

Lithology and Coal Seam Interpretation Using Qualitative Analysis Based On Gamma-Ray and Density Log Data at “Puy” Pit In West Banko Mining Area

Zidane Anung Andita¹, Ivana Jayarani Sitompul², Rahmat Catur Wibowo^{2*}

¹Department of Geophysical Engineering, Faculty of Engineering, University of Lampung, Rajabasa, Bandar Lampung, 35145, Indonesia.

²Department of Geophysical Engineering, Faculty of Engineering, University of Lampung, Rajabasa, Bandar Lampung, 35145, Indonesia.

Riwayat Artikel

Submitted : 8/01/2026
Published : 28/04/2026

* Email Korespondensi:
rahmat.caturwibowo@eng.unila.ac.id



Abstrak: Batu bara adalah salah satu sumber energi alternatif selain minyak bumi yang bisa digunakan sebagai bahan bakar pengganti yang lebih ekonomis. Potensi batu bara di Indonesia sangat besar dan merupakan salah satu potensi menjanjikan untuk dikembangkan, mengingat ketersediaannya yang melimpah. Well logging adalah metode geofisika yang digunakan untuk mendapatkan data litologi bawah permukaan yang tepat. Konsep well logging adalah untuk mengidentifikasi karakteristik batuan melalui respons data log di dalam sumur pada titik kedalaman yang tepat untuk mendapatkan informasi tentang lokasi dan ketebalan. Penelitian ini bertujuan untuk menginterpretasikan lapisan batu bara berdasarkan data log geofisika dan foto inti batuan untuk menentukan litologi di wilayah penelitian serta mengidentifikasi keberadaan lapisan batu bara di wilayah penelitian. Dalam praktik ini, digunakan empat sumur dengan data gamma-ray log, density log, dan foto inti batuan, serta Software WellCad digunakan untuk memilih litologi bawah permukaan. Litologi bawah permukaan yang diperoleh adalah Claystone, Siltstone, Sandstone, dan Batu Bara. Keberadaan setiap Lapisan Batu Bara

Kata kunci: coal, gamma-ray, density, keybed

Abstract: Coal is one of the alternative energy sources for petroleum that can be used as a more economical substitute fuel. The potential of coal in Indonesia is huge and is one of the promising potentials to be developed, considering its abundant availability. Well logging is a geophysical method used to obtain precise subsurface lithology data. The concept of well logging is to identify rock characteristics through the response of log data in the wellbore at the exact depth point to obtain information on location and thickness. This study aims to interpret coal layers based on geophysical log data and rock core photos to determine the lithology in the research area and identify the presence of coal seams. In this practical work, four wells were used with gamma-ray log data, density logs, and core photos, and WellCad Software was used to pick subsurface lithology. The subsurface lithology obtained is Claystone, Siltstone, Sandstone, and Coal. The existence of each Coal Seam can then be identified based on its keybed, where between Seam A1 and A2 there is a layer of Tuffaceous Sandstone, then between Seam A2 and B1 is characterised by a keybed in the form of Suban Marker, then between Seam B1 and B2 is separated by a layer of Carbonaceous Sandstone. Finally, between Seam B1 and C layers, there is a layer of Glauconite Sandstone lithology.

Keywords: coal, gamma-ray, density, keybed

1. INTRODUCTION

Coal is one of the energy sources that can be used as a substitute for petroleum, and it has been widely used as a fuel because coal has economic value, can produce high heat energy, and is durable [16]. In addition, coal is also used in various industries, especially in power generation. It is also an ingredient in making briquettes, often used in the household industry for heating. Indonesia has abundant coal reserves, so the potential for development in terms of coal exploration and exploitation in Indonesia is quite promising [3]. Based on data from the Performance Achievement of the Ministry of Energy and Mineral Resources of

the Republic of Indonesia in 2021 and the 2022 work program of the ESDM sector, the realisation of domestic coal utilisation or DMO reached 133 million tons from the total production of 614 million tons or 98.24% of the target of 625 million tons. In 2022, the Ministry of Energy and Mineral Resources will prioritise coal needs in fulfilling domestic interests with a DMO target of 165.7 million tons from a total production of 663 million tons [6]. Coal is also an excavation material that has become one of the national energy resources, and it certainly requires an efficient and maximum exploration process. Geophysical methods that can be used in coal exploration are well-logging methods [6].

Coal is formed very complexly and takes a very long time (tens to hundreds of millions of years) under the influence of physical, chemical, and geological conditions. The contents of coal-forming materials consist of peat-forming plants and sedimentary streams, while the deposition location is where the coal is formed [9]. Theoretically, coal is formed from plant residues through biochemical and thermal processes that begin with the destruction of plants as coal-forming materials and then solidify in one place (basin), becoming solid peat [10]. Conditions of temperature, pressure, and coal age

strongly influence the process of coal maturation. However, coal maturation can also proceed very quickly if there are significant changes in pressure and temperature, such as magmatic intrusion. In the process of weathering and dissolution, the factors that influence it are plant evolution, climate, geography, location, pressure, and time [3]. This research was conducted to obtain information on the lithology and coal seam of PIT "Puy" in the West Banko Mine Area.

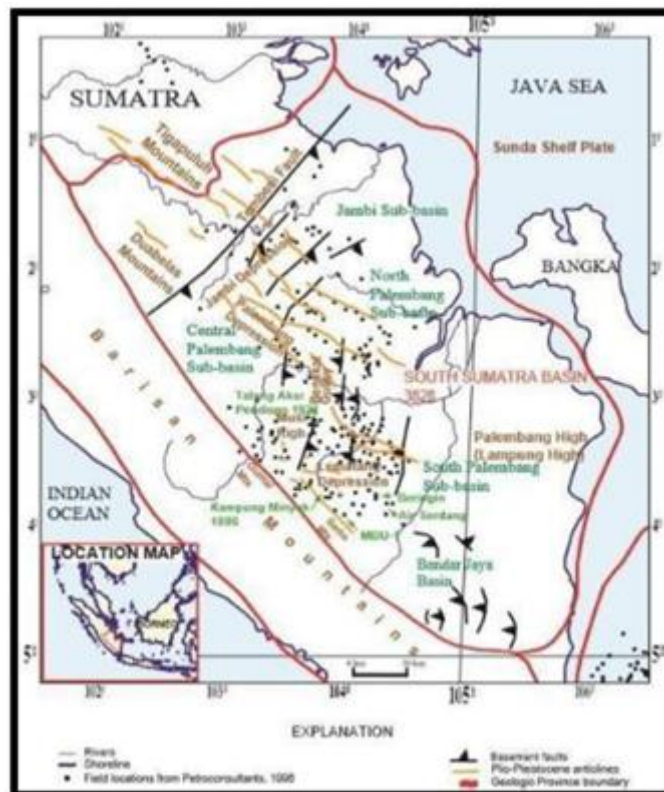


Figure 1. Regional Tectonics of the South Sumatra Basin [4].

