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Coalbed methane potential and coal characteristics in the Lati region, Berau basin, East Kalimantan

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ABSTRACT

A geological research was performed in the Berau Basin, to provide a better understanding on the potential and resources of coalbed methane (CBM) in Berau Regency, East Kalimantan Province, particularly in the Lati Coalfield. Field observation conducted in the coalfield, shows that the banded to bright banded Lati coal is dominated by the bright banded one. Petrographically, the coal consists of vitrinite comprising typical telocollinite and desmocollinite; with rare to sparse exinite, and minor inertinite, and mineral matter. Geochemical analysis shows the range of volatile matter content is from 32.65–39.60%, total sulfur from 0.35–3.04%, ash varies between 2.78–14.50%, and moisture from 12.23–19.98%. Vitrinite reflectance values (Rv), varying from 0.42–0.57%, tend to indicate that the Lati coal rank ranges from sub-bituminous B to high volatile bituminous C category, with low ash content in general. Moreover, the coal maturity level, thermally immature to early mature, leads to the assumption that the expected gas present is suggested to be of biogenic origin. The fairly well cleated Lati coal shows cleat orientations trending north - northeastward, perpendicular to nearly oblique to the syncline axis. Furthermore, coal microcleat occurs as open tensional, sub-curved to curved lines microcracks, diagonally to perpendicular to bedding plane, but some are parallel to the bedding plane. An in-situ coal gas calculation tends to indicate a low to moderate methane content level, with a value of 44.20–47.08 scf/t. However, the Q1 plus Q2 calculation exhibits the gas content ranging from 41.69 to 78.71 scf/t. Moreover, total calculated gas in-place of the P, Q, and R Seams = 5.33 m^3/t = 191.56 scf/t.

Keywords: coalbed methane (CBM), Lati Coalfield, Berau Basin, East Kalimantan

SARI

Penelitian geologi yang dilaksanakan di Cekungan Berau, terhadap lapangan batubara Lati, Kabupaten Berau, Propinsi Kalimantan Timur, adalah untuk mengetahui potensi sumber daya "coalbed methane" di daerah tersebut. Pengamatan lapangan yang dilakukan di lapangan batubara menunjukkan bahwa litotipe batubara yang teramati berkisar dari "banded – bright banded", dengan dominasi tipe bright banded. Secara petrografi, batubara terutama tersusun atas kelompok maseral vitrinit berupa telokolinit dan desmokolinit; dengan sedikit eksinit, inertinit, dan bahan mineral. Sementara itu, dari analisis geokimia terlihat kisaran kandungan zat terbang antara 32,65–39,60%, belerang total 0,35–3,04%, abu 2,78–14,50%, dan air lembab 12,23–19,98%. Peringkat batubara Lati berkisar antara "sub-bituminous B" sampai "high volatile bituminous C", yang ditunjukkan oleh kisaran nilai reflektan vitrinit (Rv) 0,42–0,57%. Sementara itu, kisaran tingkat kematangan termal batubara dari belum-matang sampai awal matang, memperlihatkan bahwa gas metana yang akan dihasilkan berasal dari proses biogenik. Kehadiran "cleat" dalam batubara Lati yang cukup baik, berarah umum utara baratlaut, dengan posisi tegak lurus atau hampir menyudut terhadap sumbu sinklin. Lebih jauh lagi, "microcleat" dalam batubara muncul sebagai "microcracks" yang bersifat "open-tensional", berbentuk subkurva atau kurva, menyudut atau tegak lurus, dengan beberapa sejajar terhadap bidang perlapisan. Kandungan gas batubara secara perhitungan "in-situ" menunjukkan tingkatan rendah sampai menengah, dengan nilai 44,20 – 47,08 scf/t. Sementara *itu, dari penjumlahan Q1 dan Q2, kandungan gas berkisar antara 41,69 hingga 78,71 scf/t; sedangkan kandungan total gas in-place dari seam P, Q, dan R adalah 5,33 m^3/t atau 191,56 scf/t.*

Kata kunci: *"coalbed methane" (CBM), metana, lapangan batubara Lati, Cekungan Berau, Kalimantan Timur*

INTRODUCTION

Background

The increased exploratory interest in coalbed methane (CBM) is due to the growing recognition of its source. A notable predictable CBM expectation occurs in the Berau Coalfield (Figure 1), due to its geology and coal characteristics within the Lati (Berau) Formation. The coal characteristics significantly enhance the opportunity for profitable exploitation of the CBM resource in this area.

To gain a better understanding on the potential and resources of the CBM in the Berau Regency of the East Kalimantan Province, particularly in the Berau Coalfield, a coalbed methane research was performed in the Berau Basin, under the 2004-Coal Bed Methane Development Project (*Proyek Pengembangan Coal Bed Methane*), a program of the Research and Development Centre For Oil and Gas Technology (*Pusat Penelitian dan Pengembangan Teknologi Minyak dan Gas Bumi*) "LEMIGAS".

Several related previous research data gained from both published and unpublished types, predominantly the PT Berau Coal reports, have supported the current field and laboratory studies. More actual data, especially its coal geology of the Mio-Pliocene coal measures occupying the Berau Coalfield, can be revealed to decipher coalbed methane possibilities of the area.

Aims, Objectives, and Methods of the Study

The primary aim of the study is to collect information obtained from coal and its coal measures, both field and laboratory analyses. In order to define future exploration objectives in the region that is considered to contain rich CBM resources, to evaluate the CBM potential of the Mio-Pliocene Berau Coal Measures in the Berau Coalfield, is the focused of the study.

