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The Coalbed Methane Potential from Sajau Coal in Eastern Part of Berau Basin, East Kalimantan

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Abstract: ***The coal seams of Sajau Formation in Berau basin, Indonesia are lignite to sub-bituminous in nature and categorized as high gaseous seams. To evaluation of coalbed methane (CBM) prospects have to attention the gas resources and deliverability. Proximate analyses of the investigated coal samples reveal that the average moisture content 53.02%, whereas, volatile matter 40.63%. The ash content is low which average 5%. Fixed carbon has average 39.42%. The study s on the adsorption isotherm experiments carried out under controlled P–T conditions for determination of actual gas adsorption capacity of the coal seams. The result shows that there is variation in methane gas holding capacity due to difference in burial history and relatively distance to fault core. Based on the comparison with other productive CBM in Powder River Basin; the Sajau coal in Berau Basin is a good prospective for CBM development.***

Keywords: Coalbed methane, Sajau coal, Berau Basin, adsorption

1. Introduction

The increasing demand for energy resources, especially oil and gas, as well as a growing concern of the effects of global warming that partly as a result of the sharp increase in anthropogenic greenhouse gas emissions; climate change will result in adverse implications for the various activities of human life. The results of the analysis of the International Energy Agency (IEA) show the grim situation of the earth, which is projected by 2030 will occur in the future economic development of developing countries in pace with the increase in the energy needs of industrialized countries that continue to move up as high as 40% of current needs.

To anticipate the possibility of poor arising from the global energy crisis (Doomsday) in the future; at this time in the world began to develop ideas of non-conventional energy use, one of which is methane gas in coal (CBM) as a source of energy. At this time CBM has become an important energy source in the world and one of them is in the United States, until the year 2010 recorded proved reserves of 17.5 TCF with achievement levels of production + 1.9 TCF per year produced from production wells located 15,000 in 20 different sedimentation basin, which included the Powder River Basin, San Juan Basin, Black Warrior Basin, while other countries such as Australia, Canada. China, India and New Zealand have begun to methane gas exploration on large scale in various major coal basins, and are approaching commercial production. The success of developing a methane gas obtained in low rank coals (sub-bituminous lignite) in various basins and tectonic regimes are different in different parts of the world has been well documented. The great resources coalbed methane which followed by produced in low rank coals in the San Juan Basin, Powder River Basin, Uinta Basin and the Raton Basin in the United States [1,2] , Surat Basin and Bowen Basin in Australia [3] and Ordos Basin in China [4,5]. Has opened a new paradigm that coal with a low ranking may give high CMB production; was not as reported in several studies that only coal with a high rank (bituminous coal - anthracite) which have great potential GMB. Vast lignite resources are under-utilized about 1 billion tones of in-ground lignite resources are present in Berau basin, Northeast Kalimantan, Indonesia [6] but to mined due to low rank coal.

The present work provides a coal characterization together with methane adsorption isotherm of coals from the Pliocene Sajau Formation in Berau Basin, East Kalimantan (Indonesia). The purpose of this paper is to: determination the gas storage capacity and measure the permeability and porosity of the coal core sample, and finally is to calculate gas-in-place based on the Berau basin

2. Geological Setting

The Berau Basin is located in the onshore of Northeast Kalimantan Island and was initiated simultaneously with the formation of the Sulawesi Sea by rifting of north and west Sulawesi from east Kalimantan [7] during the early Tertiary and which also led to the formation of the Makassar Strait. The evolution of Berau Basin with the formation of tectonic units is related to evolution of Makasar Strait as rifting tectonics during Early Eocene, and then followed by anti—clockwise rotation of Kalimantan with respect to the collision of micro-continent in Eastern Indonesia.

Berau Basin encompasses a wide variety of faults, structural elements and trends. Tectonics of the basin was initiated by extension and subsidence during the Middle to Late Eocene formed wrench faults arid resulted in the formation of major NW-SE oriented arches and had stopped by the end of Early Miocene [8]. The area was more tectonically stable from Middle Miocene up to Pliocene with deltaic sedimentation from the west. During this phase, the combinations of basin subsidence and gravity induced listric faulting created accommodation space for an increased volume of deltaic sediments of Latih, Domaring and Sajau Formations, which also caused the formation of roll-over anticline structures in the area. The coal seams in the Berau Basin are present within the following formations: Latih of Early to Middle Miocene age, Domaring of Late Miocene and Sajau of

Pliocene age. Coal samples in the present study originate from the Sajau coal in the Berau Basin.