In general, the study area is located in the South Sumatra Basin. The South Sumatra Basin extends from the Asahan elevation in the northwest to the Lampung elevation in the southeast. The South Sumatra Basin is divided into four sub-basins: Central Palembang Basin, South Palembang Sub-basin, Jambi Sub-basin, and North Palembang Sub-basin [12]. Tectonic activity that affects the regional geology of the South Sumatra Basin is divided into three major phases, namely:

1. Extensional phase is a phase where the continental crust on the southern Sumatra Island during the Late Cretaceous to Early Oligocene Period. This phase has a northeast-southwest and north-south orientation and forms half-grabens and horst blocks. In this period, sedimentation consisted of coarse clastics and vulcanoclastic deposits, with a lacustrine depositional environment.
2. The Subsidence Phase is from the end of the Oligocene to the Early Miocene, when the basin changed into a marine environment. Subsidence in

the South Sumatra Basin continues due to the existence of lithospheric thermal equilibrium.

3. The compression phase occurs very strongly during the Pleistocene period. It is characterised by the uplifting of the volcanic arc, which causes the orientation to change to northwest-southeast [4].

The study area is a part of the Muara Enim formation. The stratigraphy of the Muara Enim formation is divided into four sub-sections [13] named (from bottom to top) M1, M2, M3, and M4. Of the four subsections, the majority of coal resources in Tanjung Enim Village are in the M2 subsection. The layers are then divided into four groups of layers, namely:

1. Upper Mangus Layer (Seam A1 Coal)

The Seam A1 coal layer has a thickness of 6.8-10 meters. Seam A1 coal is covered by bentonite mudstone with a thickness of about 70-20 m, known as Seam A overburden. In the overburden of Seam A, hanging coal is formed due to the relatively fast coal deposition process, so only a small amount of

coal is formed. Seam A1 coal has an impurity band, such as tuffaceous claystone or tuffaceous sandstone, with a 1-15 cm thickness, where Siltstone lenses are found in the seam.

2. Lower Mangus Layer (Coal Seam A2)

The Seam A2 Coal seam is 9.8-14.7 meters thick, and there are thin inserts of Claystone as an impurity layer, referred to as the Clay band. Above this, the A2 coal seam is covered by Tuffaceous Claystone and Tuffaceous Sandstone with a thickness of 0.5-3 metres and is referred to as A2-A1 interburden. Seam A2 coal has an impurity band in the form of Carbonaceous Claystone.

3. Suban Layer (Coal Seam B)

Coal Seam B has a thickness of about 15.3-20 meters but, in some places, splits into B1 and B2 with thicknesses of 8.0-14.55 m and 3.0-5.8 m, respectively. Between the B1 and B2 layers, 2.0-5.0

m thick mudstones and siltstones are found, called interburden. Meanwhile, above the Coal B (or B1) layer is covered by Clay with a thickness of 15.0-23.0 meters. Above, Coal seam B or B1 is covered by Clay with a thickness of 15-23 m, intercalated with Sandstone and Siltstone, and there is a thin (0.4-0.6 m) layer of Coal or Carbonate Clay as the Suban Marker.

4. Petai Layer (Coal Seam C)

This coal seam C has a thickness of between 7.2-11.4 meters and, in some parts, experienced splitting into C1 and C2 with a thickness of 5.0 and 10.1 meters, respectively, and encountered thin inserts of carbonaceous siltstone with a thickness of between 2 to 10 cm. Above this C coal seam is covered by very hard silty sandstone with a thickness of 25.0-44.0 meters.

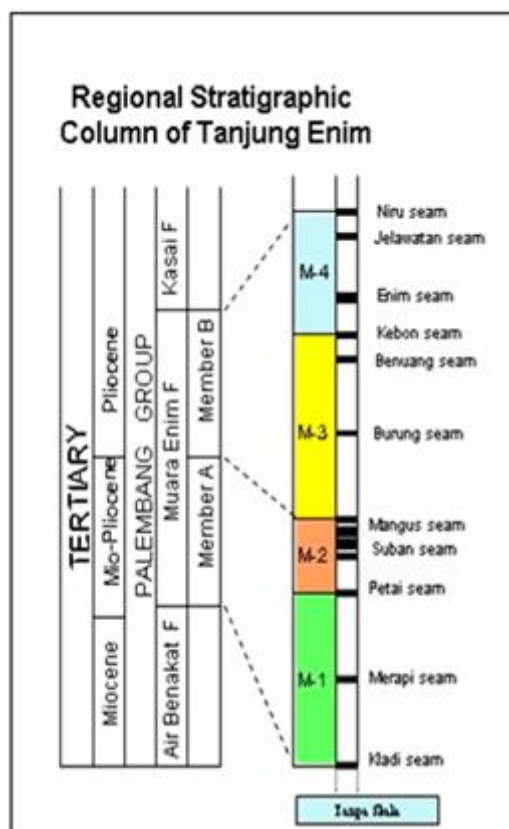


Figure 2. Regional Stratigraphic Column of Tanjung Enim [16].

2. METHODS

Well-logging is a measurement method that uses physical principles such as resistivity, radioactivity, acoustic waves, conductivity, and several others. In coal exploration, accurate and precise measurements are needed to determine coal resources and reserves. Measurement results with the well logging method are accurate, especially for the thickness function in coal exploration [5]. The well logging method is the continuous recording of data from measurements made in a bore hole to investigate variations in

some physical properties of rocks derived from borehole drilling [13], according to [11], well logging is one of the relatively accurate geophysical methods in determining the depth and thickness of a layer using a combination of gamma ray and density, based on the description of well logging, parameters that are often used in determining lithological interpretation using 2 kinds of logs, namely log density and gamma ray. **Table 1** explains the measurement using a wireline log.