The specific objectives include to: (a) determine quantity and quality of CBM generated from the Berau

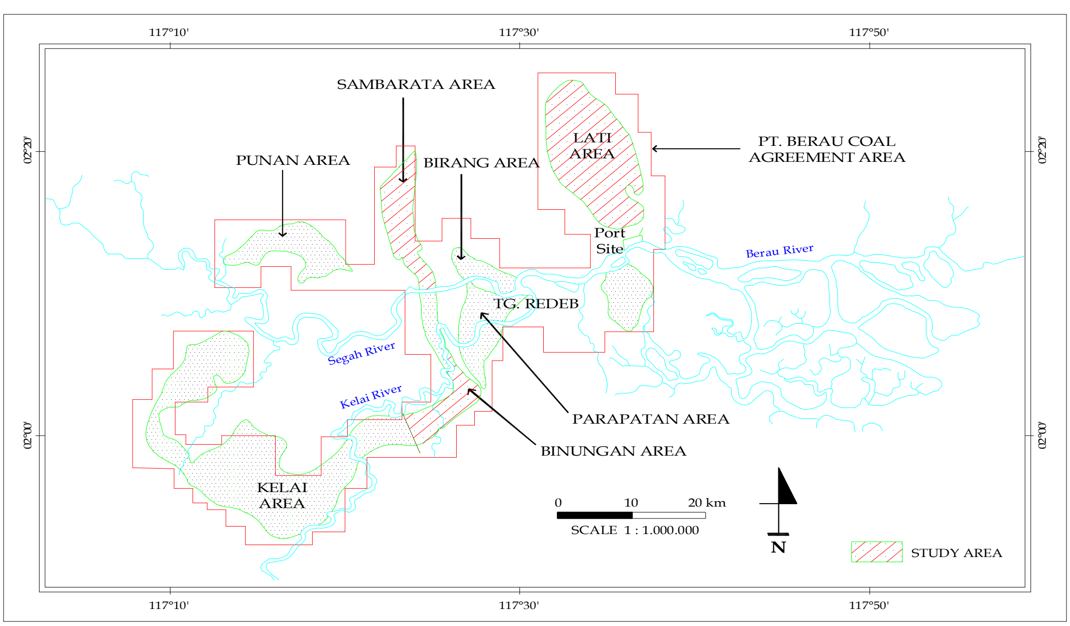


FIGURE 1. LOCALITY MAP OF THE STUDY AREA.

FIGURE 2. PHOTOGRAPH OF COAL SAMPLES OF SEAM P GAINED FROM THE CORE DRILLINGS.

FIGURE 3. PHOTOGRAPH OF COAL OUTCROP OF SEAM P AT A COAL WORKING FACE NEARBY THE DRILLING SITE, AS SHOWN IN FIGURE 2.

coals, and exploration implications of CBM as a source for new alternative energy, and (b) determine, analyze, and evaluate the characteristics of coal deposits related to the coalbed methane content.

In order to achieve the aims and objectives of the study, several geological field investigations and laboratory techniques were performed in 2004. The fieldwork investigations comprise detailed examinations, observations, and measurement on lithotype, cleat, stratigraphic position, and physical and chemical characteristics of the coals within the Berau Coal Measures. The study was focused on selected coal samples gained from the core drillings (Figure 2), supported by investigation on surficial and subcrop coals of the same seams nearby the drilling sites (Figure 3).

Furthermore, collection of field data and samples for organic petrology, SEM, and geochemical analysis purposes were conducted. The essential laboratory techniques deal with organic petrology including rank, volatile matter analysis, and micro-cleat determination. To gain effective gas seam information, preliminary determination on its adsorption index has been carried out.

The goals of this paper are to present new information of CBM potential, based on coal characteristic examination using both macroscopically and microscopically methods.

Terminology

Methane from Coal

Coalbed methane (CBM) is an economic source of methane gas that is generated and stored in coal beds. Methane, both primary biogenic and thermogenic gas types, present in coal is a result of coalification. However, in some cases, a post-coalification biogenic activity occurred. Coalification is a process by which peat is transformed into the stage of coal rank during progressive burial, involving the expulsion of volatiles, mainly methane, water, and carbon dioxide.

A bacterial activity associated with groundwater systems generates late-stage or secondary biogenic methane. Due to the presence of a well-developed cleat (fracture) system, most coals at shallow depth are aquifers. The sub-bituminous coals are the dominant target of coalbed methane exploration, due to the late-stage biogenic methane is significant and reaching a maximum phase at the sub-bituminous level or lower rank coal. Thereby, low rank coals that exist at shallow depths and crop out significantly may contain mainly late-stage biogenic (secondary biogenic) methane.

Gas stored within the organic molecular microstructure of coal is in four basic ways: (1) as limited free gas within the micropores and cleats of the coals, (2) as dissolved gas in water within the coal, (3) as adsorbed gas held by molecular attraction on coal particle, micropore, and cleat surfaces, and (4) as adsorbed gas within the molecular structure of the coal (Yee *et al*., 1993, *in* Montgomery, 1999).

The ability of any particular coal to store methane is a function of several factors, including coal rank and type, burial depth (increasing pressure and temperature allows for increased storage), and water saturation. Gas migration within the coal takes place by a combination of desorption, and free-phase flow, and occurs as a direct result of pressure decrease.

Gas content is also affected by moisture content, because potential gas sorption sites are occupied by water. The moisture content also inhibits gas sorption and significantly lowers coal sorption capacity (Joubert *et al*., 1973, *in* Montgomery, 1999). Thereby, gas contents are sometimes, corrected to a dry basis.

Kim (1977, *in* Scott *et al*., 1995) stated that the gas storage capacity of coal beds was generally assumed to correlate with coal rank. In lower rank coal, gas-release rates are faster than in higher rank coal. Coal type, rank, porosity/permeability, the presence or absence of seals, stratigraphic or structural traps, local pressure variations, and basin hydrodynamics, are the factors controlling the distribution of gas content in coal beds. Moreover, sampling procedure, sample type, coal properties, and analytical methods and coal quality are factors that affect gas content measurement.

