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Porosity and Fracture Pattern of Coal as CBM Reservoir

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Abstract

This paper discusses the results of an investigation carried out to study the microstructure of coal enhancing the understanding of the phenomena involved in release of methane and its movement in coalbeds. Scanning electron microscopy (SEM), thin slice analysis were used to obtain information about the rank and structure of coal and its macerals properties, porosity, surface properties, size and distribution of pores, and presence of microfractures and cleats. The samples collected from Sumatera Selatan coal field

Micrographs obtained clearly showed the highly porous nature of coal, and also showed that coal as a Coalbed Methane (CBM) reservoir have three types of porosity, they are: macroporosity, mesoporosity, and microporosity. Most of the pores, however, appeared to have a very small volume and large surface area, which explains the large quantities of methane that are retained in adsorbed form in coalbeds. On the surface of coal, a network of microfractures and cracks was seen, indicating that it is these fractures that are mainly responsible for gas flow. The results illustrate the use of physical models for simulation of gas flow in coalbeds, involving dual flow behavior. Our coal sample show that macropores size variater between 0,5 mm to 2mm, while mesopores variates between 0,0136 mm – 0,3060 mm. The effective porosity of our coal sample is very small 5,10% to 5,77% compared to conventional reservoir. Using Vitrinite Reflectance we have determined that our sample classified as sub-bituminous rank. Furthermore, the microstructure of coal explains some of the unusual gas flow characteristics of coal.

Keywords : *CBM, Coal Porosity, Microporosity, Mesoporosity*

I. Introduction

Storage mechanism of CBM in coal differ from conventional gas reservoirs, such as sandstone. Gas in the coal can be present as free gas within the macropores or as an adsorbed layer on the internal surfaces of the coal micropore. Instead of occupying void space as a free gas between sand and grain, the methane is held to the solid surface of the coal by adsorpstion in numerous micropores[1].

A small quantity of free gas is stored in cleats and open pores, and also dissolves in the water content in the coal. But most of the gas absorbed on the solid surface of the coal.

Study of fracture pattern and pore structures of the CBM reservoirs are very important study, because directly related to economics of CBM productions.

This paper will discuss the microstructure characteristic of the CBM reservoirs. Porosity determined using Digital Helium Porosity Meter. Natural fracture or cleats displayed using digital camera, mesoporosity presented using thin slice analysis, rank, maceral analysis and microporosity determined using SEM (Scanning Electron Microscope).

II. Theory

Recent studies showed that much more gas volume can be retain by CBM reservoirs than conventional gas reservoirs, even if the porosity of the CBM reservoirs smaller then conventional gas reservoirs [1]. This facts indicating different storage machanism of gas in CBM reservoir.

CBM reservoirs has complex pores system, consisted three pore system: macroporosity, mesoporosity, and microporosity. Macroporosity is cleat network, a natural fracture system in coal. The size of cleats has many variation between 0,001 up to 20 mm [2]. Mesoporosity is small fracture in coal, has smaller size than cleats between 20-500Ao. Microporosisty appear in very small pore system, the size may less than 20o [3].

The study of microstructure, fracture pattern, porosity and permeability, maceral composition, and rank, are very important variabels to in estimate the quantity and volume of CBM stored in coal.

Natural fracture or cleats in CBM reservoirs is controling the permeability of the reservoirs. Different from conventional gas reservoirs, the natural fracture of the coal is not directly related to the volume of the gas. Cleats is only responsible to gas flow from matrix to wellbore. Therefore, the permeability of a coal seam depends on properties of its cleats. Methane is predominantly stored in the micropores in an adsorbed state [4]. Many studies showed that organic constituents like macerals compositions is related to CBM abundant in coal. Vitrinite maceral have a greater methane adsorption capacity than other maceral [5]. The rank of the coal related to maceral type, and so also related to quantitiy of methane in coal. Generally increasing rank is relate to the increasing the quantitiy of the CBM in coal [6]. Therefore the studies and measurment to these properties should be performed, to estimate the prospect of the CBM reservoirs.

Several analysis was performed as follows:

- Maceral analysis
- Rank analysis
- SEM analysis
- Thin slice analysis
- Porosity measurment

III. Methods

Porosity measurment was perfomed using Digital Helium Porosity Meter. Boyle's principle is used in this equipment, where the product between pressure and volume is constant.

Figure 1. Digital Helium Porosity

Comparing pressure and volume between two chamber, wich is one of them pluged by core sample, the we can determine the helium gas volume in the coal pore.

Cleats in many case could be seen by naked eyes, so using digital camera, we can see two type of cleats: butt cleat and face cleats, as we can see in figure 2.

Figure 2 Coal sample showing Butt Cleats and Face Cleats

Micropores was observed using SEM (Scanning Electron Microscope) with magnification upto 40.000 times. Maceral analysis is important because the quality of coal is influence the quantitiy of CBM in reservoir.

IV. Results

The results we have from Digital porosity meter showing that porosity of the coal is very small 5,10% to 5,77% while conventional gas reservoir porosity is 15% to 25% conventional gas reservoir such as sandstone reservoir.

