International Journal of Science and Research (IJSR)
ISSN (Online): 2319-7064
Index Copernicus Value (2015): 78.96 | Impact Factor (2015): 6.391

Well Log Application for Determined CBM Resources of Sajau Formation, Berau Basin, Indonesia

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Abstract: ***The coal reservoir quality for the CBM production such as coal thickness, gas contents, coal porosity and permeability, reservoir pressure and critical reservoir are generally influence the CBM production. Among of them the porosity and permeability of coal are the main factors controlling the potential of the coal seams for the CBM reservoir. The wire line logs have been used to identify the petrophysical of Sajau Coal Formation in Tanah Kuning , Mangkupasi and Kasau area , Berau Basin to assess the potential of coal bed methane (CBM) reservoir in the field. The coal seam permeability data for 13 major coal seams, The estimation of seam permeability values ranging 5.03 md to 25.06 md. The gas contents were different between seams which have ranges of 11.32 – 32.36 cc/g . Based othe CBM reservoir parameters and the gas contents; the Sajau coal has a good for CBM development.***

Keywords: Sajau coal Formation, Berau basin, wire lne log, CBM, permeability

1. Introduction

In Indonesia the coal is the most abundant fossil fuel resource. At favorable depths, coal may contain a significant volume of natural gas that can be used as a source of energy. Coal gas is composed primarily of CH4 (80 – 95% by volume) with a small volume of CO2, ethane, propane and butane. Based on the study of the ARI [1,2] the hypothetical CBM resources in Indonesia approximately 453 TCF, which are distributed in several major coal basins.

The main factors that affect the gaseous hydrocarbon generation from coal are macerals composition, degree of thermal maturity, type of organic matter [3, 4]. One the method for determined gas content from the coals is from the canister well log measurements. Other coal parameters which can be determined from wire logs technique in CBM Exploration and production are ash content and other proximate parameters for the estimation of gas content, and CBM reservoir parameter such as porosity and permeability [5,6 and 7].

Several studies have been published on the coal and CBM exploration in Berau Basin, but mostly of works have been carried out only for Miocene Coal of Latih Formation [8, 9 and 10]. Limited studies have been done for Pliocene to Pleistocene coal deposits in Berau basin ([11, 12].

The objective of this paper is to show the wide application of well log analysis in the CBM exploration; to determined the reservoir quality of CBM including coal porosity and permeability and finally to measure the gas content of Sajau coal Formation in Berau Basin..

2. Study Area

The Mangkupadi coalfield located in the northern part of Kalimantan Island is roughly spoon-like shaped, its longer axis running northwest–southeast (Fig. 1). The dip of the Formation in general is southerly (15^0). The general stratigraphic succession of Sajau coalfield is given in figure 1 [12]. The stratigraphic units of the Kalmerah-1 well in the Sajau area was marked by the presence of two coal-bearing horizons: the Latih Formation and the Sajau Formation. Latih Formation coals of which exposed in the western part of basin are of Miocene age deposited in fluvio/deltaic condition having coal rank from sub-bituminous to low volatile bituminous coal and are considered as potential reservoir for CBM [8]. The other coal bearing formation is a low rank coal (lignite to sub-bituminous) of Sajau formation which were exposed in the eastern part of the basin are also considered as the Pliocene to Pleistocene CBM reservoir in the basin [13]

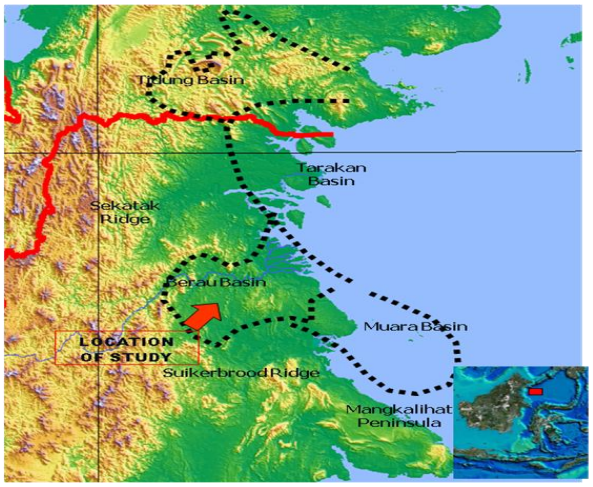

Figure 1: The research location map in Berau Basin, North Kalimantan, Indonesia)

3. Wireline Logs Coal Analysis

3.1. Coal Identification from Well logs

The identification of coal from wire line log is done by making cross plot and cross section in the area of research.

The cross plots in this study using data from wells with a density log as parameter x, gamma ray log as a parameter y. The cross plots in the study area were made of the coal zone with gamma ray values ranging from 5-10 API, density values ranging from 1 to 1.18 g / cc and acoustic impedance values ranging from 6150-6775 g / cc * ft / s (Figure 2).