Table 1. Measurement classification using wireline [8].

	Log Type	Measured Parameter Formation
Mechanical measurements	Caliper	Hole Diameter
Spontaneous measurement	Temperature	Borehole temperature
	SP (Self Potential)	Spontaneous electrical currents
	Gamma-ray	Natural radioactivity
Induced measurements	Resistivity	Resistance to electrical current
	Induction	Conductivity of electrical current
	Sonic	Velocity of sound propagation
	Density	Reaction to Gamma-ray bombardment
	Photoelectric	Reaction to Gamma-ray bombardment
	Neutron	Reaction to neutron bombardment

In coal mining exploration, well-logging is used to detect the distribution of coal. *Log* combinations that are often used in coal exploration are *gamma-ray logs* and *density logs* with several additional *logs*, such as *caliper logs* and *resistivity logs* [2].

2.1. Gamma-Ray Log

A gamma-ray log is one of the logging methods resulting from the recording of the Earth's natural radioactivity. The radioactivity is obtained from radioactive elements found in rocks such as Uranium (U), Thorium (T), and Potassium (K), which emit gamma rays in the form of pulses of high radiation energy. The gamma rays can penetrate the rock and are detected by a sensor in the form of a scintillation detector. The amount of log gamma ray produced in a record is the total amount of all

radiation produced by radioactive elements in rocks. Gamma ray logs are very effective in determining permeable zones, on the basis that radioactive elements are abundant in impermeable shale and only a few in permeable rocks. In impermeable rock formations, the gamma ray curve will deviate to the right, while in permeable rock formations, the gamma ray curve will deviate to the left. Radioactive elements in sedimentary rocks are concentrated in shale and clay, so that the presence or absence of clay minerals can be easily indicated through radioactive intensity. Rocks with high clay content will be indicated by high radioactive concentrations. So it can be seen in the log data that the gamma ray value is high, so that the log plot curve deflection tends to the right [2].

Table 2. Radioactive response based on the lithology [8].

Radioactive Very Low (0-32.5 CPS)	Radioactive Low (32.5-60 CPS)	Radioactive Medium (60-100 CPS)	Radioactive Very High (>100 CPS)
Anhidrit	Sandstone	Arkose	Shale
Salt	Limestone	Granite	Volcanic Ash
Coal	Dolomite	Shaly Sand	Bentonite
		Sandy Limestone	

In coal exploration, gamma ray logs are used to interpret rock types and determine layer thickness with the help of log density. In determining lithology, the log data obtained is compared with the results of description and core data. Gamma ray logs are in units of CPS (Counts Per Second). Each count corresponds to the incident gamma rays detected. Similar probes give similar counts per second for specific rock types. The most common crystal size is 1" X 3", based on the bounding diameter of the

probe. However, it may be difficult to compare absolute values given by different tools. The number of API or CPS units for a given formation depends on the crystal volume, instrument electronics, recording method, and recording speed. In older analogue recording systems, resistor/capacitor networks were used to "flatten" the random fluctuations of radioactive decay to give smooth results that could be plotted by a chart recorder. In modern recording systems, each

sample (whether obtained from depth or time sampling) contains a total of API or CPS units. These individual data samples are then averaged with a PC program to give a smooth output for presentation as a log. Raw data samples still contain random radiation data, which is the actual measurement. Geologists and engineers prefer to see smooth output, which minimises the noisy (but real) appearance of radioactive logging tools. By convention, radioactivity values increase towards the right on the log.

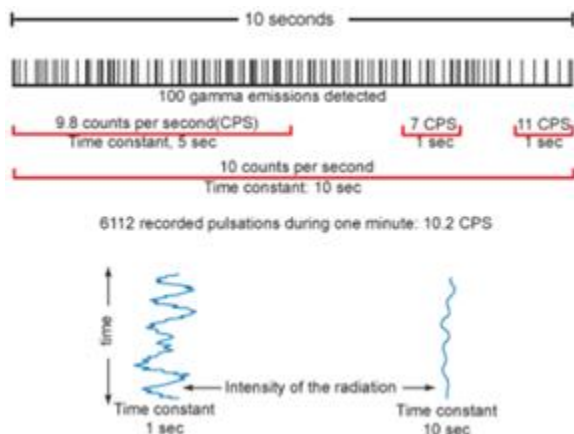


Figure 3. Log Gamma-ray CPS.

2.2. Density Log

Log density is a curve that represents the bulk density of the rock penetrated by the borehole in units of g/cc. The basic principle of this log is to shoot gamma rays into the formation, where these gamma rays can be considered as particles travelling at very high speeds. The amount of gamma ray energy lost indicates the electron density in the formation, which is an indication of the formation density. Bulk density is an important indicator for calculating porosity when combined with the log neutron curve, as the log density curve will show the density of the medium and its contents. Coal has a low density value because as a result of high pressure and temperature, the porosity produced in coal will be high. The lower the density, the better the quality of the coal. The log density curve is expressed in units of g/cc because the energy received by the deflector is influenced by the rock matrix and the content in the rock pores. Log density can also be expressed in Counts Per Second (CPS) units, but to simplify calculations, CPS units must be converted to g/cc because the CPS value is inversely proportional to the g/cc value. If CPS is high, then g/cc shows a low value, indicating low rock mass density [1]. The concept of log density involves the use of a radioactive source in the measuring device that emits gamma rays with a certain energy intensity. The gamma rays then penetrate the formation or rock being observed to measure its density. The rock is made up of mineral grains, where minerals are made up of atoms consisting of protons and electrons. When gamma

ray particles collide with electrons in rocks, there is a reduction in energy (loss of energy) [7].