Cleats

Cleats are natural fractures in coal, predominantly caused by stresses exceeding the strength of the coal. However, recent review of relevant data suggests that cleats are fracturing results from a number of interdependent influences, including lithification, desiccation, coalification, and paleotectonic stress (Close, 1993; *in* Ayers Jr., 2002). The cleats, face and butt, usually occur in orthogonal fracture systems. The face type is commonly perpendicular or nearly perpendicular to bedding, which impact significant permeability anisotropy to a particular coal reservoir for transferring methane. The face cleat orientation reflects the far-field stress present during their formation (Nickelsen and van Hough, 1967; Laubach *et al*., 1998; *in* Ayers Jr., 2002). The butt cleat is the less pronounced set. It generally forms parallel sets that are aligned normal to the face cleats, with relatively short fractures, often curved, and tends to terminate on the face cleat plane. Its origin is more obscure, but it may be related to the depositional and early coalification history of the seam concerned.

Cleats, which are best developed and most continuous in bright coal bands, but are poorly in dull coals, can be determined and observed by megascopic (macro cleats) and microscopic (micro-cleats, micropores, and micro-cracks) analyses.

Geological Setting

The fieldwork sites, located in the Lati region, cover the northeastern part of Berau Coalfield (Figure 1). The Berau Coalfield is situated in the Berau Basin. Administratively, the Lati region belongs to the Berau Regency of East Kalimantan Province.

The geological setting of the Berau area has been described in several published and unpublished reports cf. Situmorang and Burhan (1995a,b) and PT Berau Coal (1999; Figure 4). Geologically, the study area includes the Lati Syncline and Rantaupanjang Anticline. The fold, presented in a simplified geological map of the Berau area, shows NNW - SSE fold axis (Figure 4). During the Late Cretaceous-Early Tertiary, the basin, presumed to develop in a back-arc setting, was filled with Tertiary paralic to marine clastics.

Physiography

The Berau Basin, separated from the Kutai Basin by the Mangkaliat Highs (Tossin & Kadar, 1996), occupies the area along and around the Berau River, East Kalimantan (Figure 5). To the west, the basin is bounded by the Kuching Highs underlain by the pre-Tertiary rocks, whilst to the north; the Latong Highs separate the Berau Basin from the Tidung Subbasin.

Stratigraphy

The study area is occupied by the Sembakung, Tabalar, Birang, Lati, Labanan, Domaring, and Sinjin Formations, all overlain by the alluvial deposits (Situmorang and Burhan, 1995). However, according to PT Berau Coal (1999), the Tertiary units, occupying the region, comprise the Tabalar Marls (Tes), Lepidocyclina Limestone (Tol), Globigerina Marls (Tog), Sterile Formation (Tms), Berau Formation (Tmb), Labanan Formation (Tmp), and Bunyu-Sajau Formations (Tp) (Figure 4).

The Lati Formation (Situmorang and Burhan, 1995a & b) or the Berau Formation (PT Berau Coal, 1999) or the Berau Coal Measures of late Early to Middle Miocene age, is a potential coal-bearing unit in the area. The lower part, barren in coal seam, was deposited in a delta plain environment; whilst the upper part, deposited in a fluvial to upper delta plain zone, contains coal seams. The coal measures, generally, comprising quartz sandstone, claystone, siltstone,

