Identification of Coal Distribution Pattern Using Well Logging Method Based on Gamma Ray Log Data and Log Density in Area X PT PMC Site Sungai Lilin

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Abstract :
Physiographically, the research area is included in the South Sumatra Basin, precisely in the Muara Enim Formation, a coal-bearing formation. In this study, secondary data is used in the form of LAS file data from recording well logging data as many as 7 wells which are then processed using WellCAD 5.5 software to obtain log sheet results, namely gamma ray logs and density logs which are then interpreted for subsurface lithology by reading the log curve deflection, from the results of reading the log curve, the lithology in the research area is obtained in the form of claystone, siltstone, carbonaceous claystone, and coal. Coal is characterized by low gamma ray log response (<10 CPS) and high density log response (>900 CPS). To determine the distribution of coal seams in the study area, structural correlation and stratigraphic correlation of coal seams on strike (northwest - southeast) and cross strike (southwest - northeast) were found to be 1 coal seam, namely seam A. Seam A experienced splitting into seam A1 and seam A2 due to structural influence. From the correlation results, it is found that the coal slope is towards the southwest - northeast by experiencing thickening and thinning layers.

Keywords: Muara Enim Formation, Well Logging, Coal Distribution

1. Introduction

Coal is a strategic excavation material that is one of the economically important national energy resources. Coal is a non-renewable energy source but the potential of coal is currently able to rival the role of petroleum (Anshari, f. 2016). Coal is a hydrocarbon fuel with a solid form derived from the process of dissolution and welcoming that is in the basin through a geological period (Sukandarrumidi, 1995). Each coal layer has a thickness that is not always the same, this is controlled by the processes that take place during deposition and processes after deposition (Kuncoro, 1996).

The distribution of coal in Indonesia itself is quite widespread in both western and eastern Indonesia. Most of them are found in coal basins in several places on Sumatra Island and Kalimantan Island, such as the South Sumatra Basin and so on.

The area where the author conducted the research is in the South Sumatra basin in the coal bearing formation, namely the muara enim formation which is part of PT Putra Muba Coal which is located in the x Sungai Lilin area, South Sumatra.

In connection with this, exploration activities as the first step in a mining stage need to be carried out which later from existing data and after careful study further activities are expected to be useful until the production or exploitation process.

The stages in determining subsurface conditions in this coal field research with the well logging method. According to Harosono 1993, the purpose is not only to obtain geological information but also to obtain various data such as depth, thickness, coal quality, and geomechanical properties of rocks that accompany the addition of coal. The log curve provides sufficient information about the properties of rocks and fluids, the author performs structural correlation and stratigraphic correlation based on the results of log sheet interpretation to determine the coal distribution pattern. The coal distribution pattern itself can be needed to find coal deposits that have economic reserves for exploitation activities.

This research aims to determine the distribution pattern of coal based on well logging data of gamma ray log and density in the research area. administratively the research area is located in B2 village, Sungai Lilin sub-district, Musi Banyuasin Regency, South Sumatra. Access to the research area can be reached from Jambi city about +200 km, stratigraphy is in the Muaraenim Formation (Tmpm).

2. Research Methods
Geological Setting

Physiographically, the South Sumatra Basin is a northwest-southeast trending Tertiary basin, bounded by the Semangko Fault and Bukit Barisan in the southwest, the Sunda Shelf in the northeast, the Lampung Plateau in the southeast that separates the basin from the Sunda Basin, and the Twelve Mountains and Thirty Mountains in the northwest that separate the South Sumatra Basin from the Central Sumatra Basin. The South Sumatra Basin is one of the most important basins in terms of oil, gas and coal deposits. The basin contributes one-third of Indonesia's coal resources, and has undergone three orogenies, namely the Middle Mesozoic, Late Cretaceous-Early Tertiary, and Plio-Plistocene (de Coster, 1974; Gafoer, Amin and Purnomo, 2007).The South Sumatra Basin produces coal deposits with a fairly wide distribution, but the coal rank is not very high, except around areas of igneous intrusion, such as those found in the Air Laya, Suban, and Bukit Kendi coal fields.
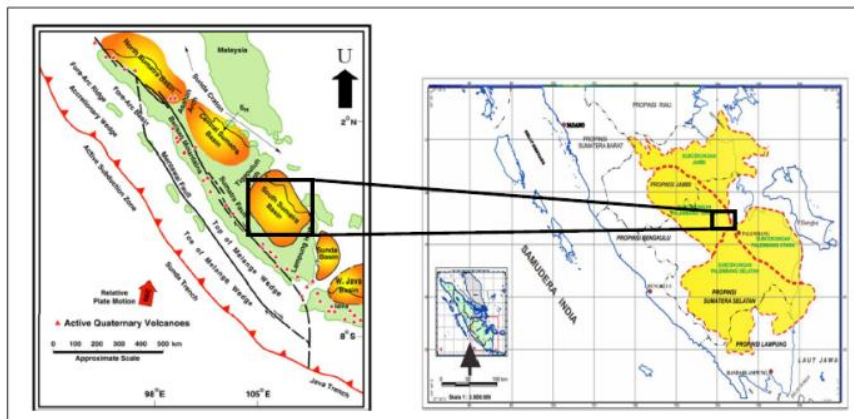