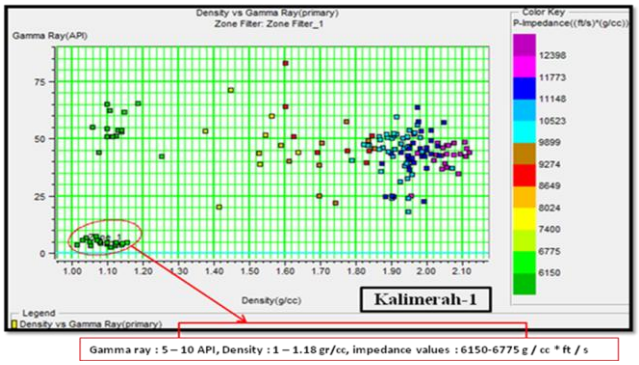

Figure 2: The density versus gamma ray cross-plots of Sajau Formation of Kalmerah-1 well

The coal zone sequence models of the seams as identified from well logs was used from well log of Kalmerah-1 which is shown in Fig. 3. The logs were demonstrated of gamma ray, resistivity (LLD, LLS), MSFL and density log corresponding to the identified major coal seams. Only eight (8) coal zone (A, B, C, D, E, F, and G) can be determined.

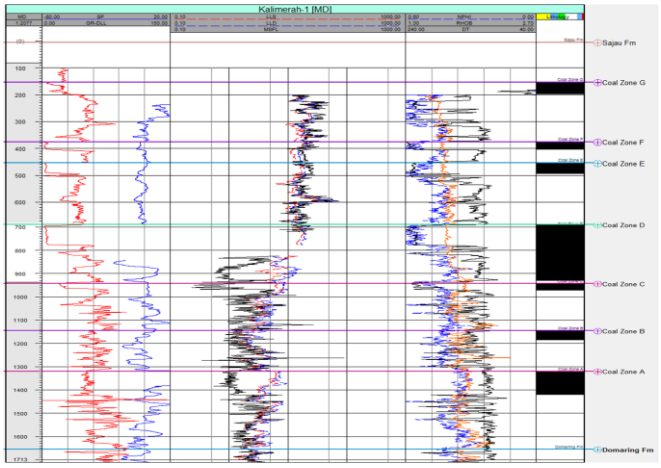

Figure 3: The display of geophysical log of Kalmerah -1 well which identified

However, the well log correlation of the geophysical logs of 4 deep wells and 19 shallow wells and combination with 80 litho-logs of coal exploration well were identified the major coal zone. In this study there were identified thirteen (13) coal zone from A – M, which are designated as: coal zone A (bottom seam) through coal zone M (top seam) as shown in Figure 4. The range of coal thickness from 0.90 m (coal seam D) and 36.20 m (coal seam E).

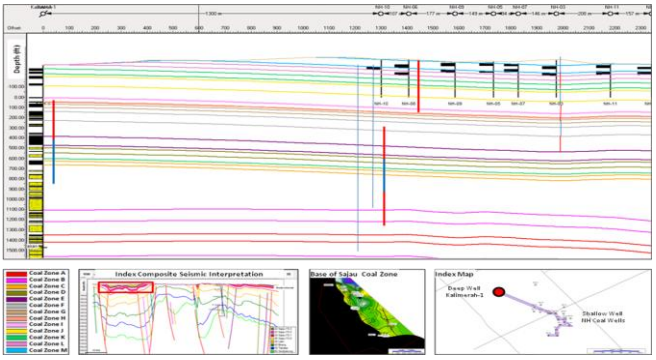

Figure 4: Deep and Shallow Well Calibration of Sajau Coal Zone Distribution

3.2 Quality of CBM Reservoir from well logs

The permeability is the one's of key factor controlling the migration and flow of gas in CBM reservoir and thus controls CBM production [14] . The resistivity logs of the 15 have been used for estimation of the permeability of 13 major coal seams (seam A-M). Coal seams are typically characterized by medium to electrical resistivities (9.46 – 56024 ohm m). To calculation the cleat volume/porosity of Sajau coal, The Archie's equation [15] has been used :

$$\mathbf{F = 1/Ø^m} \quad (1)$$

$$\mathbf{Ro = F.\ Rw} \quad (2)$$

$$S_w^n \quad (3)$$

where,

F : is the formation resistivity factor;
Ro ; is the resistivity of rock sample with 100% water saturation;
Rt : is the true resistivity of formation;
Rw : is the formation water resistivity;
Sw : is the water saturation (fraction);
Ø : is the porosity (fraction),
m : cementation factor
n : saturation exponents

