Characteristic of pro delta environment on coal seam PAF and NAF, warukin formation, South Kalimantan

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Abstract. Coal seam of the Kusan Bawah block, Warukin Formation, Asam-Asam Basin, South Kalimantan has age middle Miosen to Late Miosen. The purpose of this study is to investigate the characteristic of the coal, PAF, and NAF, the depositional environment. The method used in this research is taking rock samples from core drilling and then testing the quality of rock geochemistry by using Net Acid Generating test. Rock geochemical analysis results are entered into modeling software to determine its distribution based on stratigraphic principle. Results of rock geochemical quality analysis based on SNI 6597-2011 to Non-Acid Forming and Potential Acid Forming. The advantages of identification PAF or NAF value are about preventive activity to decrease acidic pollutant material in the environment. Potential Acid Forming material is above seam G and is between EL and seam D. The percentage of Potential Acid Forming material is 33.17% and NAF 66.83%. The depositional environment of the Kusan Bawah block is interpreted in pro delta and transgressive conditional.

1. Introduction

Today the environmental problems in mining activities are often in the spotlight of the community. Activities that do not consider environmental issues both biotic and physical environment will face problems and may even incur greater costs to mitigate it than to prevent it. One of the problems that often arise in coal mining is due to taking and stockpiling of overburden material to get coal that has economic value. This overburden material can contain sulfides, especially iron sulfide (FeS) as pyrite, so that when exposed to air and water it will produce acidic water[1].

The presence of acidic water can also dissolve compounds of dangerous or toxic metal ions such as mercury, lead, cadmium arsenic and others contained in overburden so it can cause adverse effects on aquatic life, groundwater quality, soil quality and relaxation. The formation of acid mine drainage can be prevented by knowing the layered rock of material that has the potential to produce acid. Finding out acid mine drainage material can be done by conducting Net Acid Generating testing[2]. The NAG test results produce potential acid forming (PAF) and non-acid forming (NAF) materials. This data material will be used to make rock geochemical models. The results of predictions of materials that have the potential to produce acid mine drainage can be used as consideration in mining design and
environmental management efforts to minimize undesirable impacts on the environment. The final results expected from this study are the distribution of PAF and NAF rocks in Kusan Bawah block, the volume of rock PAF and NAF, the effect of depositional environment on the characteristics of coal and PAF NAF rocks.

The basins in South Kalimantan are the Barito Basin and the Asem-Asem Basin which generally have relatively similar stratigraphic features from old to young. The Barito Basin and the Asem-Asem Basin are separated by the Meratus Mountains. In the north, it borders the Kutai Basin which is separated by the Andang Fault. Whereas the western part is limited by the Sunda Exposure. At first the Barito Basin and the Asem-Asem Basin were the same basin, until the Early Miocene the Meratus Mountains were removed which caused the separation of the two basins [3]. The South Kalimantan stratigraphy includes several formations, namely basement in the form of Malihan Rock, Tanjung Formation, Berai Formation, Warukin Formation, and Dahor Formation and Alluvial Deposits. These formations are Eocene to Pliocene.

The Warukin Formation is deposited on the Berai Formation which is composed of gray-colored claystone, sandstone and coal inserts [4]. The lower part of this rock formation consists of the dominance of gray to blackish claystone with fine grade-to-medium sandstone inserts with parallel laminated sedimentary structures from carbon material, flaser and burrow [5]. Local sandstones and carbonate clay contain iron concretion. This unit is deposited in the litoral to paralic environment and is 250-750 m thick. This formation is deposited in the marsh and tidal depositional environments of the Early Miocene - Late Miocene age, indicated by fossils of Heterosgina sp, Lepidocyclina sp and Spyroclypeus leupoldii.