Figure 1. The South Sumatra Basin

The geology of the study area is arranged in stratigraphic sequence from old to young, namely groups of tuffaceous mudstone, siltstone and Miocene-Pliocene aged coal beds known as the Muara Enim Formation. The Muara Enim Formation was deposited in line above the Air Benakat Formation. This formation represents the final stage of the Tertiary regression phase, aged Upper Miocene which is composed of mudstone, sandstone, siltstone and coal.
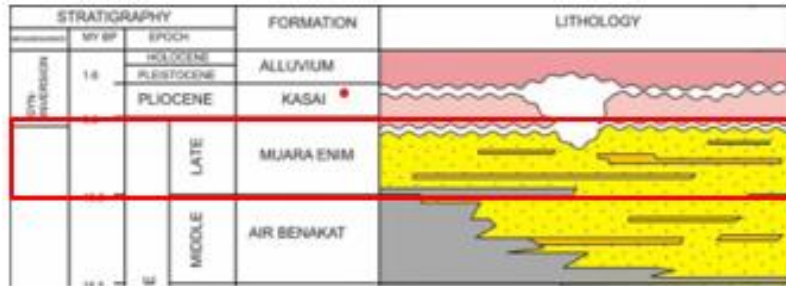
Figure 2. The South Sumatra Basin

Methods

This research uses descriptive-observative method, which is used consists of literature study, and interpretation of Well Logging data, The method used in the interpretation of Well Logging data by taking Gamma ray logs and density logs to determine the underground lithology and coal in the study area. The analysis was carried out using 7 well logging data with different elevations and depths on each log. The logging data used in this study are gamma ray logs and density logs. Both logs are useful for interpreting subsurface lithology. The results of the interpretation done by the author can be compared with cutting data from the wellsite to get accurate data. Identification of coal distribution patterns is carried out by structural correlation and stratigraphic correlation of boreholes to obtain 3D modeling.

3. Results and Discussion

The research location is in the mining area of PT Putra Muba Coal with an area of 2,949 Ha. The research area has an area of 31.21 Ha and the number of drill points is 7 points with the depth and elevation of the drill points varying from one to another.In geophysical recording, the logging equipment used is a set of Robertson Geo in the form of radioactive substance Cesium 137, Gamma Ray and Density Probes, Digital data logger, Laptop, Speed Control, Winch System, and Generator.
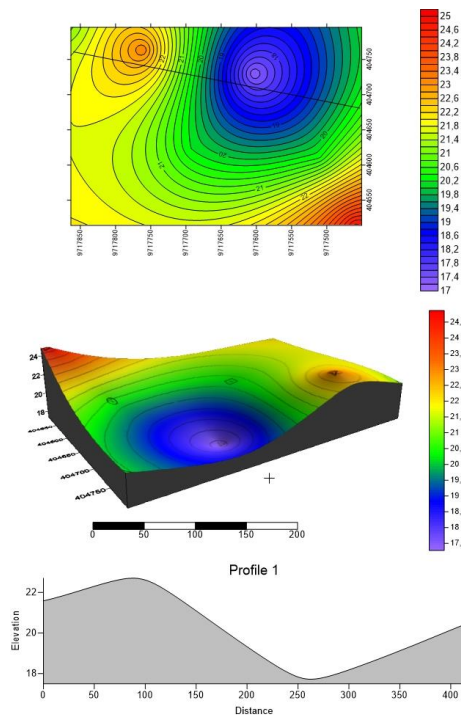

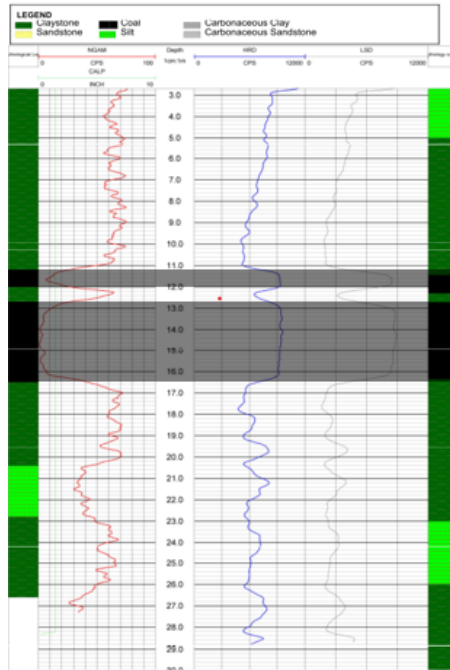Figure 3. Contour Map of the Research Area