The Sajau formation is composed of conglomerate, sandstone, siltstone, mudstone, shale and coal (lignite – sub bituminous). The dip angle of Sajau formation showed 10^0 to 15^0 toward east. The faults mainly appear as NW-SE normal fault and reverse fault and minor W-E normal fault; which divided the areas into three CBM compartment. The cleats were good developed in Sajau coal; distribution and orientation of face cleats shown NNW-SSE and NE-SW direction.

3. Samples and methods

Eight samples were taken directly from the coal drilling of the Berau Basin (5 samples from the A seam) and (3 samples from the B seam). All coal samples originate from the Sajau Formation (seam A and B). The coal samples were split and subjected to methane adsorption isotherm measurements, proximate analysis and MICP analysis. Location of the coal samples is shown in Fig. 1.

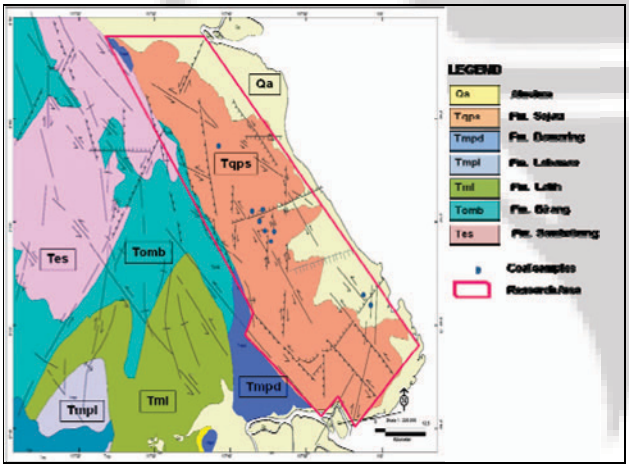

Figure 1: Geological map of Tanjungredeb Sheet showing the location coal samples of Sajau coal Formation in Berau Basin

3.1. Gas adsorption

Samples for adsorption were collected to assess the potential methane holding capacity of the target coal seams. Adsorption samples were collected both from the freshly retrieved core. Adsorption analyses were conducted according to procedures outlined by CSIRO Australia at a reservoir temperature of approximately 32° C. All gas adsorption analyses were conducted at the Coalbed Methane Laboratory Lemigas, Jakarta, For methane gas nine pressure steps were used up to a maximum pressure of 10 MPa. At each pressure step a fixed volume of gas was introduced and monitored to the nearest 1 kPa until there was no change in pressure for a period of at least 1 hour. Equilibrium generally took around 2 - 4 hours to obtain. Adsorption isotherms for both gases were fit to the Langmuir equation assuming a mono-layer gas adsorption mechanism [9] and results have been standardized to 20°C and 1 atmosphere pressure.

3.2. Mercury Injection Capillary Pressure

The mercury injection capillary pressure (MICP) was used to measured the coal porosity by injection of mercury at 60,000 psia mercury is forced through pore throat diameters as small as 36 Å. The MICP test was done in Coalbed Methane Laboratory, LEMIGAS, Jakarta.

4. Result and Discussion

The Sajau coal seam is classified lignite to subbitumibous (ASTM Standard) rank with low ash and low to high sulphur contents. Sajau coal well cleated. Coal quality results from the current research (Table 1).