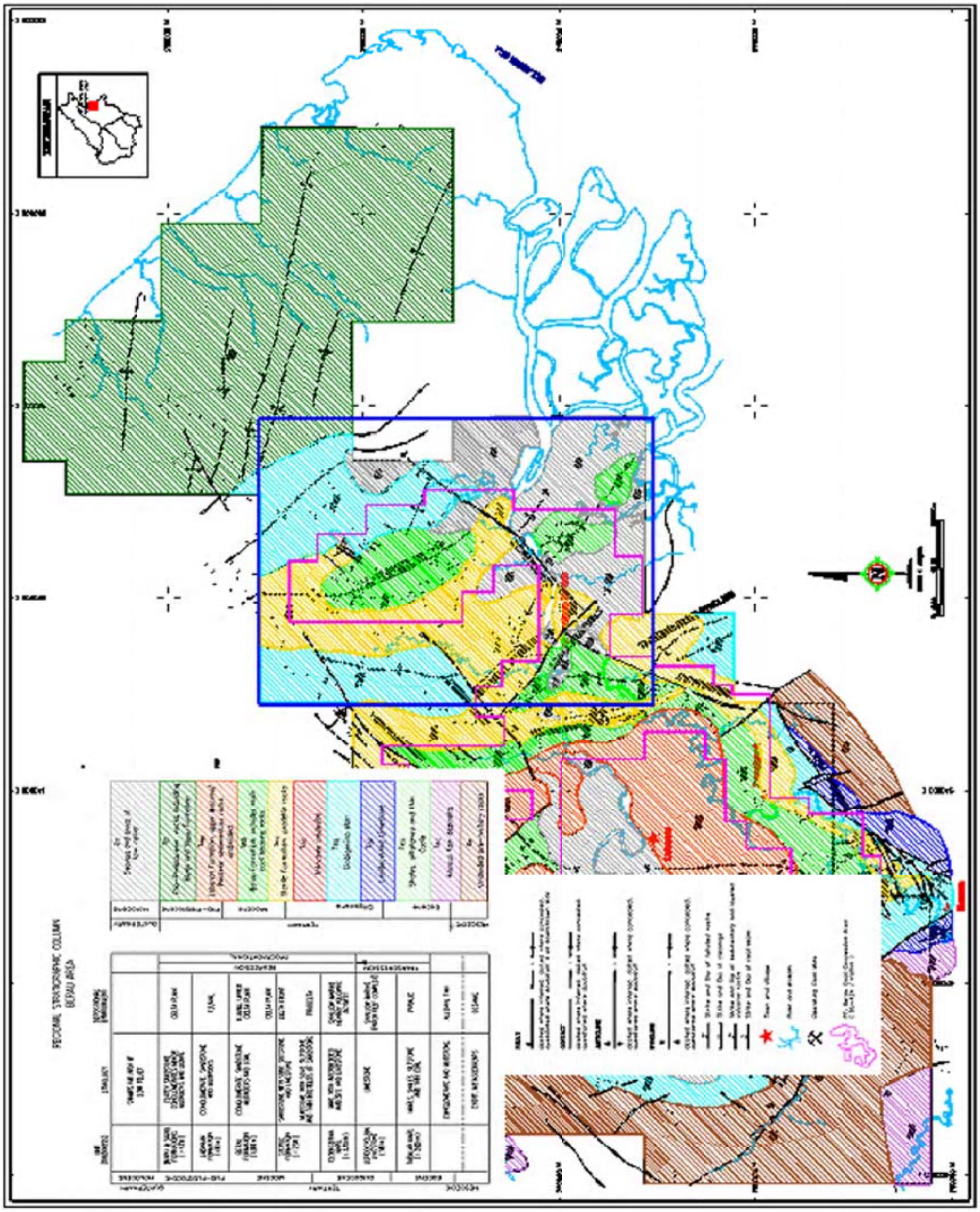


FIGURE 4. GEOLOGICAL MAP OF THE STUDY AREA (AFTER PT BERAU COAL, 1999).

conglomerate, and coals, alternate with sand shale in the upper part. The formation section is up to 800 m thick.

Results of Investigation

In the Lati area, located in the Lati Syncline, four coal seams, the P, Q, R, and T (Figure 6 – 8), gained from core drillings (Figure 2) were observed. Supporting observation on the same coal seam outcropping and subcropping next to the drilling sites was also performed (Figure 3).

Field Characteristics, Resources, and Lithotype

Coal cores and also outcrop samples, comprising Seam P (Figure 2 and 3), Q, R, and T, show average thickness of 2.41 m, 2.49 m, 3.03 m, and 2.40 m respectively. The estimated coal area of the Lati Region is 945,000,000 m^2. Megascopically, coals collected show lithotype ranging from banded (BD) to bright banded (BB). However, they are dominated by the

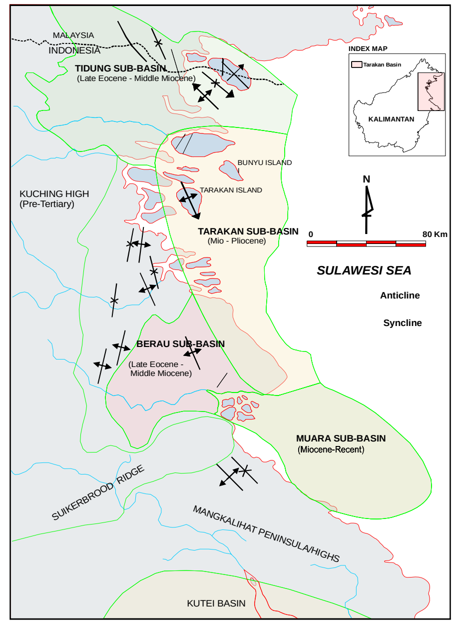
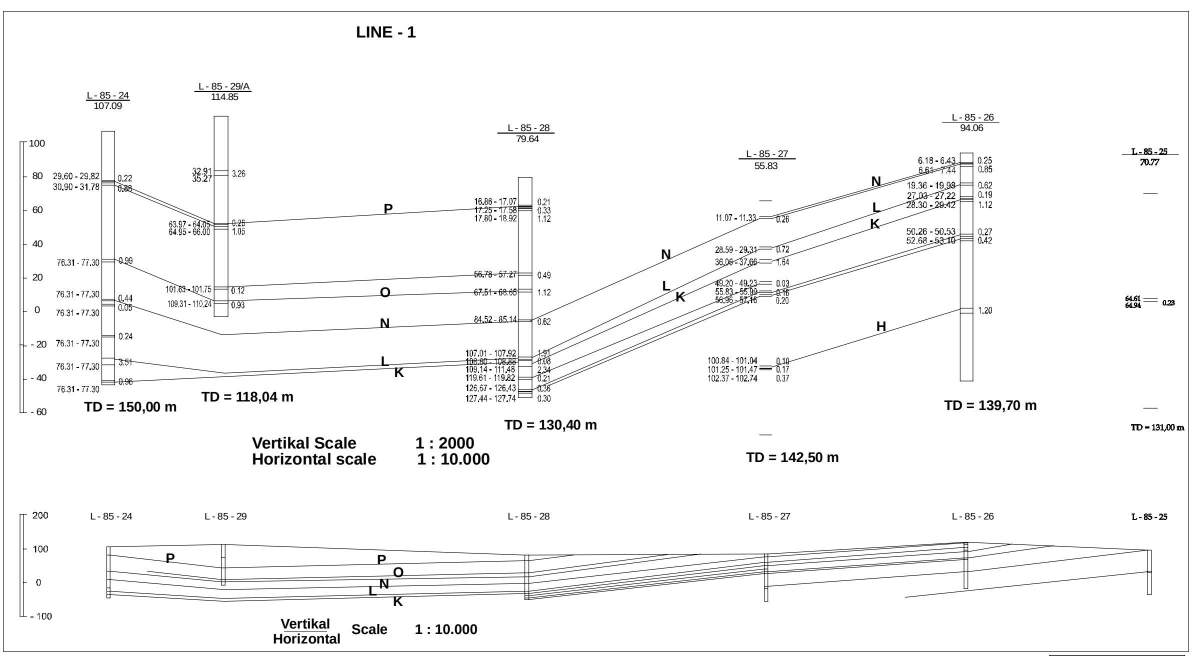


Figure 5. Basin map, showing the Berau Sub-Basin as southwestern portion of the Tarakan Basin (after Tossin & Kadar, 1996).