Figure 4. Well Logging Data Well PJ_03

On PJ_03 log sheet with a depth of 26 meters, GRmin and GRmax are obtained, namely 5.68 CPS and 68.13 CPS in seam A1 coal so that the Vshale result is 23% then 0.98 CPS and 71.27 CPS in seam A coal so that the Vshale result is 36%. Then 31,470 CPS - 48,720 CPS is siltstone, and 41,078 CPS-76,667 CPS is claystone. At drill point PJ_03 there is one coal seam. At a depth of 11.20 m to 12.00 m, a coal layer with a thickness of 0.80 m was found. The layer with the largest thickness at point PJ_03 is claystone which is also the most dominant lithology with a thickness of 8.51 m.
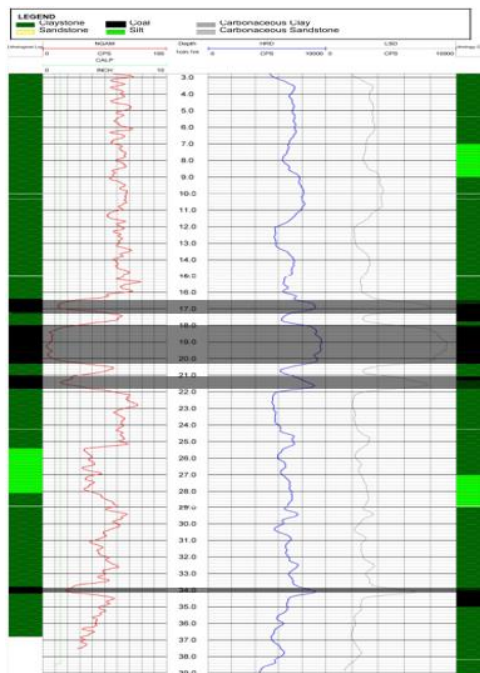

Figure 5. Well Logging Data Well PJ_04

On PJ_04 log sheet with a depth of 36 meters, GRmin and GRmax are obtained, namely 2.94 CPS and 59.51 CPS in seam A1 coal so that the Vshale result is 50%, 1.56 CPS and 53.73 CPS in seam A coal so that the Vshale result is 50%, then 15.09 CPS and 70.78 CPS in seam A2 coal so that the Vshale result is 26%. After that 28.430 CPS - 44.220 CPS is siltstone, and 46.470 CPS - 79.85 CPS is claystone.

At drill point PJ_04 there are three coal layers with one main seam and splitting in the main layer. Namely at a depth of 16.40 m to 17.20 m a coal seam was found which was a splitting of the main seam with a thin thickness of 0.80m. Then at a depth of 18.00 m to 20.30 m, the main coal seam is found with a thickness of 2.30 m. Then at a depth of 21.00 m to 20.30 m, the main seam is found. Then at a depth of 21.00 m to 21.80 m, a coal seam was found which was also a splitting of the main seam with the same thickness as the first coal seam of 0.80m. The layer with the largest thickness at point PJ_08 is claystone which is also the most dominant lithology with a thickness of 13.64 m.
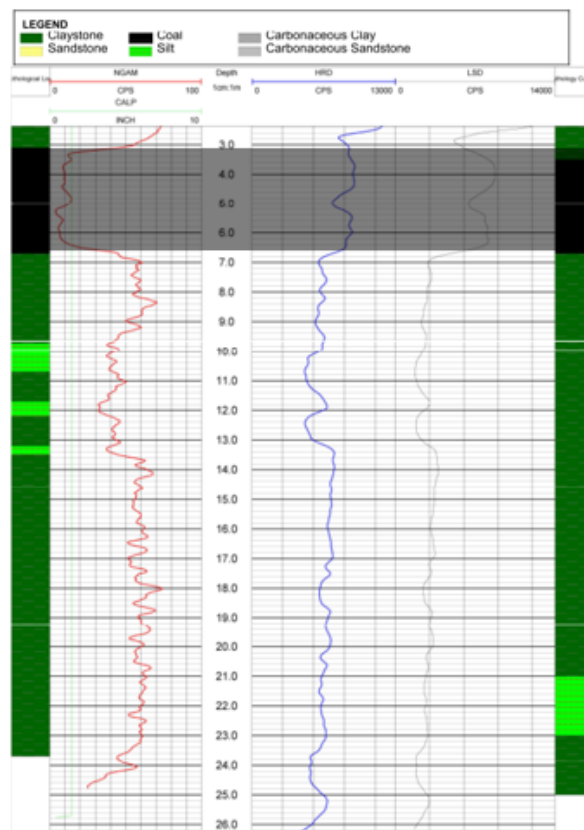

