THE EFFECT OF GEOLOGICAL STRUCTURES ON THE COAL QUALITY OF THE SEMBAKUNG FORMATION IN BERAU REGENCY, EAST KALIMANTAN

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Abstract— *The Subsurface coal resources are 43.533 billion tons with total reserves of 173.51 million tons. The Berau Regency area has coal-bearing formations of the bituminous - sub bituminous type, namely the Latih Formation, Labanan Formation, Domaring Formation, Sajau Formation and Sembakung Formation. The research methods used are surface geological mapping, rock sampling and drilling. The analysis used is coal quality and geological structure. The results of analysis of changes in the dip of rock layers caused by geological structures in the form of folds and thrust faults can cause changes in coal quality. The dip of coal seam in the LP 54 outcrop sample is 24º, which has lower coal quality compared to LP 38 that has a seam dip of 65º. The quality of coal in LP 38 seam position N 203º E/65º has a calorific value of 6,393 Kcal/kg, while in LP 54 seam position N 30º E/24º has a calorific value of 4,888 Kcal/kg. At the drill point, location MMA_19-T has better coal quality compared to MMA_18-T and MMA_20-T, this is because the seam in MMA_19-T experienced folding accompanied by faulting with a calorific value of 7326 Kcal/kg*.

Keywords: Geological structure, coal quality, Sembakung Formation

I. INTRODUCTION

Indonesia is rich in exploitable natural resources such as minerals, coal, geothermal energy and water. In order to discover new energy sources, it is necessary to study many geological phenomena in Indonesia, such as the state of underground rocks, faults and fissuresThe availability of coal resources in Indonesia is quite abundant [1]. Sourced from ESDM data for 2021, total surface coal resources in Indonesia are 143.43 billion tons with reserves of 38.80 billion tons, and subsurface coal resources of 43.533 billion tons with reserves of 173.51 million tons. In 2019, around 48% of coal use in Indonesia was for the benefit of domestic power plants, which amounted to 67.01 million tons [2]. One of which factors detrimental to the use of coal in the industry is the high content of impurities contained in coal, one of which is the ash content [3]. The temperature, pressure and time are influencing factors on coal quality [4].The process of coal formation either during deposition or after deposition such as geological structures, intrusions, etc. will greatly affect the quality and greatly affect the quality and content of elements in the coal [5]. The presence of andesite intrusion factors and geological structures are estimated to have an influence on coal ranking [6].

Coal is one of the natural resources in Berau Regency, East Kalimantan. The study area in the Mining Business Permit (IUP) area of PT. Mahkota Megah Abadi in the Sembakung Formation. Administratively, the research area is located in Sambarata area, Segah District, Berau Regency, East Kalimantan Province. Berau Regency is also one of the areas with Mining Business Permit Areas so it can affect river water quality [7].

The research area is geologically part of the Tarakan Basin, especially the Berau Sub-Basin [8]. The Tarakan Basin is one of the Tertiary basins in eastern Kalimantan and is part of the delta in a passive margin-type basin with minor lateral shear tectonic control [9]. The Berau Regency area has bituminous – sub-bituminous coal-bearing formations, namely the Latih Formation, the Labanan Formation, the Domaring Formation, the Sajau Formation, and the Sembakung Formation [10].

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The purpose of this research is to obtain proximate analysis (total moisture, volatile matter, ash content, and fixed carbon), understand the effect of geological structure on the calorific value of each coal seam in the Sembakung Formation.

II. RESEARCH METHODS

The research methods carried out in the research area are direct and indirect activities in the field. Direct activities such as drilling, and indirect activities include structural geological and coal analysis (proximate analysis). Search and observe rock outcrops, coal, joints/fractures and faults to obtain an accurate picture of strike, dip, coal thickness and geological structure of the research area. Figure 1 shows the flowchart of research methods and implemented in the study area.