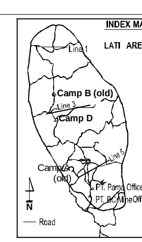
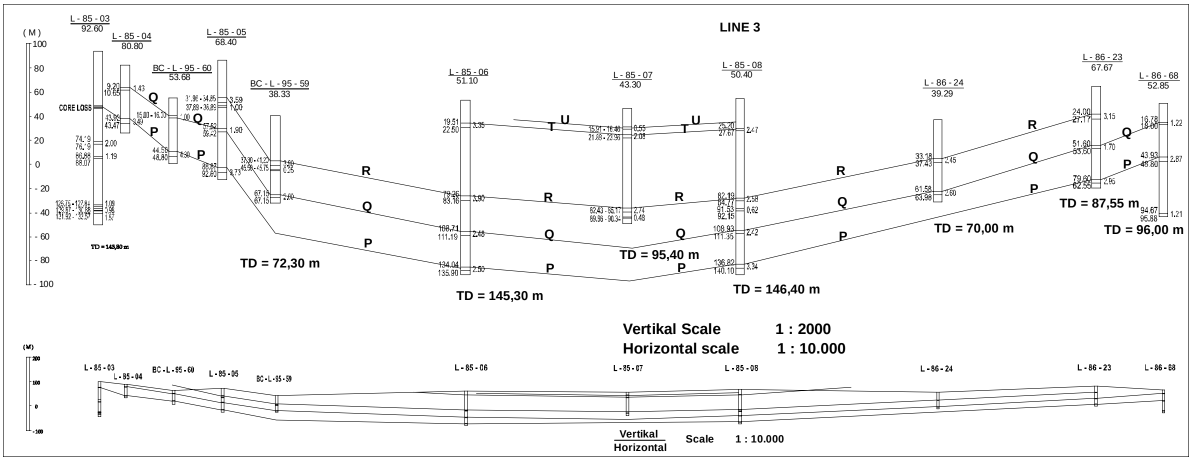


Figure 6. General correlation of coal seam in the Lati Area (Line 1) (PT Berau Coal, 1996).



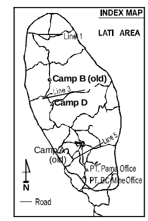


FIGURE 7. GENERAL CORRELATION OF COAL SEAM IN THE LATI AREA (LINE 3) (PT BERAU COAL, 1996).

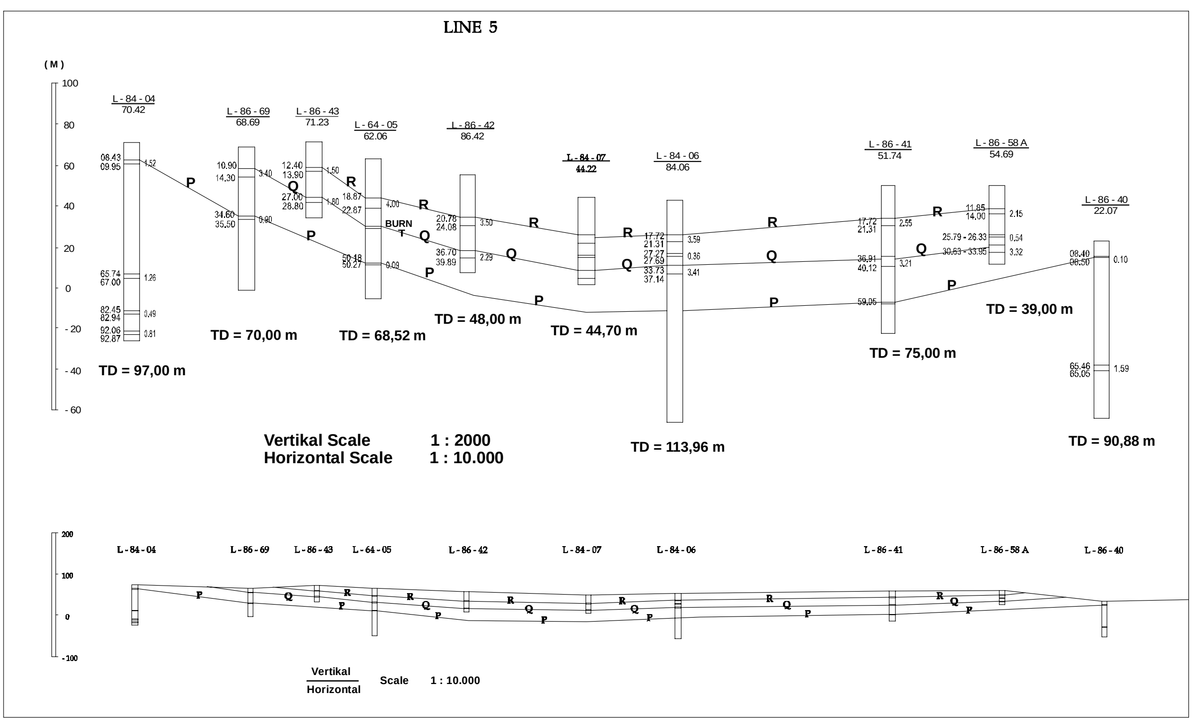


FIGURE 8. GENERAL CORRELATION OF COAL SEAM IN THE LATI AREA (LINE 5) (PT BERAU COAL, 1996).

