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Research Article

ESTIMATION OF COAL BED METHANE POTENTIAL OF COAL SEAMS OF MARGHERITA COAL FIELD, ASSAM, INDIA

Prasenjit Talukdar[1*], Ranjan Das[2] and Rishiraj Goswami[1]

[1]Department of Petroleum Engineering, Dibrugarh University, Dibrugarh, 786002, Assam, India
[2]Oil and Natural Gas Corporation Limited (ONGCL), India

*Corresponding Author's Email: rrj.goswami@gmail.com

Abstract

The rapid industrialization and growing energy needs have put a great stress on the conventional energy resources. This is even more concerning for a country like India which is a net importer of oil. To meet the ever increasing need for energy, it is essential that the search for unconventional energy is intensified. This paper deals with the estimation of coal bed methane potential of the Margherita Coal Field of Assam, India. For this purpose, eight coal samples were collected from Tirap O.C.P., Ledo UG Incline and Tikak O.C.P collieries of the Margherita coal field. Proximate analysis, megascopic study and finally qualitative analysis of these eight samples was undertaken. After analysis, the inferred reserves of CBM at Margherita Coalfield, was found to be in the range of 42.5-49.04 Billion Cubic Meter.

Keywords: Coal Bed Methane; Proximate Analysis; Qualitative Analysis; Megascopic Study; Coal Bed Methane Reserves

Introduction

Margherita coal field generally known as ″The Makum Coal Field" is the most important in the entire North-Eastern India so far as the resource of coal and the infrastructural facilities are concerned. The Margherita coalfield lies along the outermost flank of the Patkoi range between the latitudes 27°15' and 27°25' North and longitudes 95°40' and 95°55' East and is well connected by roads and railway with the rest of the country. The coal seams are confined mainly within the basal part of Tikak Parbat Formation and also a few thin coal seams within the Baragolai Formation of Barail Group. Coal seams of Titak Parbat Formation are fairly thick where as those of Baragolai Formation are varying in thickness from 0.5 to 0.8 m only. Five regionally persistent coal seams were reported from the Margherita Coalfield confined within the basal 200 m section of the Titak Formation. (Geological Survey of India, 2009).

The Margherita coal, mined by Coal India Limited (CIL), can be utilized to produce methane entrapped in the coal bed, for the benefit of tea gardens to fuel existing tea dryers at a reasonable cost and run their electric generator sets (instead of using diesel) to power tea processing plants. The integrated use of methane for combined heat and power can convert coal's inherent energy into useable electricity more efficiently up to 50 percent or more. Otherwise, traditional coal-based thermal power plants can convert only one third of coal's inherent energy into electricity. Higher efficiencies translate into less costly power and potential savings for rate payers. A more efficient plant uses less coal, meaning fewer greenhouses gases. North-eastern India is industrially less developed due to many reasons. Although, one of the reasons is lack of inflow of investment from outside, the region also lacks adequate supply of skilled technicians and engineers to support the needs for faster growth and industrialization. Coal bed Methane, if produced commercially, can positively contribute for the growth of the region. Also, introduction of CBM technology may reduce country's dependence on foreign import of petroleum and natural gas.

Geological Framework

The regional geological structure of the Margherita Coal Field is represented by a well-defined, roughly NE-SW trending, doubly plunging asymmetric syncline known as Namdung Syncline. The syncline is narrow in the Namdung area in the SW and gradually widens out towards NE. The trend of the axis gradually changes to NE-SW eastward and to ENE-WSW further east. The northern limb of the syncline is again folded into an anticline known as Ledo Anticline and corresponding syncline abuts against Margherita thrust towards north. Towards south, the southern limb of the syncline is cut off by the Haflong-Disang thrust. Broadly, the coalfield lies within the belt of Schuppen and is bounded by the Margherita thrust in the north and the Haflong – Disang thrust in the south.
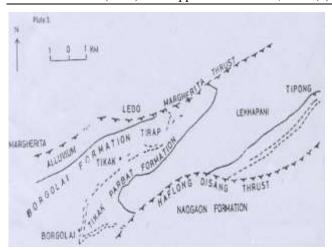
Fig. 1: Map of the Margherita Coal Field, Assam

Methodology

For the study of the prospects of the Coal bed Methane of the Margherita Coal Field, eight samples collected from the following collieries – Tirap O.C.P., Ledo UG Incline and Tikak O.C.P., during field survey were studied for evaluation purpose.

Proximate analysis of the coal samples (Procedure)

Proximate analysis of the coal samples are usually carried out on "Air Dry Basis". First samples are left in the open air for a few days to dry out. They are sometimes are kept at standard conditions of 60% R.H. and 40°C. After that samples are completely powdered and passed through 200 mesh sieve. Then sample of 1 gm is taken in a platinum crucible and heated in an oven.