![Figure 1. Research area stratigraphy.](image)

The coal contained in the study area has been ranked lignite with very soft black, high moisture content, low dust content, and low calories content. Coal seams intersect with claystone gray, 0.5 m-1.0 m thick, and medium-grained sandstones, well divided, 0.5 m thick - 2.0 m. The thickness of the coal layer is from 0.5 m to> 20 m.
2. Method

2.1. Database
The data used for rock geochemical modeling of the Kusan Bawah Block area consists of full coring or geotechnical drilling data in the form of lithology data and laboratory analysis data, and the Kusan Bawah Blok coal model. Determination of drill points considers the representation of lateral and vertical distribution of rocks. The lateral distribution represents rock distribution in the direction of strike while vertical distribution represents rock distribution from old to young. The number of full coring drill for rock geochemical modeling in the Kusan Bawah Block area is 9 points with an average of 94 meters. The samples analyzed were all rocks except coal [6].

2.2. Sampling
Samples obtained from full coring drilling were nine points. From the full coring drill obtained the number of samples for rock geochemical analysis is 116 rock samples, which are taken every 5 m apart from coal. Composite sampling used if a thickness of lithologies longer than 5 m the samples were taken every 5 m and for lithologies, less than 5 m thick were represented by one sample. The sample is taken in the form of a 2-2.5 cm thick disc using a saw or other equipment (Figure 2). One sample consisted of 10 discs to reach a minimum weight of 2.5 kg. The number of samples is used to create a database or determine the characteristics of rocks, namely NAF and PAF. Drill spacing is between 250-500m.

![Figure 2. Sampling of coring](image)

2.3. Analysis
The analysis consisted of survey data, lithology data, and NAG quality data. Survey data used for topography and collar of the drillhole. Lithology data determined by geological logging and geophysical logging. Quality data are the results of geochemical analysis derived from samples using NAG dan pH testing. The geochemical analysis used for distribution vertical and lateral of the PAF NAF material. Geochemical data is used to model layers that have the potential to form acids with the help of computer software.

Lithology data, geophysical logging, and material geochemical quality data are used in the classification layer of lithologies. Each material will be named referring to the stratigraphic position. The layer with the same type of material is then correlated from a drill hole to another drill hole.

The code on the overburden is made only in layers located above or below the coal layer until the coal seam to be mined. The rock code will be described in the schematic model. The parameter used for rock correlation PAF NAF is by continuous method. Correlation of PAF NAF rock layers with continuous methods was carried out with similarity assumptions and lithology or interburden continuity between coal seams. The limit of the pH value for NAF is > 4.5 while for PAF <4.5. The result of these studies is ratio volume of PAF and NAF material [7].
3. Result and Discussion

3.1. PAF and NAF Rock Distribution

PAF NAF rock distribution for the Kusan Bawah Block area is divided into vertical and horizontal or lateral. Vertical distribution is the distribution of coal seam and PAF NAF layer which shows the oldest layer to the youngest layer in the modeling area, by making a cross-section perpendicular to the motion of the rock layer. Horizontal distribution is the distribution of the coal layer and PAF NAF layer extensively by making the cropline or PAF NAF rock outcrop so that it can be seen overlaying.

3.1.1. Vertical PAF and NAF Rock Distribution

The cross-section image under the polygon with fill dots in green is the NAF layer while the polygon with the red fill points is the PAF layer, while the polygon with the solid fill is the coal seam. PAF layers are between EL and D seams and also between Seam F and G. shown in red at the bottom and top of the cross-section.

![Figure 3. (a) Coal correlation between drilling hole. (b) Lateral PAF NAF distribution. Cross section of PAF NAF Kusan Bawah Block.](image)

3.1.2. Lateral PAF and NAF Rock Distribution

Laterally the spread of rock PAF NAF follows the alignment of coal cropline seam. Distribution of PAF and NAF rocks can be modeled using lithology data from the results of full geotechnical coring drilling and drill for NAG. The distribution of existing PAF NAF cropline rocks still follows the coal stratigraphy pattern and the geological structure of the Kusan area. The oldest layer NAF is the NAF EL layer located in the eastern part of the study area. This layer is composed of dominant mudstone with an average thickness of 11.90 m and a pH value of 7.23. The oldest layer PAF is PAFDL with an average thickness of 6.09 and pH value of 2.98 (Figure 4).