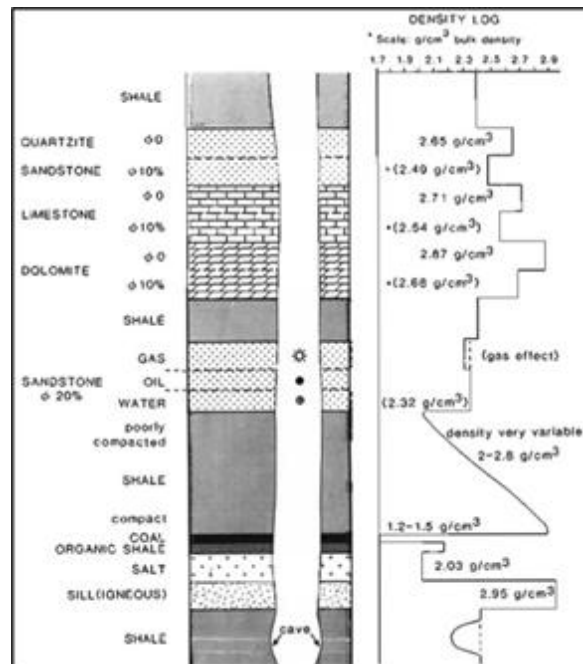


Figure 4. Log density response [14].

The research work steps (Figure 5) begin by collecting well data in the form of LAS, namely *Log_A*, *Log_B*, *Log_C*, and *Log_D*, which are then loaded using WellCad v.5.5 software. Then, lithology picking and lithology description are made. These two processes are carried out by setting the upper and lower limits of the layer depth and annotating the columns beside them.

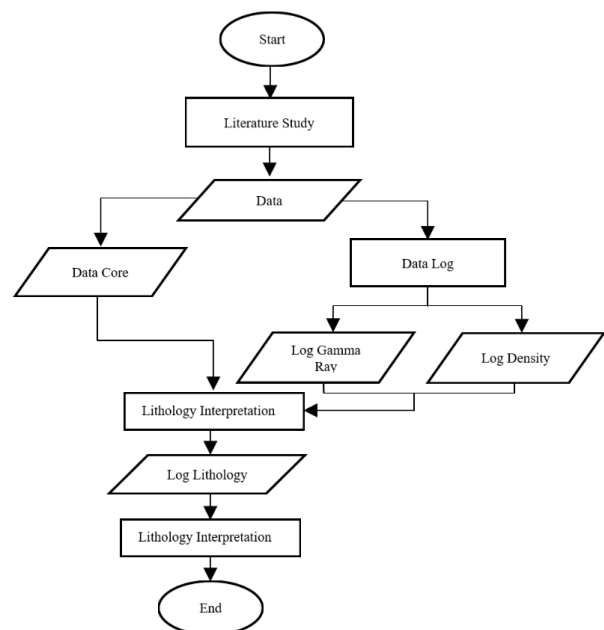


Figure 5. Flowchart of this research.

3. RESULT AND DISCUSSION

The elevation of the Log A well is 62 meters, and the total depth reaches 162.7 meters with different rock layers. The rocks contained in the Log_A well

can be seen in **Table 2**. In this well, four coal layers are found, namely Seam A1 Coal, Seam A2 Coal, Seam B1 Coal, and Seam B2 Coal. Overburden in well Log_A starts at a depth of 3 meters to 88.5 meters, under which there is then a 13.24-meter-thick clay layer at a depth of 16.44-29.68 meters, which is yellowish brown, with a well-rounded grain shape, good grain arrangement, and other clay sizes. The log response of this clay layer has an average GR value of 18.63 CPS and a density value of 684.77 CPS. There is also a layer of Tuffaceous Sandstone at a depth of 30.38-35.20 meters with a light grey colour, angular grain shape, well-sorted grain arrangement, and other sand-sized minerals. This overburden has a layered structure in the form of a loop, namely Siltstone, Claystone, Sandstone, Claystone, Sandstone, Siltstone, Claystone, and Siltstone, before heading to the Seam A1 coal layer. Seam A1 coal is characterised by a black, shiny, scratchy colour and consists of organic materials. In this Seam, there are four impurity bands (clay bands), namely at depths of 89.20 m-89.70 m, 91.40 m-91.70 m, 94.00 m-94.60 m, and 96.40 m-

96.60 m. There is an interburden between Seam A1 coal layers. There is an interburden between Seam A1 Coal and Seam A2 Coal layers as thick as 11.5 meters with lithology in the form of Claystone and Tuffaceous Sandstone. The gamma-ray log response of this seam has an average value of 39.36 CPS and an average log density value of 1496.1 CPS. Seam A2 coal is black, shiny, scratchy black, and consists of organic materials. The third Seam coal layer in Log_A well is Seam B1 coal, characterised by black, glossy, black scratches, and consists of organic materials. In this seam, there are 4 layers of impurities (Clayband) with thicknesses of 0.22 m, 0.22 m, 0.20 m, and 0.3 m, respectively. Seam B1 and Seam B2 coal seams are separated by a 5.3-meter-thick interburden with lithology in Carbonaceous Claystone. This layer is distinctive, with dark gray, massive, fine-grained, and clay-sized minerals. Seam B2 has one impurity layer (Clayband) at a depth of 152.1-152.2 meters with a thickness of 0.1 meters.

Table 2. Lithology and Response of GR-Density at Log_A

BORE ID	Depth (m)		THICK (m)	GR (CPS)	DENSITY (CPS)	LITHOLOGY
	Top	Bottom				
LOG_A	0	3.00	3.00	18.99	No Data	Open Hole
	3	16.44	13.44	11.52	732.37	Siltstone
	16.44	29.68	13.24	18.63	684.77	Claystone
	30.38	35.20	4.82	11.81	626.16	Tuffaceous Sandstone
	35.2	38.90	3.70	13.01	535.18	Carbonaceous Claystone
	38.9	42.5	3.60	12.54	670.22	Tuffaceous Sandstone
	42.5	51.00	8.50	19.08	679.57	Carbonaceous Claystone
	51	55.20	4.20	19.24	795.23	Siltstone
	55.2	60.20	5.00	15.78	750.01	Claystone
	60.2	72.10	11.90	15.64	1001.11	Siltstone
	72.1	74.00	1.90	15.84	1083.88	Claystone
	76.16	79.80	3.64	13.27	1823.20	Carbonaceous Claystone
	79.76	87.00	7.24	16.46	1898.86	Siltstone
	87	88.50	1.50	20.12	1695.43	Carbonaceous Claystone
	88.5	99.20	10.70	1.72	2278.07	Coal Seam A1