TABLE 1. SELECTED INVESTIGATED LATI COAL SAMPLES OF THE BERAU COAL MEASURES

No.	Sample No. (04)	Seam	Type of Sample	Coordinates/Location	Lithotype
1	TS.01A	Q	Outcrop	N 02^{0}17'33.1"/ E117^{0}33'30.6"	Banded (BD)
2	TS.01B	Q	Outcrop	- " -	Bright Banded (BB)
3	TS.01C	Q	Outcrop	- " -	Bright Banded (BB)
4	TS.02A	R	Outcrop	N 02^{0}17'49.6"/ E 117^{0}33'42.3"	Banded (BD)
5	TS.02B	Parting	Outcrop	-" -	Tonstein
6	TS.02C	R	Outcrop	- " -	Bright Banded (BB)
7	TS.02D	R	Outcrop	- " -	Bright Banded (BB)
8	TS.03	R	Core	N 254 926.82 / E 561 330.00	Bright Banded (BB)
9	TS.04	Q	Core	- " -	Bright Banded (BB)
10	TS.05A	T	Outcrop	N 02^{0}18'1.9" / E 117^{0}34'19.5"	Banded (BD)
11	TS.05B	T	Outcrop	- " -	Bright Banded (BB)
12	TS.05C	T	Outcrop	- " -	Bright Banded (BB)
13	TS.05D	T	Outcrop	- " -	Bright Banded (BB)
14	TS.06	P	Core	N 02^{0}17'49.6"/ E 117^{0}33'42.3"	Bright Banded (BB)
15	TS.07	T	Core	N 256 635.47 / E 530 847.07	Banded (BD)
16	TS.08	Q	Core	N 256 862.67 / E 560 286.12	Bright Banded (BB)

bright banded type (Table 1).

The investigated lowermost portion of the main coal seams is the P Seam, having thickness varies from 0.88 m to 1.05 m in the north, and 2.87 m to 4.30 m in the central areas; whilst in the south region, it ranges between 0.10 and 1.52 m in thickness (Figure 6; PT Berau Coal, 1996). Generally, the P Seam has a minimum thickness of 0.15 m, maximum of 5.05 m, and average thickness is 2.41 m. The thickness measured at the outcrop varies from 2.40 m up to 2.70 m (Figure 3). The calculated estimated reserve is 945,000,000 m^2 x 2.41 m x 1.3 x 60% = 1,776,411,000 m.ton.

Then upwards, the Q Seam showing thickness of 3.26 m in the north block, 1.00 m to 2.60 m in central area, and it varies from 1.80 m to 3.41 m in the south portion (Figure 7). The minimum thickness of the seam is 0.23 m, maximum of about 4.23 m, and the average thickness is 2.49 m. At the coal working face, the Q Seam's thickness is up to 2.50 m. The estimated reserve is 945,000,000 m^2 x 2.49 m x 1.3 x 60% = 1,835,379,000 m.ton.

The upper seam, R Seam, has thickness of 2.45 m to 3.90 m in the central area, and between 1.50 m and 4.00 m in the south block (Figure 8). The minimum thickness of the seam is 0.10 m, and the average of 3.03 m. At the coal working face, thickness of the R Seam varies from 2.50 m to 3.00 m. The coal reserve calculated is 945,000,000 m^2 x 2.5 m x 1.3 x 60% = 1,842,750,000 m.ton.

Additionally, the uppermost observed coal seam in the Lati area is the T Seam, which shows thickness of 2.08 m to 3.35 m in the central block (Figure 7). The coal seam varies between 1.14 and 4.13 m in thickness, with average thickness of 2.40 m. The reserve estimate is 945,000,000 m^2 x 2.4 m x 1.3 x 60% = 1,769,040,000 m.ton.

Quality, Macerals, and Rank

The general tendencies of coal quality, projected in aspects of coal lithotype, vitrinite reflectance, macerals, ash, sulphur, moisture, and volatile matter, are summarised and compiled in Tables 1 - 3.

The P Seam, showing banded lithotype, comprises predominant vitrinite maceral group (85.8%) with minor exinite (4.2%) and inertinite (4.6%), and vitrinite reflectance value (Rv) of 0.47% (Table 2). Telocollinite of vitrinite maceral group predominantly forming coal with rare desmocollinite, rare exinite and inertinite are observed. Droplet of oil occupies the sample. Its volatile matter content is 36.78 to 38.04%, total sulfur is 1.59%, ash content of 4.08%, and moisture content is 16.22 to 17.87% (Table 3).

The Q Seam is bright banded coal, with having volatile matter content varies from 35.03 to 38.44%, total sulphur and ash contents are 1.14% and 3.69%, respectively; whilst the moisture content is of 18.18% to 18.22%. Maceral composition is dominated by

TABLE 2. RESULT OF COAL PETROGRAPHIC ANALYSIS OF THE LATI AREA

No.	Sample No. (04)	Seam	Lithotype	V (%)	I (%)	E (%)	Rv (%)
1	TS.01	Q	BB	89.2	1.8	3.4	0.57
2	TS.02	R	BB	89.0	3.8	3.6	0.52
3	TS.03	R	BB	77.0	11.8	6.8	0.42
4	TS.05	T	BD	81.6	5.6	3.8	0.56
5	TS.06	P	BB	85.8	4.6	4.2	0.47
6	TS.07	T	BD	83.2	4.8	6.8	0.51
7	Lati	Q	BB	85.4	5.4	1.8	0.45

Notes: BB – bright banded; BD – banded; V – vitrinite; I – inertinite; E – exinite; Rv – vitrinite reflectance

vitrinite (85.4–89.2%), with minor amount of exinite (1.8–3.4%) and inertinite (1.8–5.4%); whilst Rv varies from 0.45–0.57%.