3.2. Characteristics of PAF and NAF

Based on the results of rock analysis with geochemical results, PAF rocks can be found in mudstone, sandstone, and siltstone. But PAF rocks are dominated by siltstone which is between EL to D seams, Siltstone is based on the results of modeling flanked by coal seams which indicate PAF rocks are
affected by coal deposits. NAF rocks are found in layers of mudstone, siltstone and siltstone with dominating rocks namely mudstone (Table.1).

![Figure 4](image.png)

**Figure 4.** Underlying lateral distribution of PAF NAF dan coal cropline.

| PAF Rock | Lithology | Thickness Average (m) | pH  | NAF Rock | Lithology | Thickness Average (m) | pH  |
|----------|-----------|-----------------------|-----|----------|-----------|-----------------------|-----|
| MSPAF    | Mudstone  | 2.88                  | 4.11| NAF3     | Mudstone  | 11.98                 | 5.06|
| SSPAF2   | Sandstone | 4.65                  | 4.03| NAF2     | Siltstone | 2.70                  | 6.70|
| SSPAF1   | Sandstone | 2.95                  | 3.10| NAF1     | Sandstone | 3.05                  | 5.34|
| PAFD     | Siltstone | 20.45                 | 3.89| NAFG     | Mudstone  | 14.21                 | 6.19|
| PAFDL    | Siltstone | 6.09                  | 2.98| NAFF     | Mudstone  | 21.58                 | 6.87|
|          |           |                       |     | NAFF1    | Mudstone  | 2.16                  | 8.05|
|          |           |                       |     | NAFFL    | Mudstone  | 3.23                  | 7.73|
|          |           |                       |     | NAFE     | Mudstone  | 27.40                 | 7.96|
|          |           |                       |     | NAFE1    | Mudstone  | 13.00                 | 7.64|
|          |           |                       |     | NAFEL    | Siltstone | 11.90                 | 7.23|
3.3. PAF and NAF Rock Volumes

The volume calculation of the NAF rock geochemical model is limited by the boundary Kusan Bawah Block, with the lower elevation boundary being 150 meters deep. NAF volume is calculated from the smallest thickness to the largest thickness of the NAF layer without distinguishing using expressions or minimum limits as in the calculation of coal volume. Based on the model that has been made, we can calculate the amount of PAF material and NAF material. The volume of material PAF and NAF is obtained from models that have been made using software. The PAF material volume was 373,438,062.62 BCM with a percentage of 33.17% and NAF material of 752,515,184.08 BCM with a percentage of 66.83% seen in Table 3.

Table 2. PAF and NAF Volumes Kusan Bawah Block.

| PAF   | PAF Volume (BCM) | NAF   | NAF Volume (BCM) |
|-------|------------------|-------|------------------|
| MSPAF | 13,804,745.55    | NAF3  | 33,813,625.93    |
| SSPAF2| 15,618,936.28    | NAF2  | 9,884,970.52     |
| SSPAF1| 11,986,302.25    | NAF1  | 13,871,821.98    |
| PAFD  | 254,366,704.78   | NAFG  | 89,587,373.17    |
| PAFDL | 77,661,373.76    | NAFG1 | 401,420.91       |
|       |                  | NAFF  | 168,836,689.22   |
|       |                  | NAFF1 | 14,384,850.50    |
|       |                  | NAFFL | 17,893,773.56    |
|       |                  | NAFE  | 266,760,467.94   |
|       |                  | NAFE1 | 4,599,279.18     |
|       |                  | NAFEL | 132,480,911.17   |
| Total | 373,438,062.62   | Total | 752,515,184.08   |
|       | Percentage       | Percentage | 33.17% |
|       |                  |       | 66.83%           |

4. Conclusion

PAF layers are between EL and D seams and are also found between Seam F and G. PAF material volume was 373,438,062.62 BCM with a percentage of 33.17% and NAF material of 752,515,184.08 BCM with a percentage of 66.83%. Preventive activity to decrease acidic pollutant in the mining area are managing PAF rock to keep above NAF material and topsoil. It can isolate a PAF rock and decrease the reaction between PAF rock (acidic) and surface air (such as Oxygen).

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