Stable Isotope Geochemistry of Coalbed Gas with Special Focus on CO2

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Abstract

Coalbed gas is generated during coalification process and remain in the coal as an adsorbed form. This paper discusses the mechanism of generation of coalbed gas and identification of its origin. Two samples has been retrieved from exploratory borehole of Jharia Coalfield. Location of the study area was shown in figure 1. Gas content of these coal samples has been found and some gas is collected in glass bottle from desorption canister. After collection of this adsorbed gas, it was analyzed through gas chromatography and isotopic ratio mass spectrometer. Analyzed coalbed gas contains primarily CH4, ranges from 72.25% to 83.21% and CO2, ranges from 2.63% to 3.05%. Stable isotope geochemistry shows that isotopic fraction is between CH4, C2H6 and CO2. Stable isotopic fractionation and coalbed gas composition is shown in table 1. Isotope of δ13CO2 varies from -21.3% to -17.9%. CDMI and hydrocarbon index (CHC) was also calculated. CDMI index ranges from 3.51 to 3.54 which that coalbed gas might be of thermogenic origin. CHC index ranges from 68.77 to 95.07 % which shows generated CO2 is of organic in nature. Calculated dryness index ranges from 0.986 to 0.990 which shows that coalbed gas is dry to very dry in nature. Coal samples was characterized on the basis of petrochemical and petrographic for the coalbed methane recovery from Jharia Coalfield. Analyzed coalbed gas contains mainly thermogenic methane with substantial amount of biogenic methane. δ13CO2 for biogenic was assumed to be -20% to -15% for the samples. Biogenic proportion for the samples was observed 24.65% and 13.77% respectively while for thermogenic proportion, it was found around 75.35% and 86.23%.

Stable isotope geochemistry of coalbed gas with special focus on CO_2

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INTRODUCTION

- Coalbed gases are the mixture of mainly hydrocarbon and CO_2
- Geochemical analyses of coalbed gases help us to predict and prevent the gas outburst from mine and CO_2 is one of the main reasons for gas outburst
- Coalbed methane is unconventional source of energy to mitigate the growing energy demand of the globe
- CO_2 sequestration is often used to enhance the methane recovery from coalbed and often attributed as Enhanced Coalbed Methane Recovery
- In this paper stable isotopic analysis of coalbed gas has been done to identify the source and origin of coalbed gas for management to plan accordingly for reduction of gas outbursts

METHODOLOGY

- Two coal samples have been collected from exploratory borehole of Jharia coalfield (figure 1)
- Sample descriptions are shown in table 1
- Soon after retrieval of the samples from borehole, samples were sealed into the canister to measure the gas content
- During the desorption, gas samples were collected in gas samples bottle to find its chemical and isotopic composition
- Gas bottles were filled with NaCl solution as shown in Figure 2

Table 1. Samples description

Sample	Depth Interval	Mean Depth	Reservoir temperature (° C)	Reservoir Pressure (psi)
JJ/01	389.50-389.90	389.70	41.7 °C	549.9
JJ/02	472.51-473.05	472.78	47.2 °C	667.2