Table 1: Sajau coal average properties

Coal Parameters	*Value*
Total Moisture % (ar)	53.02
Inherent Moisture % (adb)	16.29
Ash % (adb)	3.71
Volatile Matter % (adb)	40.63
Fixed Carbon % (adb)	39.42
Sulphur % (adb)	1.28
Gross Calorific (BTU/Lb (adb)	8001.09

Measurement of adsorption capacity to a standard dry and ash free basis (daf and ar basis) of the entire coal sample under study in the depth range 150-200 meters (coal seam A, B). Adsorption isotherms are shown in Fig.2 and presented for all samples in Table 2. The result shows the considerable variation in both the methane holding gas capacity within and between seam and drilling location with a range in holding capacity at 4 MPa from 45.69 scf/t to 465.57 scf/t (daf). The maximum amount of methane gas adsorbed in A coal seam is observed in sample MNH-1, A (V = 465.57 scf/t, daf, at a pressure of 2410 psi) and the minimum amount of gas adsorbed is found in sample CH-34, A (V = 50.49 scf/t, daf, at a pressure of 2.05 MPa). In the B coal seam the maximum adsorption capacity is recorded in sample ID MNH-1,B (V = 391.85 scf/t daf at pressure 2260 psi) while the minimum amount was observed in sample ID CH-53 B (V = 45.69 scf/t daf at pressure 3879 psi).

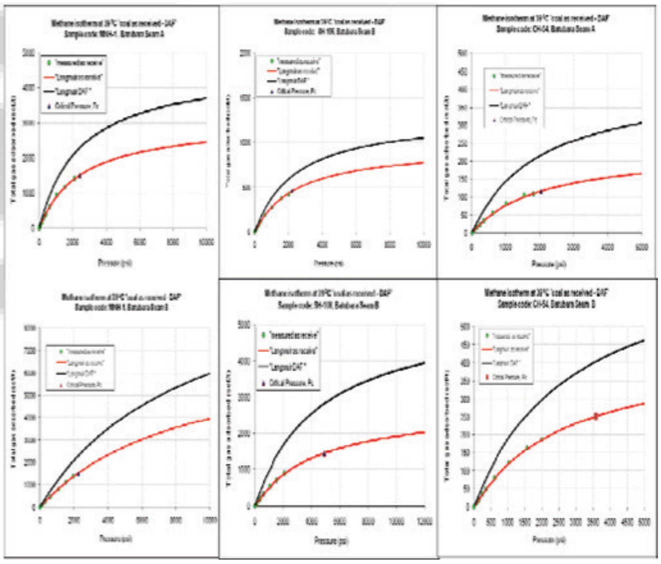

Figure 2: Representative methane gas adsorption isotherm at variable pressure from Tanah Kuning Block (left), Mangkupadi Block (centre) and Kasai Blok (right).

Table 2: Adsorption isotherm data for all samples collected from the Berau Basin

Sample ID	Coal Seam	Depth	Langmuir Isoterm		Adsorption Capacity
			VL (daf)	PL	
		(m)	(scf/t)	(psi)	(scf/t)/daf
TANAH KUNING BLOCK					
MNH-1	A	200,00	4622	2410	465,57
MNH-1	B	155,45	4528	2260	391,85
MANGKUPADI BLOCK					
CH-122	A	170,69	3216	2720	259,79
CH-102	A	159,11	2126	1660	248,35
CH-34	A	178,00	426	2049	50,49
CH-54	A	199,64	430	2012	51,80
CH-53	A	179,10	1238	4086	70,61
CH-101	A	192,00	2697	4614	137,10
CH-83	A	194,10	2999	8786	88,73
CH-54	B	178,61	844	3585	54,30
CH-53	B	164,15	828	3879	45,69
CH-101	B	169,90	5310	7874	153,54
CH-83	B	166,30	1374	3291	89,57
KASAI BLOCK					
SH-101	A	200,00	2958	8856	88,66
SH-101	B	198,17	3320	4671	183,04
SH-108	B	182,88	5652	4910	273,61
SH-106	B	154,84	1316	2464	104,18

The results of the study are shown in Table 1 indicate that there are differences in the ability to store methane gas in coal even though the samples lies in the same depth and comes from the same coal seam as shown in measurements in wells MNH-1A (465.57 scf/ton; 200 m depths) and SH-101A (88.68 scf/ton; 200 m depths). In B coal seam we also found that MNH-1B (391.85 scf/ton; 155.45 m depths) have the higher methane gas holding capacity compare the sample from SH-106 B (104.18 scf/ton; 154.84). The methane gas holding capacity tends to increase with the burial depth and is also influenced by the relative distance to the fault core. The sample location MNH-1 (A, B) has a greater distance than the distance from SH-101 (A) and SH-106 (B) to the fault core. Therefore, faulting should be one of important factor that affect the local distribution of CBM holding capacity, as mentioned by some researcher [10, 11, 12]. Thus faults that developed in the study area can serve as a boundary for CBM prospect zones.