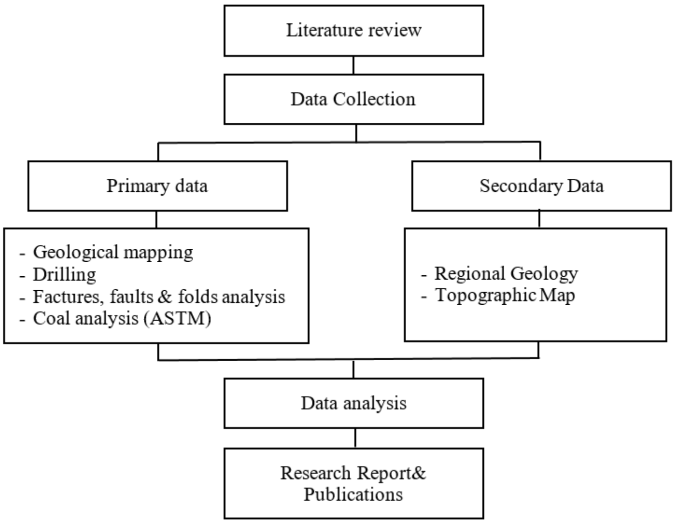

Figure 1. Flowchart of research methods in the study area

A. Structural Geological Analysis

Identify the type, position and dimensions of geological structures. The results of measuring the position of rock layers and several indications of structural layers can be analyzed to determine the presence of geological structures, both major and minor structures as a result of geological processes operating in the research area based on the Rickard's classification (1972) for faults [11] and for folds based on the Fluety's classification (1964) [12].

B. Drilling and Sampling

Drilling is carried out to determine the thickness of the coal, the distribution of the coal seams including dimensions, the number of seams, and vertical seam thickness, in addition to obtaining coal samples from below the surface, know the thickness of the overburden, and interburden layers, and the accompanying rock stratigraphy.

C. Sampling

Samples were taken from 2 coal outcrop on same seam and 8 coal coring from three drilling points. At these three points it is known that there are seams of varying thicknesses, where the sample represents each seam.

D. Laboratory Test

The analytical method used by the American Society for Testing and Materials (ASTM) for testing total moisture content, ash content, volatile matter content, fixed carbon, and caloric value [13]. Implementation of coal analysis carries out in PT. Ithaca Resources laboratory is located at the Sambarata site, Berau Regency.

III. RESULTS AND DISCUSSION

A. Stratigraphic of the Research Area

The Sembakung Formation and alluvium unit covered in the research area. The distribution of lithology in the research area is divided into 3 (three) units as shown in Figure 2, namely the sandstone unit, the claystone unit, and the alluvium unit.

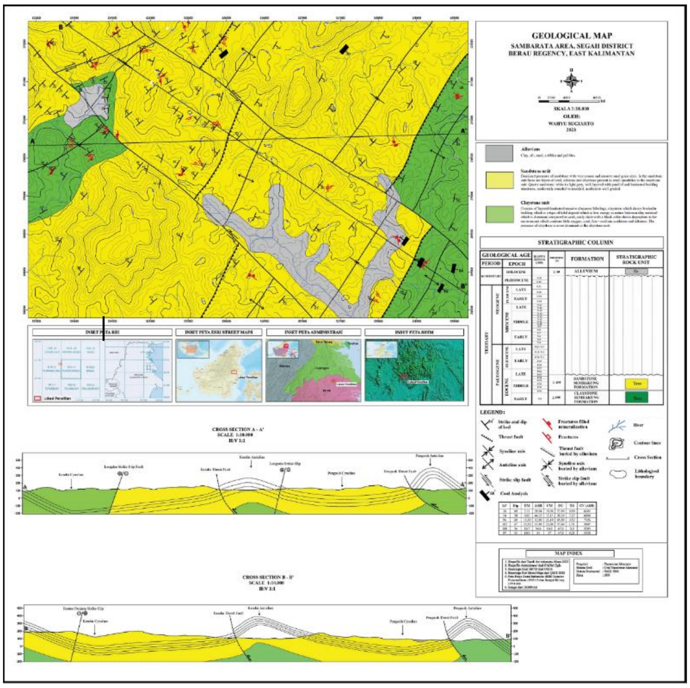

Figure 2. Geological map of research area

The sandstone unit in the Sembakung Formation in the research area is characterized by the dominant presence of sandstone with very coarse and massive sand grain sizes. In the sandstone unit there are layers of coal, siltstone and claystone present in small quantities in the sandstone unit. Quartz sandstone; white to light gray, well layered with parallel and laminated bedding structures, moderately rounded to rounded, medium to well graded. Generally it has a mineral composition of quartz, feldspar as the matrix, local contains a small amount of small foraminifers' fossils. The claystone unit in the research area consists of layered-laminated-massive claystone lithology, claystone which shows lenticular bedding which is a type of tidal deposit which is low energy in nature between clay material which is dominant compared to sand, coaly shale with a black color shows deposition in the environment which contains little oxygen, coal, fine - medium sandstone and siltstone. The presence of claystone is more dominant in the claystone unit. The alluvium units in the research area consist of loose material and deposits that have not undergone compaction, dominated by textures measuring clay, silt, sand, cobbles and pebbles. Texture is composed of the results of various types of rock breakdown that have not been consolidated, but are in the form of sediment. The stratigraphic relationship between the alluvium unit and the underlying rock units is unconformable and is characterized by erosion.