Figure 6. Well Logging Data Well PJ_06

On PJ_06 log sheet with a depth of 24 meters, GRmin and GRmax are obtained, namely 3.53 CPS and 74.56 CPS in coal seam A so that the Vshale result is 61%. Then 32,840 CPS-49,090 CPS is siltstone, and 34,216 CPS-76,331 CPS is claystone. At drill point PJ_06 there is one coal seam. At a depth of 3.10 m to 6.70 m, a coal seam with a thickness of 3.60 m was found. The layer with the largest thickness at point PJ_06 is claystone which is also the most dominant lithology with a thickness of 8.51 m.
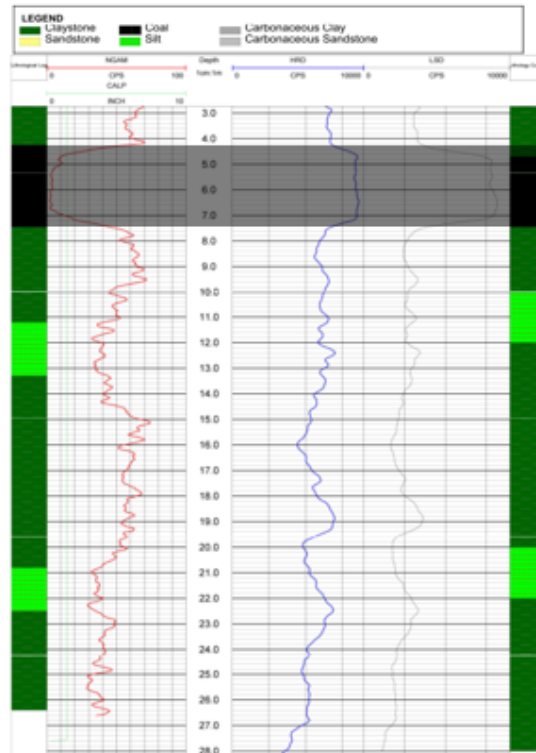
Figure 7. Well Logging Data Well PJ_07

On PJ_07 log sheet with a depth of 26 meters, GRmin and GRmax are obtained, namely 2.45 CPS and 67.75 CPS in coal seam A so that the Vshale result is 60%. Then 31,270 CPS-48,530 CPS is siltstone, and 44,510 CPS-77,451 CPS is claystone. At drill point PJ_07 there is one layer. At a depth of 4.25 m to 7.45 m, a coal seam with a thickness of 3.20 m was found. The layer with the largest thickness at point PJ_07 is siltstone of 5.40 m.
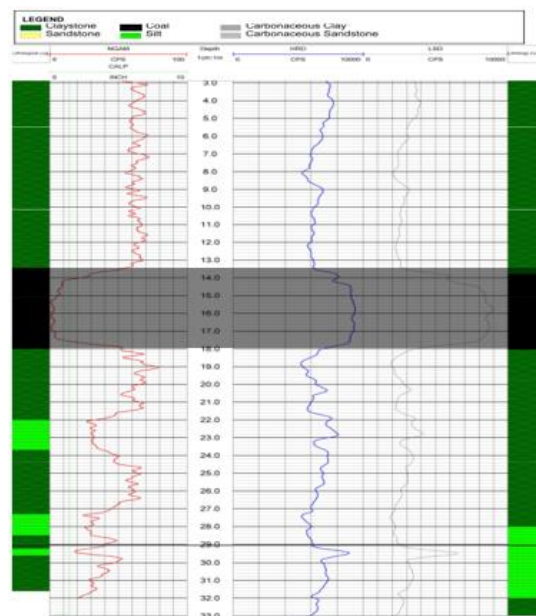

Figure 8. Well Logging Data Well PJ_08

On PJ_08 log sheet with a depth of 31 meters, GRmin and GRmax are obtained, namely 0.49 CPS and 80.0 CPS in coal seam A so that the Vshale result is 64%. Then 18,970 CPS-32,940 CPS is siltstone, and 42,255 CPS-83,922 CPS is claystone. At drill point PJ_08 there is one coal seam. At a depth of 13.45 m to 18.00 m, a coal layer with a thickness of 4.55 m was found. The layer with the largest thickness at point PJ_08 is claystone which is also the most dominant lithology with a thickness of 10.57 m.
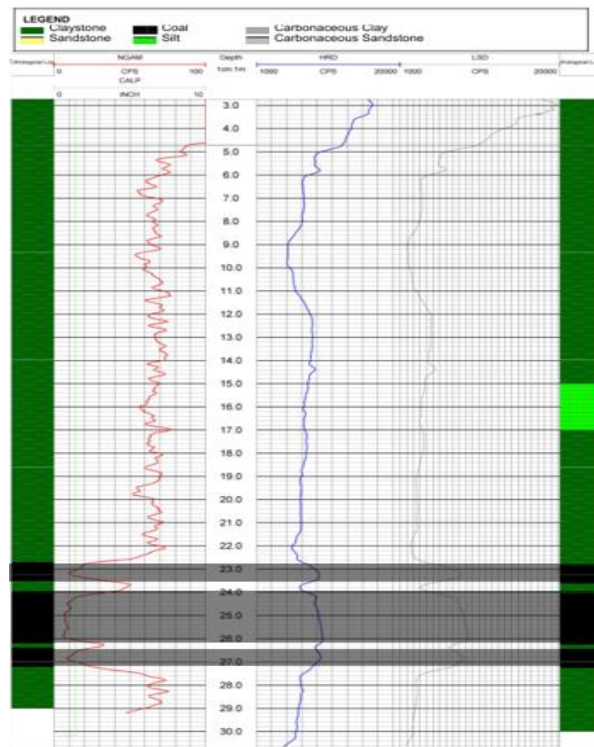