SEM analysis displays that vitrinite maceral group consists predominantly of telocollinite and desmocollinite; with sparse sclerotinite of inertinite maceral group, and rare exinite and mineral matter.

Then, the R Seam, occurring as bright banded coals, petrographically is dominated by vitrinite showing value between 77.0–89.0% with minor exinite of 3.6–6.8%, and inertinite between 3.8– 11.8%. Vitrinite reflectance value ranges from 0.42–0.52%. SEM analysis shows that the coal comprises predominantly vitrinite maceral group consisting of telocollinite, desmocollinite, and detrovitrinite, with rare exinite and inertinite. Moreover, Table 3 displays that the coal seam is characterised by total sulfur content of 0.91%, ash content in 4.20%, volatile matter content varying from 37.37 to 37.91%, and moisture content between 18.81 and 19.34%.

The uppermost investigated seam, T Seam, occurs as banded coal. The coal is composed of vitrinite of 81.6–83.2%, exinite of 3.8 to 6.8%, and inertinite varying from 4.8–5.6%. Vitrinite reflectance value varies from 0.51–0.56%. The coal shows total sulfur content of 0.36%, ash content of 2.89%, volatile matter content from 36.36 to 38.33%, and moisture content between 17.51 and 19.98% (Table 3).

In summary, the investigated P, Q, R, and T Seams, based on the vitrinite reflectance, are categorized as sub-bituminous-B to high volatile bituminous-C coal with low ash content in general. Moreover, the P, Q, and R Seams are characterised by low ash and moderate sulfur (0.91–1.45%) contents, whilst the T Seam, its sulfur (0.36%) and ash (2.89%) contents are lower than the other three investigated seams. However, in general, the deeper the coal seams, the higher the ash content; as well as the total sulfur content.

The range of vitrinite reflectance values tends to indicate that the Lati coal is thermally late immature to early mature (Rv: 0.42–0.57%). The expected gas present is suggested to be of biogenic origin consistent with the low to medium thermal maturity.

Coal Cleats

The coal cleat orientations in the Lati Area are almost similar, trending northeast – southwest, perpendicular to nearly oblique to the syncline axis. Although, the coals are thermally immature to early mature, indicating by the low to moderate vitrinite reflectance, they are fairly well cleated, most likely because of their low ash and relatively high vitrinite contents.

Table 4 displays that macroscopically, the face cleat

TABLE 3. RESULT OF COAL GEOCHEMICAL ANALYSIS OF THE LATI AREA

No.	Sample No. (04)	Seam	Litho-Lithotype	TM % arb	IM % adb	Ash % adb	VM % adb	TS % adb
1	-	T	-	26.45	19.98	2.89	38.33	0.36
2	-	R	-	26.81	18.81	4.20	37.91	0.91
3	-	Q	-	25.72	18.18	3.69	38.44	1.14
4	-	P	-	23.91	17.87	4.08	38.04	1.59
5	TS.01	Q	BB	-	17.17	3.71	39.60	1.20
6	TS.02	R	B	-	19.00	4.45	36.39	1.02
7	TS.03	R	BB	-	19.34	4.10	37.37	1.03
8	TS.05	T	BD	-	12.23	3.00	36.36	0.35
9	TS.06	P	BB	-	16.22	3.90	36.78	1.50
10	TS.07	T	BD	-	17.51	2.78	37.81	0.38
11	Lati	Q	BB	-	18.22	3.51	35.03	1.08

Notes: TM – total moisture; IM – inherent moisture; VM – volatile matter; TS – total sulfur; arb – as received basis; adb – as dry basis

TABLE 4. FACE CLEAT CHARACTERISTICS OF THE Q, R, AND T SEAMS OF THE LATI COAL

Seam	Direction Mode (N°E)			Dip Direction (N°E)	Spacing (cm)	Aperture (mm)	Frequency (cm^{-1})	Density (cm^{-1})
	General	Low Range	High Range					
T	54 – 234	(53 – 58) – (233 – 238)	(48 – 63) – (228 – 243)	144	2.5 – 10.0	1 – 2	0.1585	0.0782
R	54 – 234	(51 – 56) – (231 – 236)	(46 – 61) – (226 – 241)	144	2.0 – 10.0	1 – 2	0.1457	0.0777
Q	53 – 233	(49 – 57) – (229 – 237)	(45 – 65) – (225 – 245)	143 – 146	1.5 – 30.0	1 – 2	0.1064	0.0716
	56 – 236	(53 – 58) – (229 – 237)	(48 – 63) – (228 – 243)		1.0 – 33.0		0.1053	0.0639

spacing commonly varies between 1.5–33.0 cm on the Q Seam, 2.0–10.0 cm on the R Seam, and 2.5–10.0 cm on the T Seam. Cleat density varies from 0.0639–0.0716/cm for the Q Seam; 0.0777/cm on the R Seam; and 0.0782/cm on the T Seam. The cleat aperture on the Q, R, and T Seams is quite similar, ranging between 1-2 cm.

Moreover, SEM analysis shows, in the Lati Area, the P Seam is commonly characterised by the presence of open tensional, sub-curved to curved lines micro-cleat, diagonally to perpendicular to bedding plane. The width or aperture varies commonly between 0.2 and 2.0 µm, length of 25–150 µm, and the density ranges from 0.01 (1/100 µm) to 0.03 (3/100 µm).

Then, in the Q Seam, micro-cleat of open tensional, sub-curved to strike-lines, diagonally perpendicular to bedding plane is recognised. Range of the length is 25–40 µm, width of aperture varies from 0.1 to 0.2 µm, and density of micro-cleat is 0.01 (1/100 µm) to 0.02 (2/100 µm).

Furthermore, the R Seam is occupied by micro-cleat of open tensional, sub-curved to curved lines and strike lines, diagonally perpendicular to bedding lines. The micro-cleat commonly has width of 0.5–2.0 µm, length of 150–700 µm, and density of 0.01 (1/100 µm)–0.03 (3/100µm).