99.20	105.00	5.80	39.36	1495.10	Carbonaceous Claystone
105	110.70	5.70	25.71	1236.64	Tuffaceous Sandstone
110.70	119.60	8.90	1.53	2183.24	Coal Seam A2
119.60	126.70	7.10	19.22	2178.56	Carbonaceous Claystone
126.7	127.40	0.70	4.50	2184.00	Suban Marker
127.40	133.40	6.00	20.53	2022.37	Carbonaceous Claystone
133.4	145.10	11.70	2.01	2269.19	Coal Seam B1
145.10	150.40	5.30	27.12	1358.37	Carbonaceous Claystone
150.40	154.80	4.40	2.06	2022.25	Coal Seam B2
154.80	154.80	0.00	30.22	1099.82	Claystone
154.80	161.80	7.00	27.87	733.05	Siltstone

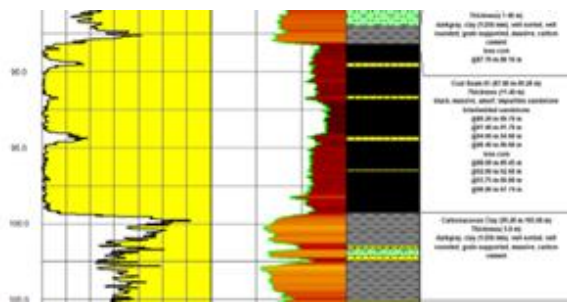


Figure 6. Log_A seam A1.

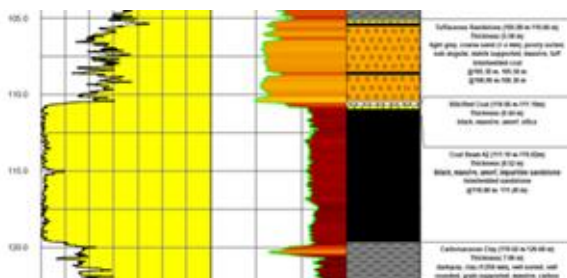


Figure 7. Log_A seam A2.

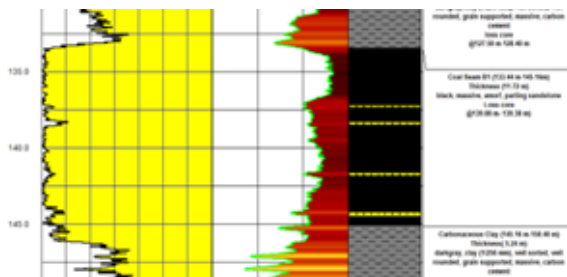


Figure 8. Log_A seam B1.

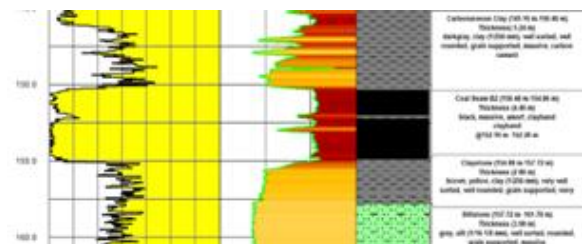


Figure 9. Log_A seam B2.

Interpretation of subsurface lithology in the Log_B well in the Banko Mine area shows that the good depth reaches 143.65 meters with different rock layers. The lithologic distribution per depth is shown in **Table 3** below. The overburden in the Log_B well ranges from 3 to 15 meters in depth, with lithologies of Claystone and Siltstone. The Siltstone and Claystone layers have thicknesses of 4 meters and 8 meters, respectively. This layer is dark grey in colour with fine, rounded, well-sorted grains and consists of quartz and other clay-sized materials. Seam A1 coal, with a thickness of 10.8 meters, has the characteristics of being black, shiny, with black scratches, and brittle and consists of organic materials. In this Seam, one layer of impurities (Clayband) is in it, with a thickness of 0.99 m at a depth of 20.25-21.24 meters. There is an interburden between Seam A1 Coal and Seam A2 Coal layers as thick as 19.00 meters, with Siltstone and Tuff Sandstone lithology. This layer has a light grey to grey colour and has a sorting structure that is classified as good or well-sorted; fine grains tend to be rounded or sub-rounded, the grain shape is fused, and quartz mineral content and other silt-sized mineral content. Seam A2 coal is black, shiny, scratchy black, and consists of organic materials.

The interval between Seam A2 and B1 coal is a 10 m thick Carbonaceous Claystone with a 0.97

meter thick Suban Marker layer in the middle. The third Seam coal layer in the Log_B well is Seam Coal, which is black and shiny, with black scratches, and consists of organic materials. In this Seam, there are 2 layers of impurities (Clayband) with a thickness of 30 m located at a depth of 78.00-78.30 meters. An interburden between Seam B1 and Seam B2 coal layers is as thick as 5.09 meters with the lithology of Carbonaceous Claystone. This layer has a dark grey colour and a sorting structure that is classified as good or well sorted; fine grains tend to be rounded or sub-rounded, and the grain shape is fused. Seam coal seams are characterised by a black colour, shiny black scratches, and consist of organic materials. In this seam, there is 1 layer of impurity (Clayband) with a thickness of 0.15 m located at a depth of 85.55-85.70 metres. Underneath the Seam B2 coal seam, there are

recurring layers of glauconite siltstone and sandstone with characteristics of grey colour, laminated structure, and well-rounded grain shape. Then, in the intersection of the siltstone, there is a layer of Glauconite Sandstone (Glauconite Sandstone), light grey, slightly greenish colour, with good sorting, well-rounded grain shape, quartz mineral content, and other sand-sized mineral content. Claystone is characterised by a grey colour, with good sorting, well-rounded grain shape, massive, has quartz mineral content, organic mineral content, and other clay-sized mineral content. The fifth Seam coal layer in the Log_B well is Seam C coal with a thickness of 10.81 metres, which is characterised by being black in colour, having black streaks, and having organic content.