Table 1. CBM Reservoirs Porosity

Measure	Mass (gr)	Rho (gr/mm^3)	Porosity (%)
1	50.3	0.001275	5.10
2	60.8	0.001275	5.77

However, CBM reservoir differs from the conventional gas reservoirs, in that the volume of gas, which it can store, is far beyond its pore volume capacity. This is because the storage mechanism in CBM reservoir is differs from conventional gas reservoirs. In fact the gas stored in coal is mainly adsorbed onto the pores large internal surface. Due to the very small volume of an individual micropore, and the pore surface in coal can be very large. For some coals the internal surface may reach several hundreds m^2 per gram of solid, thus making available large amount of surface for adsorbing gas. This large surface is caused by grained structure if the coal as we can see using SEM. Another important facts in CBM reservoir, porosity system is devided into three types. First, macropore called cleats, mesopores, and micropores.

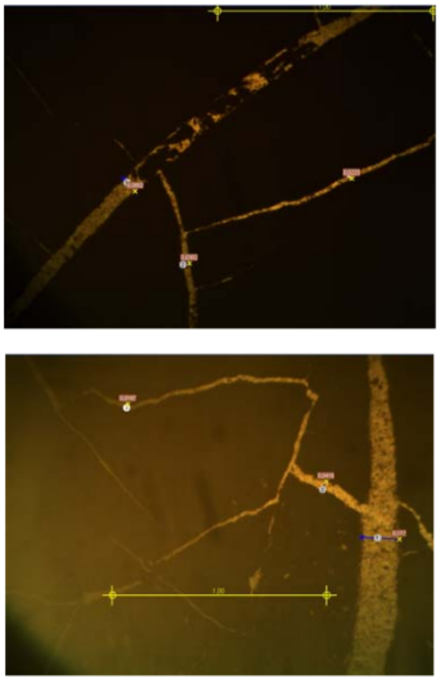

Figure 3 Mesopores observed through digital microscope

Figure 3 show the existence of mesopores and micropores using digital microscope. The crack arperture is variates beetwen 0,0136 mm – 0,3060 mm.

Figure 4 show the existence if micropores. Micropores is developed by extremely large surface area solid grain. This figures show 10000, 20000, and 40000 magnification.

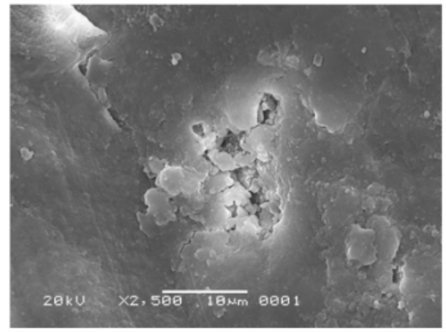

Figure 4(a) Coal using SEM 10000 x magnification

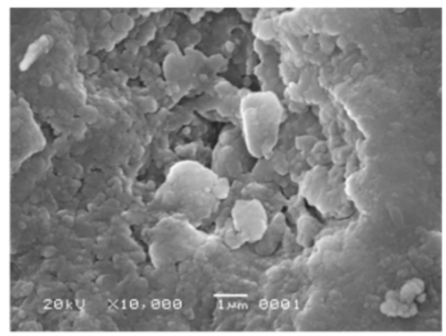

Figure 4(b) Coal using SEM 20000 x magnification

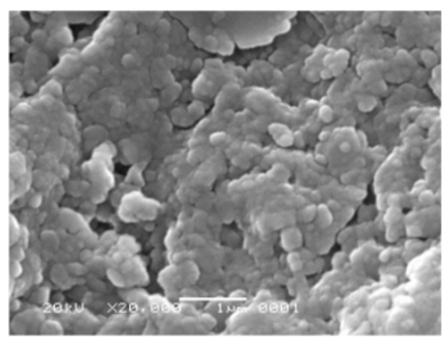

Figure 4(c) Coal using SEM 40000 x magnification

We also measure the quality of the coal using vitrinite reflectance and the results show that average reflectace is 0,42%. Using ASTM standard our sample classified as sub-bituminous rank. Macerals analysis show that our sample are dominated by vitrinite 86,2% to 90,8 %, wich are favorable for CBM.

V. Conclusion and Discussion

We have recognize three pore system in CBM reservoir: Macropores, mesopores, micropores. Our coal sample show that macropores size variate between 0,5 mm to 2 mm, while mesopores variates between 0,0136 mm – 0,3060 mm.

The effective porosity of our coal sample is very small 5,10% to 5,77% compared to conventional reservoir. Using Vitrinite Reflectance we have determined that our sample classified as sub-bituminous rank. Altough sub-bituminous rank recognized as low rank, several study show that the potential of CBM is still high in low rank by biogenic process. (Beaton, Langenberg, Pana, 2006)

Maceral composition of our selected coal is dominated by vitrinite 86,2% to 90,8. Several study showed that CBM that maceral composition is influence the sorption capacity of the coal (Pophare, Mendhe, Varade, 2008). Higher vitrinite compositions indicating high sorption capacity of the coal.

Storage mechanism, pore system, pore arperture size, maceral composistions and rank of the coal, give us initial information for the CBM existence in the Sumatera Selatan coal.

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