The value of cementation factor (m) for coal of Sajau as 1.5 due to the rock were consists of small aperture of cleats . Therefore we derived the formula for To estimation of cleat porosity (cleat volume) with assumption Rm = 0.65

$$\mathbf{F = 1/Ø^m = Rt/Rm \ \ then \ \ Ø = (Rm/Rt)^{1/1,4}}$$

$$\mathbf{Cleat\ porosity\ (Ø) = 100 \times (0{,}65/resistivity)^{0,7}} \quad (4)$$

To estimation of coal permeability we use the matchstick formula for Sajau coal formation from Seidle J. P, et al, 1992 [16] as follow :

$$\text{Cleat porosity } (Ø) = 2b/s \quad (5)$$

$$\text{Coal permeability } (K) = b^3/12s \quad (6)$$

where

b : cleat aperture
s : cleat spacing

The cleat aperture from the CT scan tomography measurements is 0.03 mm, and cleat spacing of 1.24 – 2.20 mm and porosity estimated from Eq. (5 have been used for

computation of permeability using Eq. (6). Coal seam permeability value ranges from 5.03 md to 25.06 md.

3.3. Gas Content from well logs

The existence of methane gas are found in the sequence of rocks in Sajau Formation in both the coal layer or sandstone layer [17]. The petrophysical well data interpretation of Kalmerah-1 shows the gas content in coal can be identified by their from wide separation between LLD curves LLD and MSFL in the depth interval from 259.08 to 285.60 meters and 335.28 s / d 426.72 meters (Fig. 4).

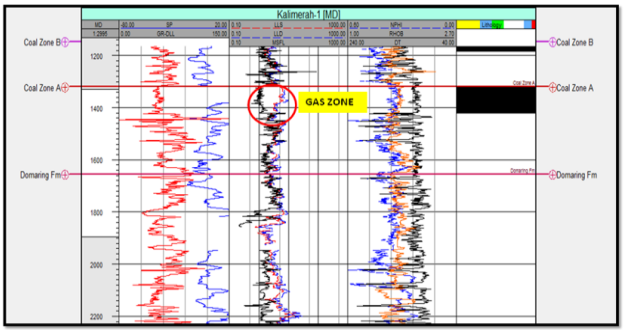

Figure 4: The wide separation of LLD curve and MSFL in the coal zone of Kalmeraha-1 well at 285,60 – 335,28 meter

Besides the narrow separation from density log (RHOB) and neutron log (NPHI) in coal from Kalmerah-1 well at depth in coal seams at 375,67 – 405,01 m indicating gas content in coal (Figure 5)

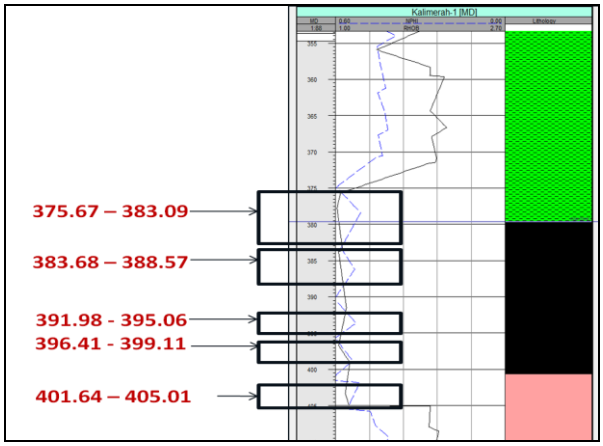

Figure 5: The narrowe separation of NPHI curve and RHOB in the coal zone of Kalmeraha-1 well at 375,67 – 405,01 meter

To calculation of gas content of Sajau coal formation from well logs, the equation from Bhanja and Srivastava was used [18] as follows :

$$\mathbf{V} = 0.767\ \{\Delta t / (\rho_c \times GR \times P_e)\} + 10.67 \qquad (7)$$

Where **V** is the volume of gas (cc/g), Δt is sonic log response, ρ_c is density log value for coal seam (g/cc), ***GR*** is gamma ray response for coal (cps), ***Pe*** is the photo-electric absorption index value for coal [1.8 barns/electron). The calculated gas content on coal seam base on eq.9 ranges from 11.32 – 32.36 cc/g .

4. Conclusion

The present study, based on the analysis of data of 4 four deep wells and 19 shallow wells from the study area in the Tanah Kuning, Mangkupadi and Kasai area in Berau Basin coalfield, India, has done for assessment of CBM potential of coal seams. Coal reservoir parameters including coal porosity and permeability of the major coal seams of the study area has been estimated by using well logs. The estimation of seam permeability values ranging 5.03 md to 25.06 md. are in good condition for CBM production. The petrophysical data from well logs were used to estimation gas content of those 13 coal seams of the study area. The gas contents were different between seams which have ranges of 11.32 – 32.36 cc/g .

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