The MICP Φ for Sajau coal is between 7.92% and 12.04%. That wide range demonstrates significant variation in gas storage capacity. The Sajau coal has averages 10.98% MICP Φ which shows that coal can be successful coalbed methane reservoirs. MICP matrix permeability of the Sajau coal is low to moderately, ranging from 0.457 to 14.57mD. In-situ permeability measurement has not been determined with confidence for the Sajau but is generally higher than matrix permeability because it includes fractures and faults. The average coals pore size was dominated by macro-pore (> 1000 nm in diameter) is 19.2%; and transition pore (10–100 nm in diameter) is 47.1%, while mesopore ((100–1000 nm in diameter) is 9.5%, and transition pore (10–100 nm in diameter) is 27.1% and micropore (below10 nm in diameter) is 23.2%. Therefore a significant proportion of the gas stored in coal may occur as adsorbed gas within transition and micropore.

The calculation of Gas in-Place (GIP) based on the formula

$GIP = 1{,}359.7\ hA\rho GC$ (1)

Where:

GIP = Gas-in-Place, scf
A = Reservoir Area, acres
h = Thickness, feet
ρ = Average In-Situ Coal Density, g/cm3
GC = Average In-Situ Gas Content, scf/ton

The calculated GIP as shown in Table 3.

Table 3: Gas in Place of Sajau Coal

Paramters	Units	Seam A	Seam B
Prospect Area	Sq. km	1276.40	1276.40
Bulk Volume	Acre Ft.	20,515,142.51	27,343,811.38
Net Gross	Frac	0.75	0.75
Net Volume	Acre Ft.	15,386,356.90	20,507,858.54
Density	gr/cm3	1.27	1.27
Phie	Frac	0.034	0.034
Swe	Frac	0.85	0.85
Bg	Rcf/scf	0.0042	0.0042
Volume Free Gas	TCF	0,81	1.09
Volume Adsorbed GasTCF		6.69	8.17
Total Gas in Place	TCF	7.50	9.26

To determine the extent of the CBM potential of low rank Sajau coals in Berau basin then be compared to the CMB productive from Powder River Basin (USA) as one of the famous CBM with low rank in the world. Comparison of Hawkdun Coalfield (HCN) & Powder River Basin (PRB). The comparison can be seen in table 4.

Table 4: Comparison of Powder River Basin and Hawkdun Coalfield [13] with the Sajau Coal Berau Basin

Paramters	PRB	SJB	HCN
Prospect Area (km2)	66820	1276.40	16.65
Coal Resource in grond (MT)	1,07 trillion	1,000 million	674 million
Coal depth	0 - 760	0 - 350	0 - 300 +
Coal Thickness (m)	91	63.87	83
Coal Rank	Lignite Subituminous	Lignite Subituminous	Lignite
Ash contents (%)	5%	5	10%
Matrix Permeability (md)	0.001 - 1.0	0.475 - 2.52	0.15 - 1.5
Absolut permeability	-	14.57	-
In situ permeability (m)	up to 1	-	-
Adsorption capacity	100 to 800	45.69 - 465.57	17.65 - 70.62

PRB : Powder River Basin; SJB : Sajau Coal Berau Basin, HCN : Hakwdun Coal New Zealand

Based on the similarity coal resource, coal seam thickness, depth, quality and coal rank between PRB and Hawkdun and Sajau coal, the Sajau coal in Berau basin have a good potential prospect. Coalfields despite the difference adsorption capacity matrix permeability; Sajau coal have more higher than PRB and HCN. The Sajau coal has a very good absulut permeability of 14.57 mD make the prospect have good gas deliverability.

5. Conclusion

The adsorption and reservoir investigation has indicated the Sajau coal ion Berau basin is prospective for coalbed methane development. This variation in the amount of CBM adsorption capacity can be attributed to the structural modification after coalification . Based on the results of this study, the potential of CBM in Berau basin area can be developed so that the problems of energy shortage in the future can be resolved.

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