B. Geological Structures of the Research Area

According to Dennis (1972) in Hatcher (1990), fractures due to pressure are called shear fractures and due to tension are called tension fractures. The characteristics of shear fractures are tight, straight, cutting through all rock layers, in pairs, and when filled with quartz the crystals are poor. Tension fractures are not tight, the fracture boundaries are relatively uneven, the quartz filling the crystals is good, and they are not paired [14]. According to Dennis (1972), a fault is a fracture whose surface area has shifted [15]. Anderson (1951) divided the types of faults into normal faults, reverse/thrust faults, and strike-slip faults [16].

The geological structure of the research area is based on measurements of the strike and dip of rock layers, joints/fractures and faults. Determination of the geological structure of the research area is also based on river straightness and topographic maps. The geological structures found in the research area are strike-slip faults, thrust faults, anticline folds and syncline folds. The horizontal faults in the research area are

Longsatu Strike-Slip Fault, Longdua Strike-Slip Fault and Rantau Panjang Strike-Slip Fault. The thrust faults in the research area are Kendai Thrust Fault and Pengasih Thrust Fault. The folds found in the research area are Pengasih Anticline, Pengasih Syncline, Kendai Anticline, and Kendai Syncline. The direction of faults and folds is relatively Southwest - Northeast, while the horizontal faults are relatively northwest - Southeast and Southwest – Northeast.

The existence of the Longsatu Strike-Slip Fault is based on a gash fracture with a position of N 278° E/72° and a shear fracture with a position of N 155° E/75°, the position of the fault plane is N 137° E/84°, and the appearance drag fold in the direction of N 144° E and slickenside on the fault plane shows the direction of movement of the left slip fault (Figure 3). The results by stereographic analysis using Rickard's classification (1972), the position of the N137° E/84° fault plane is obtained, namely Normal left Slip Fault.

Figure 3. The Longsatu Horizontal Fault, visible fault plane, drag fold, slickenside and fractures filled by iron oxide minerals.

The Longdua Strike-Slip Fault can be observed in the form of shear fracture N 098° E /72° and gash fractures N 155° E /75°. The continuity of this fault is indicated by the direction of the drag fold N 162° E, the fault plane is N164° E/67° and the slickenside on the fault plane shows the direction of movement of the left slip fault. The results of stereographic analysis using Rickard's classification (1972) obtained the name Normal Left Slip Fault.

The existence of the Rantau Panjang Stike-Slip Faults is in the form of fault planes, slickenside, drag folds, shear fractures and gash fractures. The position of the fault plane is N 064° E/67°, the slickenside direction of the fault plane shows a right slip fault and the direction of the drag fold is N 065° E. The position of the shear fractures is N 52° E/55° and the gash fractures are N126° E/66°. By Stereographic analysis using Rickard's classification (1972) obtained the name is Right Slip Fault.

The existence of the Kendai Thrust Fault is proven by the existence of a fault scarp that extends in a North-South direction and the appearance of a fault plane of N52ºE/36º with hanging wall movement to the left. Gash fractures filled with oxidation mineralization (Figure 4) with a position of N198ºE/44º. Based on Rickard's classification (1972) it is a Left Thrust Slip Fault.

Figure 4. Gash fractures filled by iron oxide minerals.

The existence of the Pengasih Thrust Fault is proven by the presence of a fault scarp that extends in a relatively north – south direction, a narrow valley indicating a drag fold, a fault plane of N 55º E/26º, and gash fractures of N 205º E/33º. Gash fracture analysis and the position of the fault plane, namely N 55º E/26º. Based on Rickard's classification (1972) this fault is a Right Thrust Slip Fault.

The axis of the Kendai Anticline has a relative direction of Northeast - Southwest in the Sandstone Unit of the Sembakung Formation. Data analysis of the bedding area in the research area found that the position of the hinge line was 3º, N 203ºE and the hinge surface axis was at a position of N 25º E/63º. Based on the Fluety's classification (1964) this fold is a Steeply Inclined Horizontal Fold.