Table 3. Lithology and Response of GR-Density at Log_B

BORE ID	Depth (m)		THICK (m)	GR (CPS)	DENSITY (CPS)	LITHOLOGY
	Top	Bottom				
LOG_B	0	3.00	3.00	16.11	1071.93	Open Hole
	3	7.00	4.00	25.41	1936.66	Siltstone
	7	15.00	8.00	22.79	1787.33	Claystone
	15	26.79	5.25	1.61	1926.30	Coal Seam A1
	26.79	27.73	0.94	41.68	1506.32	Carbonaceous Claystone
	27.73	38.99	11.26	33.95	1411.36	Siltstone
	38.99	46.66	7.67	25.09	1460.45	Tuffaceous Sandstone
	46.66	56.51	9.85	1.21	2048.67	Coal Seam A2
	56.51	62.64	6.13	13.33	2097.87	Carbonaceous Claystone
	62.64	63.61	0.97	2.22	1876.10	Suban Marker
	63.61	67.48	3.87	16.22	2169.52	Carbonaceous Claystone
	67.48	79.22	11.74	1.88	2168.34	Coal Seam B1
	79.22	84.31	5.09	19.31	2129.32	Carbonaceous Claystone
	84.31	88.70	4.39	1.80	2254.66	Coal Seam B2
	88.7	99.04	10.34	23.97	1715.59	Siltstone
	99.04	102.98	3.94	19.50	1610.87	Glauconite Sandstone
	102.98	105.28	2.30	27.66	1426.10	Siltstone
	105.28	112.53	7.25	16.31	1516.49	Glauconite Sandstone
	112.53	115.41	2.88	24.85	1595.75	Siltstone
	115.41	126.80	11.39	24.63	1895.06	Carbonaceous Claystone
	126.8	137.61	10.81	1.93	2175.30	Coal Seam C
	137.61	143.65	6.04	24.09	1302.97	Siltstone

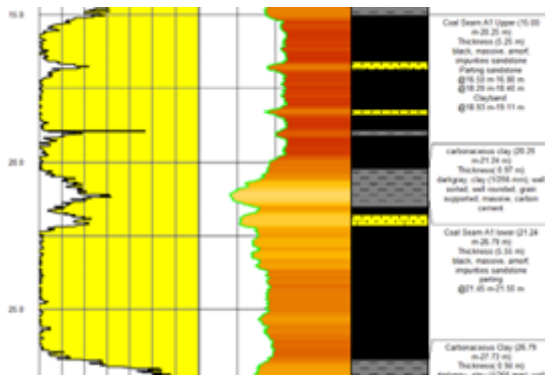


Figure 10. Log_B seam A1.

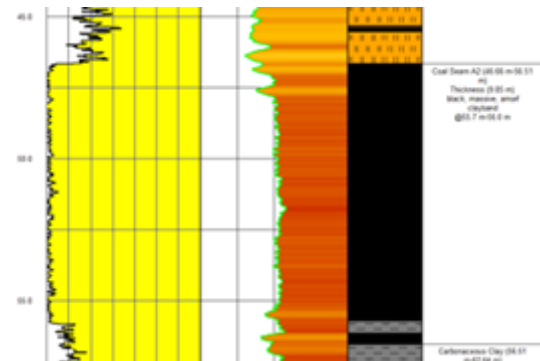


Figure 11. Log_B seam A2.

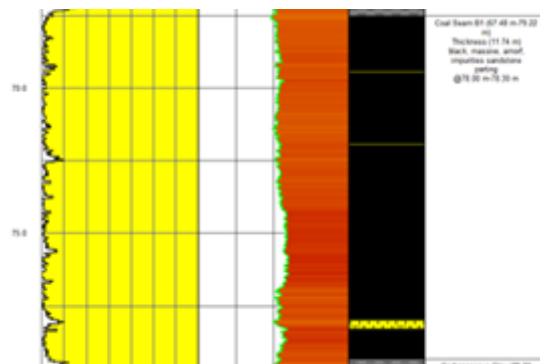


Figure 12. Log_B seam B1.

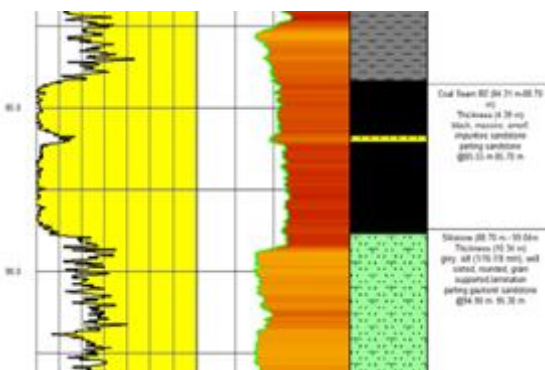


Figure 13. Log_B seam B2.

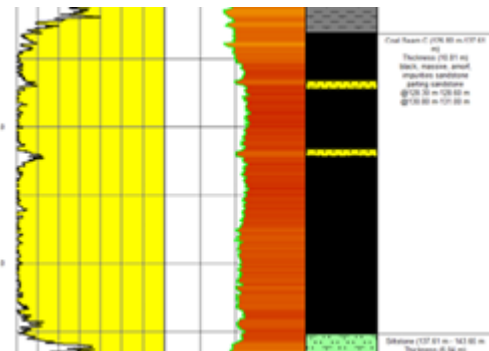


Figure 14. Log_B seam C.

Four coal layers were found in this well: Coal Seam A1, Coal Seam A2, Coal Seam B1, and Coal Seam B2. The distribution of lithology per depth is in **Table 4** below. Overburden in the Log_C well ranges from 3 meters to 97.72 meters, with lithology in the form of Carbonate Clay at depths of 3-13.40 meters and 61.94-97.72 meters. The next layer is made of siltstone and claystone with a looping pattern. The Siltstone layer is located at a depth of 14.46-26.48 meters. This layer is grey to dark grey with refined rounded grains, massive, and well-sorted by other silt-sized materials. Underneath the seam is a layer of claystone. In this seam, there is also Hanging Coal, which has a thickness of 1.18 meters. The top Seam coal layer in well Log_C is 97.72-108.54 meters below the surface. Seam A1 coal, with a thickness of 10.82 meters, has the characteristics of being black, shiny, with black scratches and consists of organic materials. This Seam has two layers of impurities (Clayband). There is an interburden between Seam A1 Coal and Seam A2 Coal layers as thick as 1.00 metre with the lithology of Claystone. There is an interburden between Seam B1 and Seam B2 coal layers as thick as 4.56 meters with the lithology of Carbonaceous Claystone. Seam B2 is located at 160.06-165.22 meters below the surface.