Figure 9.Well Logging Data Well PJ_09

On PJ_09 log sheet with a depth of 29 meters GRmin and GRmax are 8.92 CPS and 51.12 CPS in seam A1 coal so that the Vshale result is 41%, 5.49 CPS and 36.83 CPS in seam A coal so that the Vshale result is 71%, then 6.30 CPS and 73.40 CPS in seam A2 coal so that the Vshale result is 27%. After that 59,804 CPS-70,490 CPS is siltstone, and 103,235 CPS-128,501 CPS is claystone.

At drill point PJ_09 there are three coal layers with one main layer and splitting in the main layer. That is, at a depth of 22.70 m to 23.50 m, the first layer is found which is a splitting of the main seam with a thin thickness of 0.80m. Then at a depth of 24.00 m to 26.20 m a coal seam was found which is the main seam with a thickness of 2.20m. Then at a depth of 26.40 m to 27.20 m, a third coal seam was found which is also a splitting of the main seam with the same thickness as the first seam of 0.80m. The layer with the largest thickness at point PJ_09 is claystone which is also the most dominant lithology with a fairly deep thickness of 19.97m.
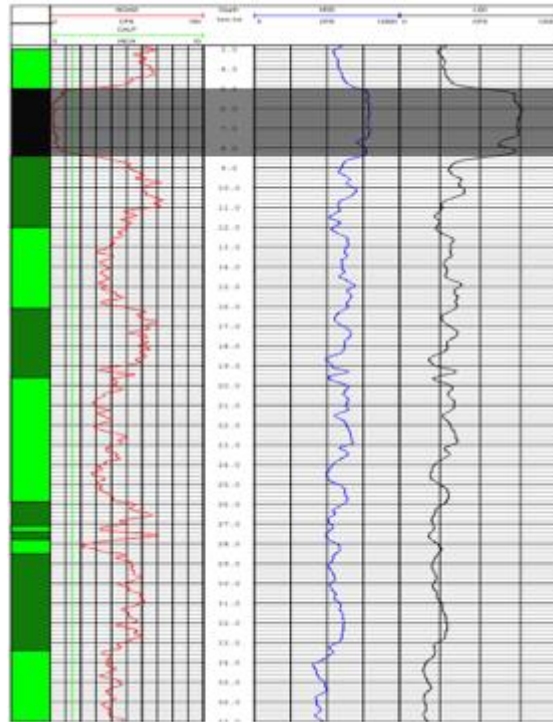
Figure 10. Well Logging Data Well PJ_11

On PJ_11 log sheet with a depth of 37 meters GRmin and GRmax are 0.90 CPS and 61.41 CPS in coal seam A so that the Vshale result is 31%. Then 23,950 CPS -42,941 CPS is siltstone, and 47,199 CPS-73,039 CPS is claystone. At drill point PJ_11 there is one coal seam. At a depth of 5.00 m to 8.40 m, a coal seam with a thickness of 3.40 m was found. The layer with the greatest thickness at point PJ_07 is siltstone of 6.30 m.
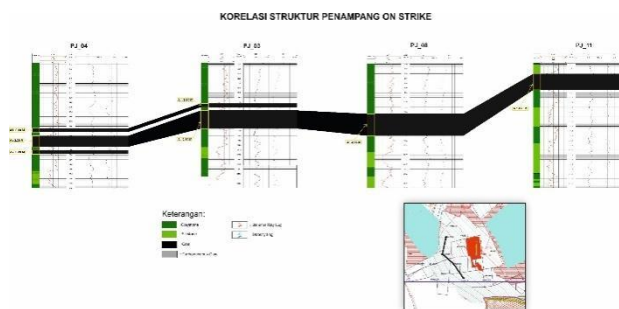

Figure 11. Coal seam structure correlation in strike direction

In this correlation, there are three seams with relatively uniform layer slopes with a northwest-southeast distribution direction.