The existence of the Kendai Syncline in the Sandstone Unit and has a relative axis direction of Northeast – Southwest (Figure 5). Analysis of the bedding plane in the research area at the hinge line position is 8º, N 42ºE and the hinge surface axis plane is at N 37º E/60º. Fluety's classification (1964) of this fold is Steeply Inclined Horizontal Fold.

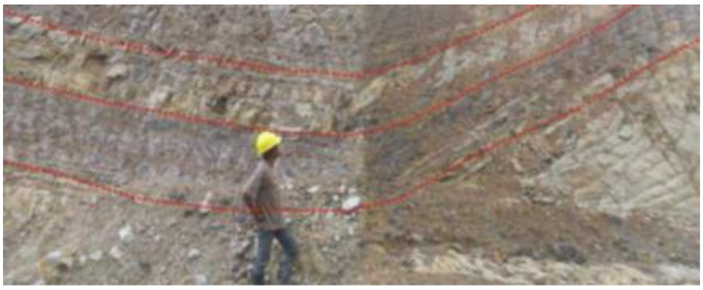

Figure 5. Appearance of the Kendai Syncline.

The axis of the Pengasih Anticline is trending relatively Northeast – Southwest in Claystone Unit of the Sembakung Formation. Analysis of the bedding plane in the research area, found that the hinge line position is 4º, N 47ºE and the hinge surface axis plane is at N 225º E/79º. Based on the Fluety's classification (1964), this fold is a Steeply Inclined Horizontal Fold.

The existence of the Pengasih Syncline in the Sandstone Unit of the Sembakung Formation and has a relative axis direction of Northeast - Southwest. Analysis of the bedding plane in the research area, the position of the hinge line is 7º, N 43º E, and the hinge surface axis plane is N 35º E/62º. Based on the Fluety's classification (1964) this fold is a Steeply Inclined Horizontal Fold.

C. Subsurface Coal Geology

Based on the results of coal drilling at 3 points in the Sembakung Formation area of the research area, there are 5 coal seams with varying thicknesses, namely 0.70 m - 2.45 m. Based on the cross-section of the Sembakung Formation coal seam, the coal seam names in the Sembakung Formation are M1, M2, M3, M3A and M4 (Table 1).

Table 1. Thickness of seam in the research area

Code Drilling	Seam	Dip (º)	Thickness (m)
MMA_18-T	M1	47	1,80
	M2	47	0,70
	M3	60	2,20
	M3A	45	0,65
MMA_19-T	M3	68	2,45
	M4	70	1,55
MMA_20-T	M3	54	2,20
	M4	55	1,60

D. Coal Quality

The results of laboratory analysis obtained are in the form of parameters total moisture (TM), ash, volatile matter (VM), fixed carbon (FC), total sulfur (TS), and calorific value (CV). Core drilling sampling was carried out at drill points MMA_18-T, MMA_19-T and MM_20-T. The location coordinates of the drilling track are 527430 E, 269069 N to 528852 E, 268688 N. Figure 6 shows a coal coring sample at drill point MMA_19-T. The coal seams quality of MMA_18-T, MMA_19-T and MM_20-T are as in Table 2.

Figure 6. Coal coring sample in the research area

Table 2. Quality of coal seams in the research area

Drilling Code	Seam	TM (%)	ASH (%)	VM (%)	FC (%)	TS (%)	CV (ADB) Kcal/kg
MMA_18-T	M1	24,7	12,6	23,0	58,1	1,49	5836
	M2	23,2	13,9	22,0	57,6	1,51	5807
	M3	22,0	6,8	22,2	64,9	1,62	6660
	M3A	26,3	15,8	22,2	56,2	1,47	5721
MMA_19-T	M3	13,3	12,8	21,1	65,8	3,52	7326
	M4	21,4	7,8	21,5	65,9	2,04	7422
MMA_20-T	M3	16,7	34,6	16,8	47,6	3,9	5205
	M4	10,9	34,0	17,0	47,9	4,21	5358

E. Relationship of Geological Structure to Coal Quality in the Research Area

The drilling track is located around the Pengasih Thrust Fault and the Pengasih Anticline folds (Figure 7). At the core drilling location in the research area as on Table 1 is the MMA_19-T drill point location has dip 68º on seam M3 and 70º on seam M4. At the location of the MMA_18-T drill point, which is on the northwest wing, dip of seam M1 is 47º, dip of seam M2 is 47º, dip of seam M3 is 60º, and dip of seam M3A is 45º. The location of the MMA_20-T drill point, which is on the southeast wing of the research area, seam M3 has a dip 54º and dip of seam M4 is 55º.