After this the proximate analysis of the particular coal sample is carried out. Proximate analysis includes determination of Moisture content, Ash content, volatile matter content and fixed carbon.

1) Moisture Content

Heating temperature = 104^0C-110^0C

Weight of the sample = 1 gm

Time = 1 hour

Moisture in analysis sample percentage $= \dfrac{A-B}{A} \times 100\%$

Where A = gm of sample used

B = gm of sample after heating

2) Ash

Heating temperature = 700^0C-750^0C

Weight of the sample = 1 gm

Time = Heat to redness and complete ignition

Ash in the analysed sample percentage $= \dfrac{A-B}{C} \times 100\%$

Where A = weight of crucible and ash residue in gm

B = weight of the empty crucible

C = weight of the analysed sample used

3) Volatile Matter

Heating temperature = 950^0C $\pm 20^0$C

Weight of the sample = 1 gm

Time = 7 minutes

Weight loss percentage $= \dfrac{A-B}{A} \times 100\%$

Where A = weight of the sample

B = weight of the sample after heating

Volatile Matter Content = C-D

Where C = weight loss %

D = Moisture %

4) Fixed Carbon

The value obtained by the difference between the sum of moisture content, volatile matter content and ash content in a sample of coal, and 100 is taken as fixed carbon.

For the estimation of the CBM resources and recoverable reserves various methods are used depending of the available data:

- Quantitative estimation
- Qualitative estimation

Quantitative estimation can be done where exploration for CBM advanced to some extent and core/cuttings and bore hole data are available. Since these data are not available for the Margherita Coalfield, for our investigation, we have adopted Qualitative Estimation methods for the estimation of the CBM.

Qualitative Estimation

The method is based on adsorption capacity of a specific sample of coal. There is a direct correlation between the volatile matter and vitrinite content and a relationship between the volatile matters in coal versus the linear volume of the methane generated.

1) Meissner's equation

The volume of the methane gas generated is empirically related to the volatile material of the coal. This is given by Meissner's equation-

Methane (cc/gm) ≈ - 325.6 log   VM % (daf) / 37.8 (Eqn. 1)

It is assumed that the volume of the methane generated is at 20^0C and at 1 atmosphere pressure.

This equation indicates that thermogenic methane is initiated when coal reaches 37.8% volatile matter.

Application of this formula to inertinite rich coals would result in an erroneous quantity of gas generation.

2) Gas Resources

Gas resources can be estimated from Gas in Place (GIP) calculation. GIP is calculated as:

$$GIP = GC \times h \times A \times R \qquad \text{(Eqn. 2)}$$

Where, GC = gas content (m³/ton), h = coal thickness (ft),

A = area, R = coal density (tons/ acre-ft)

Megascopic study of the coal samples and proximate analyses data of these samples are given in the Table 1 and Table 2.

Results and Discussion

Gradation of Coal under study

The coal rank and grade can be estimated by the value of Vitrinite Reflectance (R0 %). The Vitrinite Reflectance is calculated by the formula (Rice, 1993) which is as follows.

$$R0 \% = -2.712 \times \log (VM) + 5.092 \qquad \text{(Eqn. 3)}$$

The R0% varies from 0.42% to 0.65 % (Table 4).

From the proximate analysis and value of vitrinite reflectance (Ro), it can be estimated that the coal samples under study belong to lignite to sub-bituminous rank.

From the results it was observed that the ash content varies from 0.72% to 5.88%. Proximate analysis of the investigated coal samples reveal that the moisture content varies from 1.30% to 3.35%. whereas volatile matter ranges from 44.13 % to 52.45% and fixed carbon content varies from 39.45% to 51.72%.

For estimating the CBM resources of the Margherita Coal Field, we can use the GIP calculation, which is

$$GIP = GC \times h \times A \times R$$

Now, since the coal thickness and area is unknown for this field, a different approach has to be adopted. As height into area is the volume and density is the mass upon volume, one has-

$$GIP = GC \times h \times A \times R$$

$$= GC \times V \times R, \text{ But } R = M / V$$

$$= GC \times M / R \times R$$

$$= GC \times M \text{ (m}^3\text{/ton} \times \text{ton)} \qquad \text{(Eqn. 4)}$$

Where M= mass (ton) and as mass of the reserve either proved, indicated or inferred.

The total coal reserves of Margherita Coal Field as on 01.04.2009 (Geological Survey of India, 2009) are given in the Table 3.

An attempt is made to find out the volume of the thermogenic methane, generated from a coal by using Meissner's equation. As per this equation, any coal having volatile matter more than 37.8% should generate no methane at all.

Since the coal of Margherita Field has volatile matter more than 37.8% that means the coal contains no methane. But, there are case histories where lignite to sub-bituminous type of coal contains good amount of CBM on commercial basis.