Based on the results of the structural correlation in the strike direction, there are three seams that can be correlated well, namely seam A, A1, and A2 with varying thicknesses of each seam. Seam A in the PJ_04 well has a thickness of 2.30 m, experiencing a geological phenomenon in the form of splitting to the southeast later in the PJ_04 well so that it divides seam A into 2 parts, namely seam A1 and seam A2 which have the same thickness of 0.80 m each, for this A2 seam splitting itself does not have continuity and is only found at drill point PJ_04. Furthermore, at drill point PJ_03 there is a continuation of seam A and its splitting, namely seam A1 which has a thickness of 3.80 m each in seam A and 0.80 m in seam A1. Furthermore, in well PJ_08 there is only a continuation of seam A which has a thickness of 4.55m. Then the last in this strike direction structure correlation is at drill point PJ_11 which has a continuation of seam A which has a thickness of 3.40m. It can be seen that seam A which is the main seam starting from point PJ_04

with a thickness of 2.30 m thickens to the southeast to 3.80 m in well PJ_03 and vice versa seam A in well PJ_03 experiences thinning to the northwest in well PJ_04. Furthermore, at drill point PJ_03, it thickens to the southeast to 4.55 m in well PJ_08. Then in the PJ_08 well there is a thinning to the southeast to 3.40 in the PJ_11 well. For the subseam, namely seam A1 and A2, there is a constant distribution with the same thickness in each of the PJ_03 and PJ_04 wells, which remains 0.80 m. It was found that seam A is thicker when in the center of the study area and there is thinning towards the northwest-southeast of the study area.
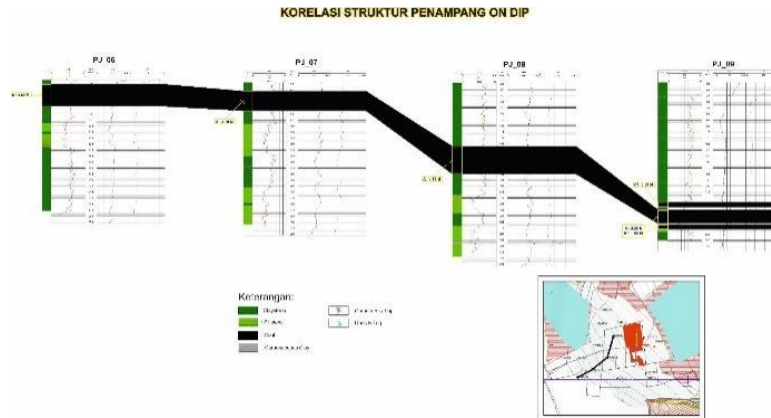

Figure 12. Coal seam structure correlation in dip direction

In this correlation, there are three seams with relatively uniform layer slopes with a northwest-southeast distribution direction.

Based on the results of this dip-direction structure correlation, there are three seams that can be correlated well, namely seam A, A1, and A2 with varying thickness of each seam. Seam A in well PJ_06 has a thickness of 3.60 m. Furthermore, at drill point PJ_07 there is a continuation of seam A which has a thickness of 3.20 m. Furthermore, at well PJ_08 there is a continuation of seam A which has a thickness of 4.55m. Then the last in this dip direction structure correlation is at drill point PJ_09 which has a continuation of seam A which has a thickness of 2.20 m. This geological phenomenon in the form of splitting to the northeast so that it divides seam A into 2 parts, namely seam A1 and seam A2 which have the same thickness of 0.80 m each, for subseam A1 and A2 itself does not have a continuation and is only found at drill point PJ_09. It can be seen that seam A which is the main seam starting from point PJ_06 with a thickness of 3.60 m experiences thinning to the northeast to 3.20 m in well PJ_07 and vice versa seam A in well PJ_07 experiences thickening to the southwest in well PJ_06. Furthermore, at the PJ_07 drill point, it thickens to the northeast to 4.55 m in the PJ_08 well. Then in the PJ_08 well there is a thinning towards the northeast to 2.20 in the PJ_09 well. For the subseam, namely seam A1 and A2, there is a constant distribution with the same thickness in the PJ_09 well, which is fixed with a thickness of 0.80 m. It was found that seam A has a considerable thickness in the PJ_08 well and is thinning towards the southwest-northeast.
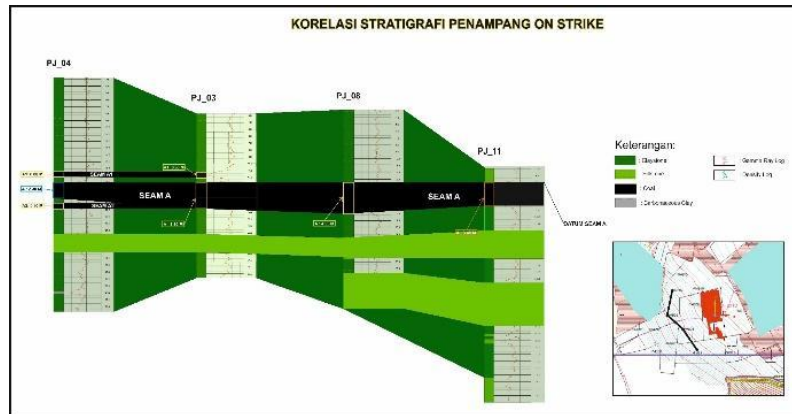
Figure 13. Stratigraphic correlation of coal seams in strike direction