Table 4. Litologi Sumur Log_C

BORE ID	Depth (m)		THICK (m)	GR (CPS)	DENSITY (CPS)	LITHOLOGY
	Top	Bottom				
LOG_C	0	3.00	3.00	19.32	93.07	Open Hole
	3	13.40	10.40	22.51	164.47	Carbonaceous Claystone

13.28	14.46	1.18	7.00	206.29	Hanging Coal
14.46	26.48	12.02	21.32	62.97	Siltstone
26.48	40.94	14.46	32.25	175.45	Claystone
40.94	47.06	6.12	17.62	241.15	Sandstone
47.06	61.94	14.88	27.00	222.69	Siltstone
61.94	97.72	35.78	28.81	95.16	Carbonaceous Claystone
97.72	108.54	10.82	2.68	267.43	Coal Seam A1
108.54	117	8.46	37.19	129.82	Claystone
117	119.34	2.34	24.2	135.4	Tuffaceous Sandstone
119.34	129.00	9.66	3.03	269.31	Coal Seam A2
129.00	136.46	7.46	26.56	218.81	Carbonaceous Claystone
136.46	137.40	0.94	7.12	280.18	Suban Marker
137.40	142.88	5.48	25.46	266.00	Carbonaceous Claystone
142.88	155.50	12.62	3.39	333.42	Coal Seam B1
155.50	160.06	4.56	28.75	249.38	Carbonaceous Claystone
160.06	165.22	5.16	3.74	320.06	Coal Seam B2
165.22	174.08	8.86	41.26	474.28	Carbonaceous Claystone
174.08	177.58	3.50	31.74	314.05	Siltstone
177.58	179.40	1.82	42.50	255.27	Carbonaceous Claystone
179.40	183.00	3.60	44.27	273.26	Siltstone
183.00	186.30	3.30	30.63	268.65	Glauconite Sandstone
186.30	196.50	10.20	45.92	425.05	Claystone

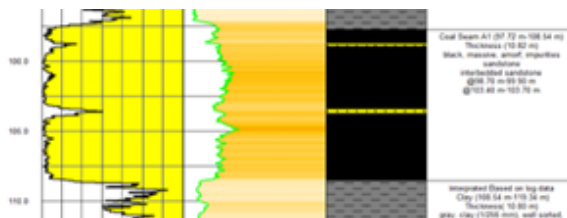


Figure 15. Log_C seam A1.

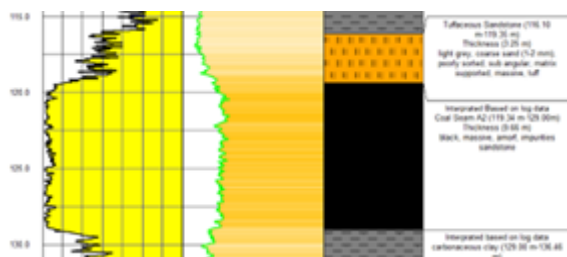


Figure 16. Log_C seam A2.



Figure 17. Log_C seam B1.

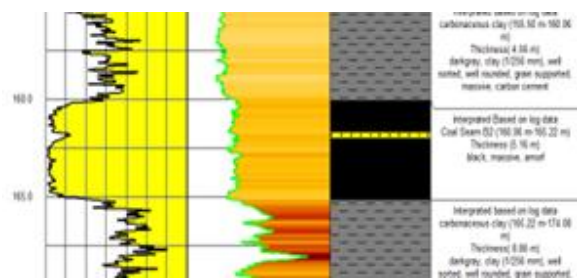


Figure 18. Log_C seam B2.

In this well, two coal layers are found, namely Coal Seam A1 and Coal Seam A2. The distribution of lithology per depth is in **Table 5** below. The overburden in the Log_D well is Sandstone, and the next layer is Siltstone, which is grey to dark grey with fine rounded grains, massive, well-sorted, and other silt-sized materials. Underneath the seam is a layer of Carbonaceous Claystone. The top Seam coal layer in the Log_D well has the characteristics of black, shiny, black scratches and consists of organic materials. There is an interburden between the Seam A1 and Seam A2 coal layers as thick as 14.7 meters, with a lithology in the form of a Carbonaceous Claystone intersection with

Tuffaceous Sandstone. This Log_D well has a 9.8-meter-thick Seam A2 coal layer located at 83.20-93 meters below the surface.

Table 5. Lithology and Response of GR and Density at Log_D

BORE ID	Depth (m)		THICK (m)	GR (CPS)	DENSITY (CPS)	LITHOLOGY
	Top	Bottom				
LOG_D	0	3.00	3.00	25.70	288.37	Open Hole
	3	7.00	4.00	29.81	367.73	Sandstone
	7.00	9.44	2.44	32.00	357.73	Siltstone
	9.44	12.56	3.12	28.13	368.38	Sandstone
	12.56	19.56	7.00	46.27	317.23	Siltstone
	19.56	24.96	5.40	47.14	231.69	Carbonaceous Claystone
	24.96	25.59	0.63	41.19	223.90	Siltstone
	25.59	26.21	0.62	32.31	327.31	Hanging Coal
	26.21	27.80	1.59	41.48	163.62	Siltstone
	27.80	36.88	9.08	39.02	214.26	Carbonaceous Claystone
	36.88	57.20	20.32	36.20	81.60	Siltstone
	57.20	68.50	11.30	3.46	161.05	Coal Seam A1
	68.50	71.80	3.30	62.02	89.61	Carbonaceous Claystone
	71.80	74.30	2.50	67.93	105.06	Tuffaceous Sandstone
	74.30	76.70	2.40	80.08	144.49	Carbonaceous Claystone
	76.70	83.20	6.50	53.60	143.26	Tuffaceous Sandstone
	83.20	93.00	9.80	3.21	433.29	Coal Seam A2
	93.00	95.00	2.00	41.13	246.17	Carbonaceous Claystone
	95.00	100.00	5.00	45.58	149.47	Siltstone
	100.00	100.80	0.80	4.38	233.54	Suban Marker
	100.80	102.20	1.40	No Data	156.70	Siltstone