Most of the gas in coal is adsorbed on the internal surface of micro pores and varies directly with pressure and inversely with temperature.

Table 1: Proximate analysis data of the coal samples

Sample No.	Moisture Content (%)	Ash (%)	Volatile Matter (%)	Fixed Carbon (%)
1	1.42	2.85	49.10	46.63
2	3.35	4.75	52.45	39.45
3	1.39	5.85	46.44	46.32
4	2.20	3.01	49.68	45.11
5	2.23	5.88	43.10	48.79
6	2.21	5.33	44.13	48.33
7	1.30	3.10	52.16	43.44
8	1.88	0.72	45.68	51.72

Table 2: Megascopic Study of the collected samples

S N.	Sample Details	Colour	Streak	Hardness	Density	Cleat Density
1	Top of 20 feet seam, Tirap open cast mine	Black	Black	Low	Low	3-4 fracture per cm
2	Bright band of 4 feet seam, Tirap open cast mine	Black	Black	Low	Low	2-4 fracture per cm
3	Middle of 20 feet seam, Tirap open cast mine	Black	Black	Low	Low	1-2 fracture per cm
4	Bottom of 20 feet seam, Tirap open cast	Black	Black	Low	Low	3-4 fracture per cm
5	Bottom of 60 feet seam, Ledo underground mine	Black	Black	Low	Low	1-2 fracture per cm
6	Top of 60 feet seam dull variety, Ledo UG. Mine	Black	Black	Low	Low	4-5 fracture per cm
7	Bottom of 20 feet seam , Tikak open cast mine	Black	Black	Low	Low	3-4 fracture per cm
8	Middle of 60 feet seam , Tikak open cast mine	Black	Black	Low	Low	2-3 fracture per cm

Table 3: Coal reserves in the Margherita Coal Field (million tonnes)

Depth	Proved	Indicated	Inferred Exploration	Inferred Mapping	Total
0-600	315.96	11.04			327

The relationship between the volume of adsorbed gas with pressure and temperature based on the moisture and ash content of coal samples was estimated by

Kim's empirical equation (Kim 1977), which is as follows:

$$G_{af} = (100-M-A)/100 \times 0.75 \times [k_0 (0.096h)^{n_0} - 0.14(1.8d/100+11)] \quad \text{(Eqn. 5)}$$

$$k_0 = 0.8 \, FC/VM + 5.6 \quad \text{(Eqn. 6)}$$

$$n_0 = 0.315 - 0.01 \, FC/VM \quad \text{(Eqn. 7)}$$

Where G_{af} = Dry, ash-free gas storage capacity, cm^3/g, M = Moisture Content (%), A = Ash Content(%), VM = Volatile Matter Content (%), FC = Fixed Carbon(%), d = Depth (m), k_0 and n_0 are constants depending on the rank and grade of coal.

The estimated gas content data of the eight samples is given in the Table 4.

Table 4: Estimated Gas Content of the Samples

Sample No.	Depth(m)	$G_{af}(cm^3/g)$	R_0 %
1	492.2	12.80	0.5057
2	460	11.67	0.4280
3	495.23	12.5	0.5713
4	498.29	13.25	0.4919
5	488	12.46	0.6592
6	469.7	12.33	0.6314
7	465	12.44	0.4345
8	489.7	13.25	0.5908

According to the investigation it was found that most of the coal mines in this area are of degree III category. Means these are of gassy seams. It has also been found that the gas content of most of the coal seams of this area is >12m³/ton of coal.

Considering the reserve estimate of Margherita Coalfield from table 3 and methane gas content in the range of 13 to 15 m^3/ton, GIP is calculated to be:

Table 5: GIP calculations of Margherita Coal Field

Margherita Coalfield	GIP (Bcm)			
	Proved	Indicated	Inferred	Total
	41.07-47.39	1.43-1.65		42.5-49.04

Conclusion

Depletion of conventional resources, and increasing demand for clean energy, forces India to hunt for alternatives to conventional energy resources. Intense importance has been given for finding out more and more energy resources; specifically non-conventional ones like CBM, shale gas & gas hydrates, as gas is less polluting compared to oil or coal. CBM is considered to be one of the most viable alternatives to combat the situation.(Singh,2002)

CBM if produced commercially from this North-East region of India, then it can be beneficial in following areas:

- Provide electricity to an anchor customer i.e. the power-thirsty tea gardens and industries in the region which will boost the overall economic health of the region;
- Nearby tea gardens can use this gas for running their gas turbines and compressors.
- Can produce pipe gas for domestic use.
- Can be used in vehicles as fuel by converting CBM to CNG.
- Enhance the flow of capital into the region, thus increasing direct employment by utilizing local resources like coal and manpower for the economic growth of the region; and
- Generate tax revenues for the government and reduce the cost of power to a significantly large population and tea industries in the Upper Assam Area.

Conflict of Interest

None

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