Stratigraphic correlation of strike direction cross section using key bed of top coal seam A. This correlation is a strike direction correlation that extends in a northwest-southeast direction using 4 drill holes namely PJ_03, PJ_04, PJ_08 and PJ_11. This correlation is shown in (Figure 13).

Based on (Figure 13) it can be seen that the research area in the northwest-southeast direction only has lithologies in the form of claytone, siltstone, and coal and is dominated by coal because of its deposition area in the form of swamps. Then there are 2 seams that can be correlated well, namely seam (A and A1) with varying thickness variations. Seam A has a thickness of 2.30 m in well PJ_04 then thickens to the southeast to 3.40 m in well PJ_11. Seam A1 has a thickness of 0.80 m and remains constant to the southeast with a thickness of 0.80 m in well PJ_03. Stratigraphic correlation in the strike direction illustrates thickening symbolized by orange lines and thinning by light blue lines.
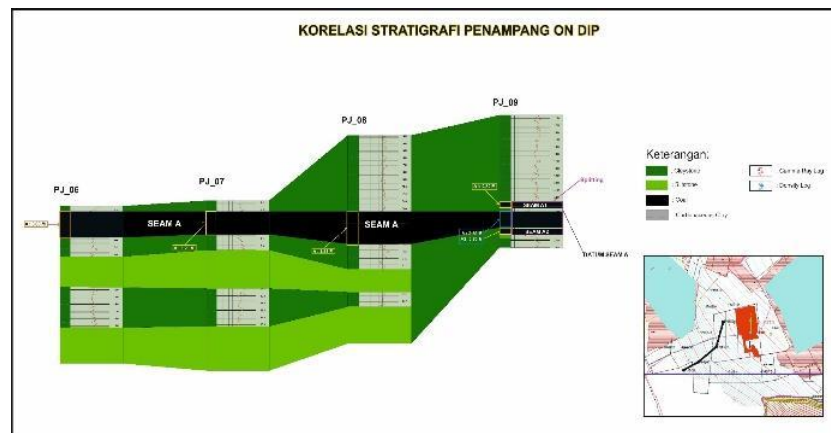

Figure 14. Stratigraphic correlation of coal seams in dip direction

Stratigraphic correlation of dip direction cross section using key bed of top coal seam A. This correlation is a strike direction correlation that extends in a northwest-southeast direction using 4 drill holes namely PJ_06, PJ_07, PJ_08 and PJ_09. This correlation is shown in (Figure 14).

Based on (Figure 26) it can be seen that the research area in the southwest-northeast direction only has lithologies in the form of claytone, siltstone, and coal and is dominated by coal because of its deposition area in the form of swamps. Then there are 2 seams that can be correlated well, namely seam (A, A1, and A2) with varying thickness variations. Seam A has a thickness of 3.60 m in well PJ_06 then thinning to the northeast to 2.20 m in well PJ_09. Seam A has a thickness of 2.20 m in the PJ_09 well then experiences thickening and geological phenomena in the form of splitting in the PJ_09 well so that seam A is divided into 2 parts, namely seam A1 and A2 with the same thickness of 0.80m. The stratigraphic correlation in the dip direction illustrates the thickening symbolized by orange lines and thinning with light blue lines. Thickening and thinning of the coal seam occurred due to the topography of the swamp before the coal was formed. The difference in lateral continuity in the strike direction stratigraphic correlation is thought to be

caused by fluvial processes resulting in coal seams with varying lateral continuity and varying thickness. This dip direction stratigraphic correlation also illustrates the presence of geological phenomena in the form of splitting depicted in purple color in (Figure 14).
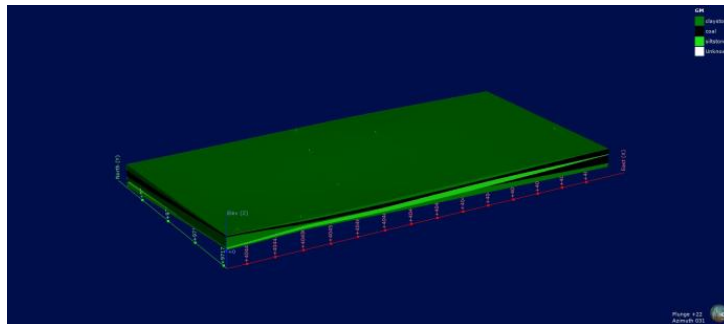