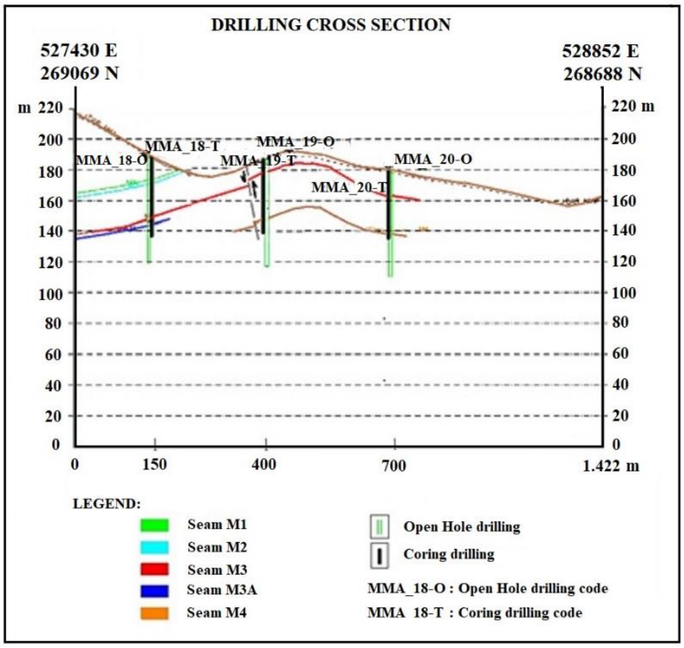

Figure 7. Drilling cross section in the research area

The seam M3 quality in MMA_18-T, MMA_19-T and MMA_20-T, and seam M4 quality in MMA_19-T and MMA_20-T have different coal qualities. The quality of coal in seam M3 in MMA_19-T is better than MMA_18-T and MMA_20-T (Table 3). The quality of coal in seam M4 in MMA_19-T is better than MMA_20-T also (Table 4).

Table 3. The seam M3 quality in the research area

Drilling Code	Seam	TM (%)	ASH (%)	VM (%)	FC (%)	CV (ADB) Kcal/kg
MMA_18-T	M3	22,0	6,8	22,2	64,9	6660
MMA_19-T	M3	13,3	12,8	21,1	65,8	7326
MMA_20-T	M3	16,7	34.8	16,8	47,6	5205

Table 4. The seam M4 quality in the research area

Drilling Code	Seam	TM (%)	ASH (%)	VM (%)	FC (%)	CV (ADB) Kcal/kg
MMA_19-T	M4	21,4	7,8	21,5	65,9	7422
MMA_20-T	M4	10,9	34,0	17,0	47,9	5358

The relationship between the dip of coal seam and the calorific value (Kcal/kg) in the research area is as shown in Figure 8. There is a difference in coal quality which is better in seams M3 and M4 in MMA_19-T than MMA_18-T and MMA_20-T.

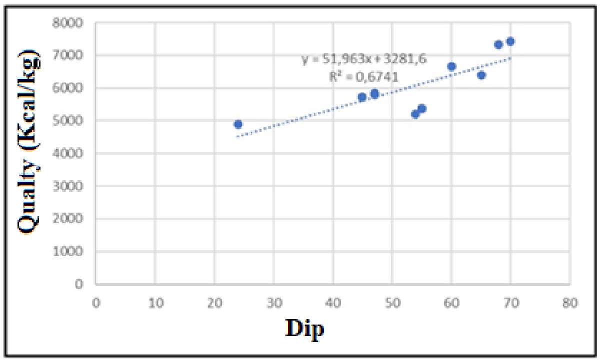

Figure 7. The relationship between the dip of coal seam and the calorific value (Kcal/kg)

IV. CONCLUSION

The quality of coal in the same seam in the study area varies. The total moisture value 7.51% - 26.33%, ash content 6.8% - 44.52%, volatile matter 15.15% - 23%, fixed carbon 38.20% - 65.9%, total sulfur 1.47% - 9.89% and calorific value 4888 Kcal/kg – 7422 Kcal/kg.

There are differences in coal quality in the same seam in the research area as a result of the presence of geological structures. The difference in dip of seams M3 and M4 in MMA_19-T is higher due to folding (Pengasih Anticline) and faulting (Pengasih Thrust Fault).

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