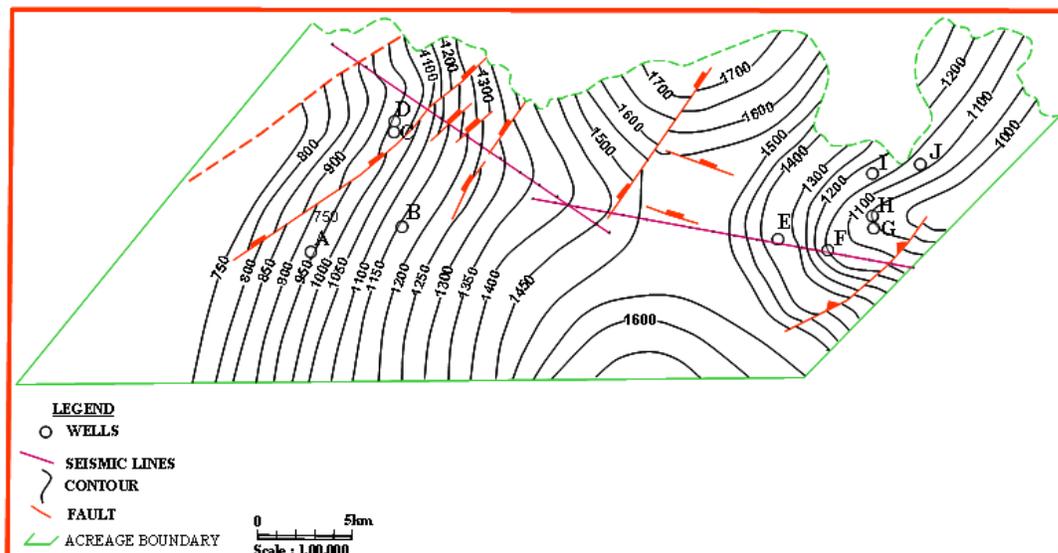


Fig-4 Structure Contour Map On Top Of Upper Coal - Mid Tharad Formation.

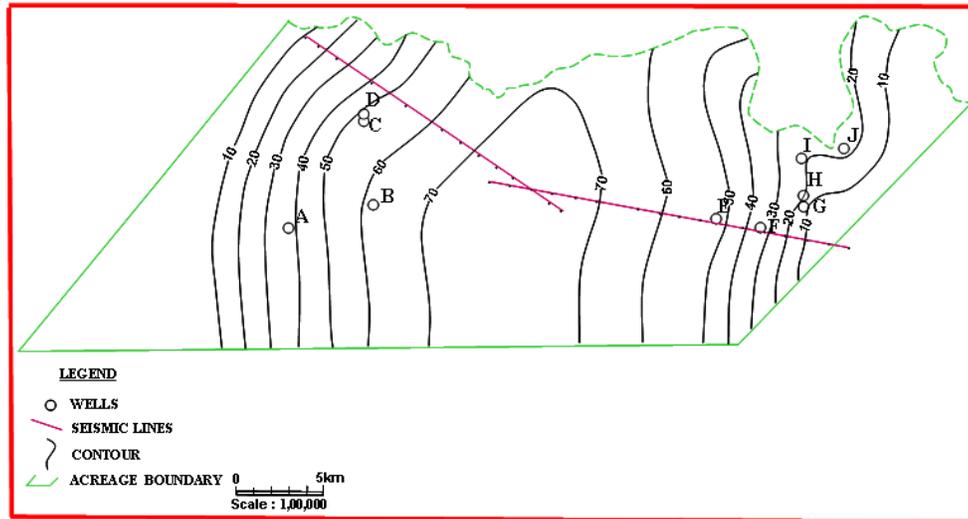


Fig-5 Net Coal Thickness Map Of Lower Coal-Mid Tharad Formation.

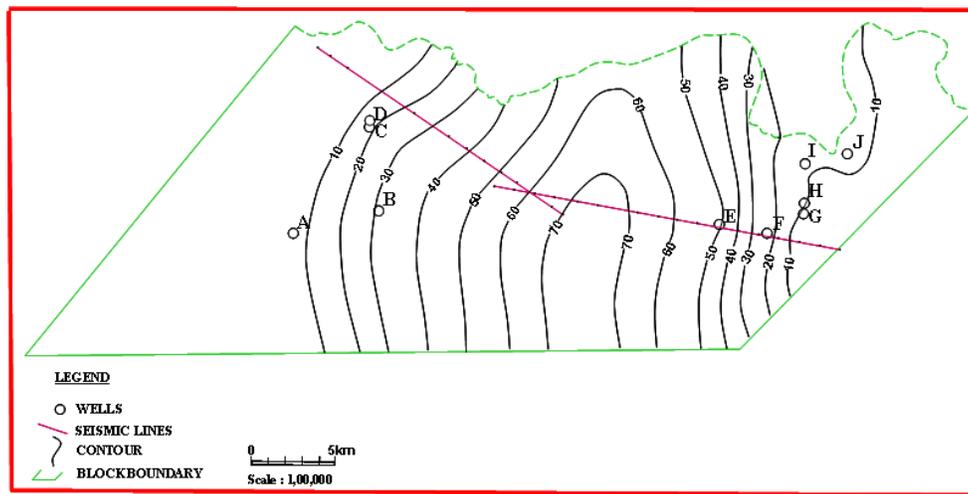


Fig-6 Net Coal Thickness Map Of Upper Coal-Mid Tharad formation

Summary Of Laboratory Studies on Coal Cores of Barmer-Sanchor CBM Wells

Table-I

Sector	Coal Layer	Moist (wt %)	Ash (wt %)	VM (wt%)	Langmuir Volume (VL) (cc/gm) (daf)	Langmuir Pressure (psi)	Gas Content (daf)	Saturation (%)	CH <sub>4</sub> Content (Vol%)	CO <sub>2</sub> Content (Vol%)	Huminite/Vitrinite Content (%)	Reservoir Pressure (psi)	Critical Desorption Pressure (CDP) (psi)	VRo %
West	Upper	17-25	4-11	34-48	10-15	760-900	3.5-5	25-43	41-56	23-39	67-81	1700-1950	250-470	0.28-0.37
	Lower	18-25	2-9	31-43	11-13	740-825	2.5-5	18-40	47-54	37-49	64-84	1600-2000	155-505	0.30-0.36
East	Upper	10-19	4-11	35-56	11-14	676-880	2-3.5	14-30	49-65	22-40	62-92			
							8-10*	58-75*						
	Lower	10-21	4-11	36-52	10-14	650-775	2-4	16-42	44-60	24-45	65-82	1800-2000	120-500	0.37
					17*		8*	62	66*	26		2400*	1026*	0.4

\* Test Well (E) data