Fig 15. 3D Modeling of All Lithologies of the Study Area

From the 3D modeling results in the figure it can be concluded that seam A coal is found at a depth of 4.25 m - 26.20 m with a thickness between 0.80 m - 4.55 m, then seam A1 is found at a depth of 16.40 m - 23.50 m with the same thickness of 0.80 m. Then seam A2 is found at a depth of 3.10 m - 6.70 m with a thickness of 0.80m. Then seam A2 is found at a depth of 3.10 m - 6.70 m with a thickness of 0.80 m. The results of coal cross-sectional modeling are shown in Figure 16.
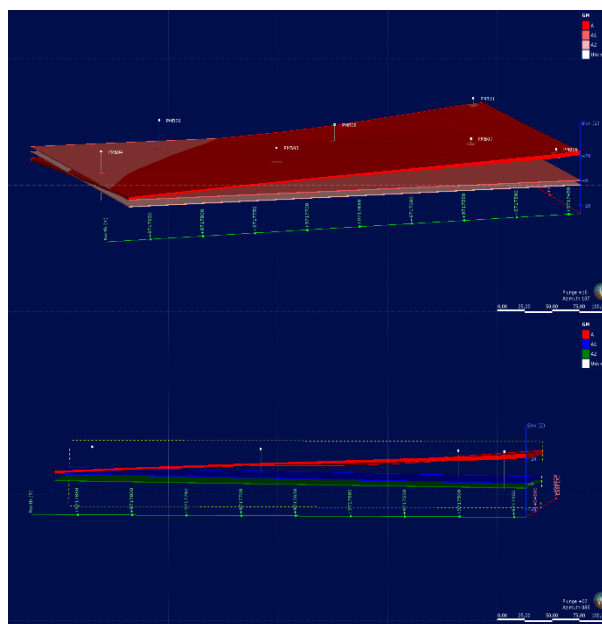

Figure 16. 3D model of coal and cross-sectional view

Based on the 3D modeling data above, the direction of coal distribution is obtained with a northwest-southeast strike direction and a dip direction that is southwest-northeast.
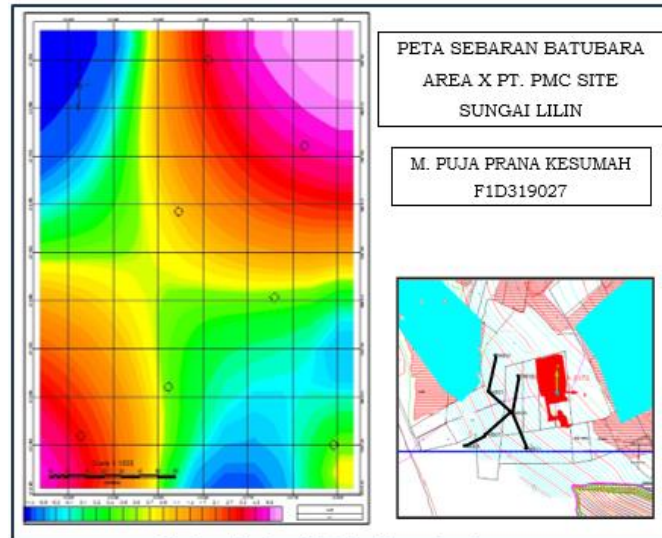
Fig 17. Map of Coal Distribution Pattern

The coal distribution map in Figure 17 was obtained using well point coordinate data, elevation and gamma ray log data. Based on gamma ray log data, it can be seen that the distribution of coal in the research area is mostly in the southwest-northeast direction.

Conclusion

The constituent lithologies of the study area are Claystone, Siltstone, and Coal. The lithology of the study area is dominated by claystone. Coal seam A is found at a depth of 4.25 m - 26.20 m with a thickness between 0.80 m - 4.55 m, then seam A1 is found at a depth of 16.40 m - 23.50 m with the same thickness of 0.80 m. Then seam A2 is found at a depth of 3.10 m - 6.70 m with a thickness of 0.80 m. Then seam A2 is found at a depth of 3.10 m - 6.70 m with a thickness of 0.80 m. Coal is characterized by low gamma ray log response (<10CPS) and high density log response (>90CPS).

The distribution of coal on strike is northwest-southeast and the distribution of coal on dip is southwest-northeast. The largest coal seam distribution is found in seam A which is found in 7 boreholes out of 7 boreholes studied. There is a branching in seam A in the form of subseam A1 and A2 which have the same distribution found in two boreholes. The thickest seam is seam A.

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