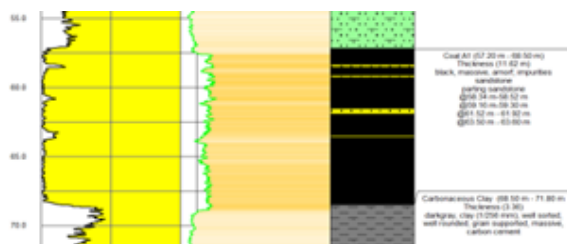


Figure 19. Log_D seam A1.

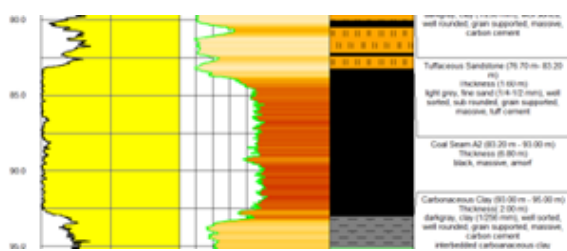


Figure 20. Log_D seam A2.

The keyed between seam A1 and seam A2 is characterised by a Tuffaceous Sandstone layer with a thickness between 2 and 7 meters. This layer is present in all wells where, in addition to tuffaceous sandstone, there are also intersections with carbonaceous clay and siltstone. Seam A2 and Seam B1 are separated by a keyed called a Suban Marker or a thin coal layer with a thickness of less than 1 meter. Where the Suban Marker layer is found in all four wells. In addition to the Suban Marker, there are other lithologies, such as carbonaceous limestone and siltstone. A key layer between Seam B1 and Seam B2 has a lithology of Carbonaceous Clay with a thickness of 4 to 5 meters. This layer can be found in wells Log_A, Log_B, and Log_C but not in Log_D because Log_D does not have deeper data. The key layer between Seam B2 and Seam C is characterized by Glauconite Sandstone layers with a thickness between 3 to 7 meters. However, the Glauconite

Sandstone layer can only be found in Log_B and Log_C.

4. CONCLUSION

Several lithologies are known in the Log_A, Log_B, and Log_D Wells, namely Claystone, Carbonaceous Claystone, Siltstone, Sandstone, Glauconite Sandstone, and Coal with a massive structure to wavy lamination. Tuffaceous Sandstone is the key bed between Seam A1 and A2 Coal. The Suban Marker layer in the form of thin Coal is the keybed between Seam A2 and B1 Coal, then between Seam B1 and B2 layers are separated by Carbonaceous Claystone as the keybed, and finally, in Seam B2 and Seam C layers are characterised by the presence of Glauconite Sandstone as the keybed.

DAFTAR PUSTAKA

- [1] Adrian, "Identifikasi dan Estimasi Sumberdaya Batubara Menggunakan Metode Poligon Berdasarkan Interpretasi Data Logging pada Lapangan ADA, Sumatera Selatan". *Jurnal Geofisika Eksplorasi*. Vol.4/No 1. 2010.
- [2] Anshari. F, "Identifikasi Pola Sebaran Seam dan Perhitungan Sumber Daya Batubara Menggunakan Interpretasi Data Log Geofisika pada Lapangan "F" Lahat, Sumatera Selatan". Skripsi, Teknik Geofisika, Universitas Lampung., Bandar Lampung.,Indonesia, 2016.
- [3] Arif. Irwandy, Batubara Indonesia. Jakarta : Gramedia Pustaka Utama, 2014.
- [4] Bishop. M. G, South Sumatra Basin Province, Indonesia: The Lahat/Talang Akarcenozoic total petroleum system. Colorado:U.S Geological Survey. Hal. 7-10, 2001.
- [5] Ellis. D. V, et al., Well Logging for Earth Scientist Second Edition, Dordrecht, The Netherlands: Springer, 2007.
- [6] ESDM, "Cadangan Batubara Masih 39 Miliar Ton, Konsumsi Energi Fosil Masih Dominan EBT Masih Jauh Dari Target". Kementerian Energi dan Sumber Daya Mineral, 2022.
- [7] Harsono. A, Evaluasi Formasi dan Aplikasi Log. Jakarta: Schlumberger Oilfield Service, 1997.
- [8] Haryono. A, "Intepretasi Log Sebaran Lapisan Batubara Berdasarkan Data Log Gamma Ray". *Fisika Mulawarman*. Vol.6 No.2. 2010.
- [9] Hilmi. A, and Ulfa. A. M Analisis Proksimat, Kandungan Sulfur dan Nilai Kalor dalam Penentuan Kualitas Batubara. *Indonesian Journal of Engineering*. Vol. 01, No.2 , Hal. 85-94, 2021.
- [10] Hower. J. C, "Coal Geology", *International Journal of Coal Geology*. Vol.53, 2002.
- [11] Musset. A. E, Loking Into The Earth. New York : Cambridge University Press. 2001
- [12] Pulunggono. A, "Sistem Sesar Utama dan Pembentukan Cekungan Palembang". Disertasi, Institut Teknologi Bandung, 1983.
- [13] PT. Bukit Asam (Persero) Tbk, "Laporan Internal Pemboran Eksplorasi dan Geophysical Logging". Satuan Kerja Unit Eksplorasi dan Geoteknik, 2007.
- [14] Rider. M, The Geological Interpretation of Well Logs. Malta: Interprint Ltd, 2002.
- [15] Setiahadiwibowo. A. P, "Analisis Karakteristik Batubara Berdasarkan Rekaman Well logging di Daerah Kabupaten Katingan Kalimantan Tengah", *Kurvatek*. I, 81-87, 2016.
- [16] Sukandarrumidi, Batubara dan Pemanfaatannya. Yogyakarta: Universitas Gajah Mada, 2017.