COALBED METHANE POTENTIAL

Based on the parameters influencing the coal adsorption capacity, coalbed methane content derived from the Lati coals is expected to be a moderate level. This level category is evidenced by the presence of banded to bright banded lithotype, maceral composition dominated by vitrinite with minor content of exinite and inertinite; moderate moisture content, moderate to slightly high volatile matter, low to medium vitrinite reflectance, and low ash content, as shown in Tables 2 and 3. In the Lati coal, present as lower rank coal, gas-release rates is presumed to be faster than in higher rank one.

The volatile matter content of the P, Q, R, and T coal seams, showing values of 36.78%, 35.03%, 36.39%, and 36.36%, respectively, indicates an in-situ coal has a moderate methane content varying from 1.23 to 4.2 m^3/t (Figure 4). Although the coals themselves are fairly well cleated with a low porosity, they are expected to be moderate in permeability. The fairly dense to homogeneous coal characteristics tend to reflect a low to moderate methane desorption capacity. However, it is not a pessimistic methane value expected from the coal.

Gas In Place Resources

Parameters used to calculate the gas in-place potential of the Lati Coalfield (Figure 9), comprise theoretical gas content based on Barbara and Winter Diagram (Figure 10), and Lost Gas during drilling (Q1) plus gas desorption during transportation (Q2).

The gas in-place potential/content of each selected coal seams are calculated as follows:

- Seam P, on the Barbara/Winter Diagram shows value of 1.23 m^3/t = 44.20 scf/t of pure coal. However, based on the Q1 and Q2 calculation, the gas content = 1,850 ml + 670 ml = 2,520 ml = 1.98 m^3/t = 71.16 scf/t.
- Seam Q, in the Barbara/Winter Diagram shows value of 1.23 m^3/t = 44.20 scf/t of pure coal. Then, on the basis of Q1 and Q2 calculation, the gas content = 2,000 ml + 790 ml = 2,790 ml = 2.19 m^3/t = 78.71 scf/t.
- Seam R, on the Barbara/Winter Diagram shows value of 1.31 m^3/t = 47.08 scf/t of pure coal. Then, on the basis of Q1 and Q2 calculation, the gas content = 350 ml + 1,120 ml = 1,470 ml = 1.16 m^3/t = 41.69 scf/t.

FIGURE 9. PHOTOGRAPH OF IN-SITU GAS IN-PLACE CALCULATION (Q1) OF METHANE GAS, USING A SIMPLE EQUIPMENT IN THE FIELD.

CONCLUSIONS

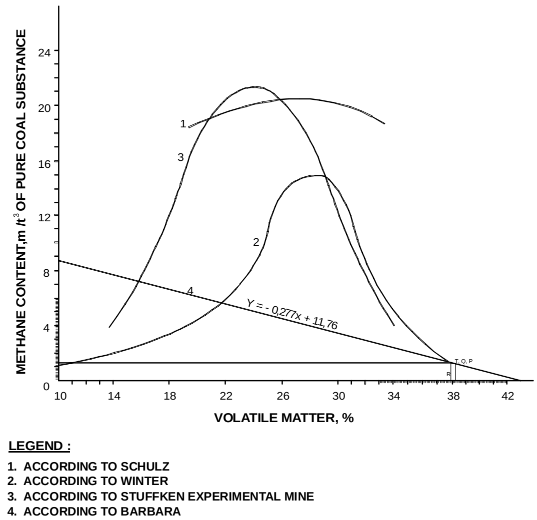
1. The Lati coal lithotype, ranging from banded to bright banded, is dominated by the bright banded one.

2. Predominantly, the coal consists of vitrinite, with minor exinite, inertinite, and mineral matter. Predominantly, the vitrinite comprises typical telocollinite and desmocollinite, appearing to be most prominent types found in all samples. Cutinite, resinite and sporinite of the exinite group are significantly rare to sparse amounts. Inertinite is composed of mostly typical sclerotinite or fungi and rare to sparsely inertodetrinite. Some “oil droplets” of solid bitumen have been identified.

3. Coal geochemical analysis shows that volatile matter content varies from 32.65–39.60%, total sulfur 0.35–3.04%, ash content 2.78–14.50%, and moisture content 12.23–19.98%.

4. Vitrinite reflectance (Rv) of 0.42–0.57% indicates that the coal rank is categorized as sub-bituminous B to high volatile bituminous C, with low ash content in general. The Rv also shows that the coal is thermally immature to early mature. Therefore, the expected gas present is suggested to be of biogenic origin consistent with a low to moderate thermal maturity.

5. The coals are fairly well cleated. Coal cleat orientations trending north - northeastward, are perpendicular to nearly oblique to the syncline axis. Microcleat of the P and R Seams is open tensional, sub-curved to curved lines microcracks, diagonally



Coal Seam	Valotile Matter	Methane Content	
		(4)	(2)
T, Q, P	37,6	1,23	0
R	37,0	1,31	0

FIGURE 10. RELATIONSHIP BETWEEN METHANE CONTENT AND VOLATILE MATTER CONTENT IN THE LATI COAL.

to perpendicular to bedding plane, but some are parallel to the bedding plane. However, microcleat/ microcracks of the Q Seam are an open tensional type, sub-curved to strike-lines, diagonally perpendicular to bedding plane.

6. An in-situ coal have a low to moderate methane content level, indicated by a value of 44.20 – 47.08 scf/t.; whilst based on the Q1 plus Q2 values, the gas content ranges from 41.69 to 78.71 scf/t. Moreover, total calculated gas in-place of the P, Q, and R Seams = 5.33 m^3/t = 191.56 scf/t.

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