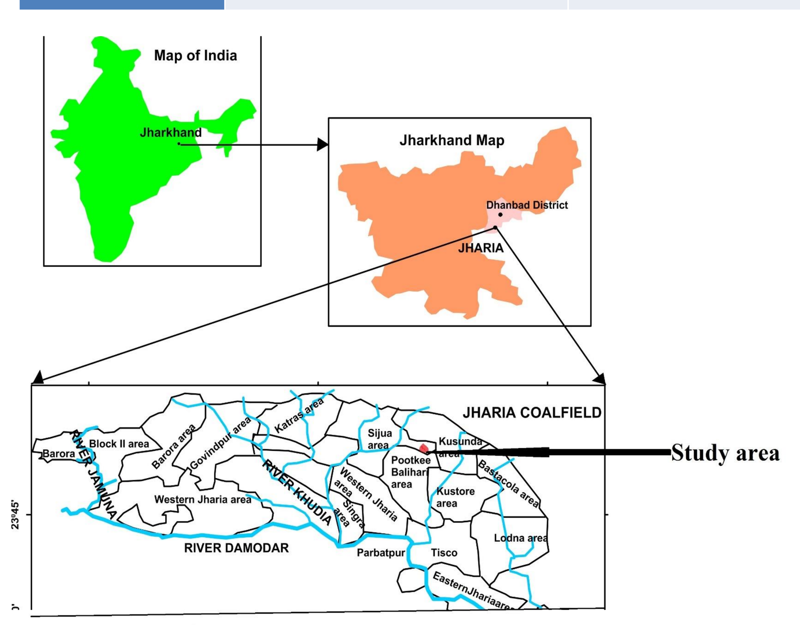

Figure 1: Location of the Study area

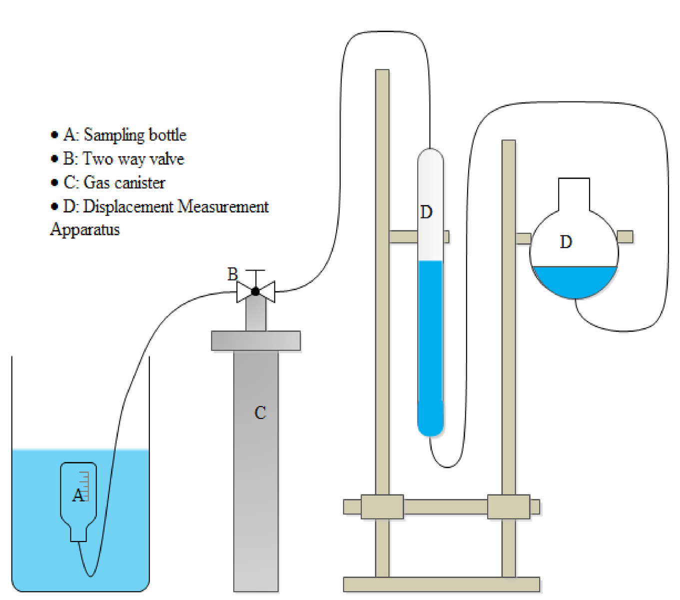

Figure 2. Gas sampling device

RESULTS AND DISCUSSIONS

- Stable isotopic fractionation and coalbed gas composition is shown in table 2

Table 2. Gas composition and stable isotope analysis

S.N.	Sample	C_1	C_2	N_2	Air	CO_2	$\delta^{13}C_1$	$\delta^{13}C_2$	$\delta^{13}CO_2$
1	J/01	83.21	1.21	4.59	7.94	3.05	-50.7	-18.9	-21.3
2	J/02	72.25	0.76	8.77	15.59	2.63	-45.5	-23.9	-17.9

- CDMI index ((Eq. (1)) ranges from 3.51 to 3.54 which shows that coalbed gas is of thermogenic origin

$$CDMI = \frac{CO_2}{CO_2 + CH_4} \times 100\% \tag{1}$$

- C_{HC} (Eq. (2)) index ranges from 68.77 to 95.07 which shows generated CO_2 is of organic in nature

$$C_{HC} = \frac{C_1}{C_2 + C_3} \tag{2}$$

- Dryness index (DI) (Eq. (3)) ranges from 0.986 to 0.990 which shows that coalbed gas is dry to very dry in nature

$$DI = \frac{C_1}{C_{1-5}} \tag{3}$$

- For the thermogenic gas, $\delta^{13}C_{CH_4}$ (X) was calculated from following equations: (R_0 for the sample was observed 1.43% and 1.78 respectively)

$$\delta^{13}C_{CH_4} = -26.20 \times \log(R_0) - 34.12 \qquad (R_0 < 1.30\%) \tag{4}$$

$$\delta^{13}C_{CH_4} = 25.85 \times \log(R_0) - 43.08 \qquad (R_0 \geq 1.30\%) \tag{5}$$

- Based on the past studies on stable isotope geochemistry, $\delta^{13}C_{CH_4}$ (Y) for the biogenic gas belongs in the range of -70% to -75%
- $\delta^{13}C_{CH_4}$ for biogenic gas is assumed the average of both the values i.e. -72.5% for these samples
- Thermogenic (x)and biogenic proportions (y) have been calculated from the following equations:

$$xX + yY = Z \tag{6}$$

$$x + y = 1 \tag{7}$$

RESULTS AND DISCUSSIONS

Z is the $\delta^{13}C_1$ for the coalbed gas

- Thermogenic proportion (x) for the samples was observed 65.20% and 75.20% respectively while for Biogenic proportion (y), it was found around 34.80% and 24.80%
- Results were tabulated in the following table

Table 2. Stable isotope analysis result

S.N.	Sample	CDMI	C_{HC}	DI	X	Y	x	y
1	J/01	3.54	68.77	0.986	-39.06	-72.5	65.2	34.8
2	J/02	3.51	95.07	0.990	-36.61	-72.5	75.2	24.8

CONCLUSIONS

- Current study shows the coalbed gas composition and stable isotope analysis of coalbed gas which is the basic study for the characterization of coalbed gas
- Analyzed coalbed gas contains mainly thermogenic methane with substantial amount of biogenic methane. Thermogenic gas is generated during the late stage of coalification
- Primary biogenic gas was observed in the studied gas samples
- This study gives the prior knowledge on CO_2 origin, so it is the ideal study for the CO_2 sequestration and Enhanced coalbed methane recovery
- Results of isotope analysis shows the complex mechanism of generation and accumulation of coalbed gas in coal

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