

Identification of Hydrocarbon Prospect Zones in the AI-1 Well, The Central Sumatra Basin

A Irawan¹, O Dewanto², and R C Wibowo^{3*}

^{1,2} Geophysical Engineering Department, Universitas Lampung, Prof. Sumantri Brojonegoro Street, No. 1, Bandar Lampung City, Lampung Province, 35145, Indonesia

³ Geological Engineering Department, Universitas Lampung, Prof. Sumantri Brojonegoro Street, No. 1, Bandar Lampung City, Lampung Province, 35145, Indonesia

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

Article Information:

Received:
18 December 2026

Received in revised form:
2 May 2026

Accepted:
1 June 2026

Volume 8, Issue 1, June 2026
pp. 38 – 49

<http://dx.doi.org/10.23960/jesr.v8i1.257>

Abstract

The Central Sumatra Basin is one of the largest hydrocarbon producing back arc basins in Indonesia. Determining the hydrocarbon prospect zone in this basin uses the well logging method and petrophysical analysis which is carried out to determine rock physical parameters such as shale volume, porosity, water saturation, net reservoir and net pay in the Menggala Formation and Pematang Formation as well as to validate the hydrocarbon content so that a value can be obtained. net (net pay) which is able to describe the thickness of the reservoir. In this research, 4 hydrocarbon prospect zones were found in the Menggala Formation at a depth of 5962.32-6125.03 feet and in the Pematang Formation there were 5 hydrocarbon prospect zones at a depth of 6142.39-6444.12 feet. In the Menggala Formation, the physical parameters of the reservoir rock were obtained, namely shale volume values of 15.1%-24.7%, porosity of 15.84%-18.07%, and water saturation of 29.15%-35.18. Meanwhile, in the Pematang Formation, the physical parameters of the reservoir rock were obtained, namely shale volume values of 4.13%-21.72%, porosity of 16.93%-19.04%, and water saturation of 28.83%-34.04%. These two formations have good quality porosity and the fluid type is gas. Based on the final results of the petrophysical analysis, it can be seen that the prospect zone in the Menggala Formation and Pematang Sumur AI-1 Formation of the Central Sumatra Basin as a whole is a hydrocarbon zone. This is because most prospect zones have a net gross value close to 1.

Keywords: Central Sumatra Basin, Menggala Formation, Pematang Formation, hydrocarbons, net pay.

I. INTRODUCTION

Energy resources from hydrocarbons in the form of oil and natural gas are still the main energy sources in Indonesia. However, hydrocarbon fuel consumption in Indonesia is not yet comparable to production. The oil and gas consumption trend is increasing [18], while the production trend is decreasing every year [23] and [18]. This results in the need to optimize hydrocarbon production by carrying out continuous and continuous exploration so as to replenish existing hydrocarbon reserves, including one in the Central Sumatra Basin.

The Central Sumatra Basin is one of the largest

hydrocarbons producing back arc basins in Indonesia. The Central Sumatra Basin has an area of around 103.500 km². The Central Sumatra Basin is separated from the North Sumatra Basin by the Asahan Plateau, while in the southern part it is separated from the South Sumatra Basin by the Tigapuluh Mountains [10]. In the Central Sumatra Basin, there is the Sihapas group which includes the Menggala Formation and the Pematang Group. The Menggala Formation is the oldest formation in the Sihapas Group [25]. Meanwhile, the Pematang Formation is one of the source rock producing formations in the Central Sematra Basin.

The Central Sumatra Basin is one of the largest hydrocarbons producing back arc basins in Indonesia.

The Central Sumatra Basin has an area of around 103.500 km². The Central Sumatra Basin is separated from the North Sumatra Basin by the Asahan Plateau, while in the southern part it is separated from the South Sumatra Basin by the Tigapuluh Mountains [10]. In the Central Sumatra Basin, there is the Sihapas group which includes the Menggala Formation and the Pematang Group. The Menggala Formation is the oldest formation in the Sihapas Group [25]. Meanwhile, the Pematang Formation is one of the source rock producing formations in the Central Sematra Basin.

Developing exploration locations requires data that provides indications that the formation in the basin has good physical parameter values. In determining the parameter values of a rock layer, it is necessary to study the petrophysical properties of the rock. These petrophysical properties can be analyzed using data from the logging process. Well logging is the process of recording data from rock measurements based on their physical properties [5].

To determine the location of the hydrocarbon reservoir zone, it is best to determine several important parameters in the reservoir zone. These parameters are permeability, water saturation, clay volume and porosity [6],[2],[20]. Determination of several parameters is used to validate the hydrocarbon content in a target formation which includes the gross value of a rock lithology [7], so that by obtaining the cut off value for each of these parameters, a net value (net pay) is obtained [22]. which is able to describe the reservoir thickness of a formation in the field to be studied [19], [26].

This research uses well logging methods and petrophysical analysis with the aim of identifying hydrocarbon prospect zones in the Menggala Formation and Pematang Sumur AI-1 Formation in the Central Sumatra Basin using physical rock parameters such as shale volume (V_{sh}), water saturation (S_w), porosity (∅), net reservoir, and net pay. The urgency of this research and the potential for desired findings to obtain hydrocarbon prospects in the AI-1 Well of the Central Sumatra Basin.

II. MATERIALS AND METHODS

A. Data

The location of this research is in the Central Sumatra Basin area which includes the administrative area of Kampar Regency, Riau. The research area is at Latitude 0° 44' 16.5" and Longitude 101° 00' 04.7" with an elevation of 29 meters.

Heidrick and Aulia (1993), explained that the Central Sumatra Basin is physiographically located between the North Sumatra Basin and the South Sumatra Basin, which are separated by the Tigapuluh High [13]. The

Central Sumatra Basin is bounded by Bukit Barisan to the west and southwest, to the east by the Malaysian peninsula, to the north by the Asahan Arc, and to the southeast by the Tinggian Tigapuluh, but the southern boundary is not well known.

Tectonics The Central Sumatra Basin is characterized by fault blocks and transcurrent faulting, such as uplift, gravity tectonics, gliding and compression folds. The system of fault blocks has a north-south alignment orientation forming a series of hors and grabens [17]. According to Eubank and Makki (1981), the Central Sumatra Basin has 2 main fault patterns, namely faults in the North-South direction (Paleogene) and northwest-southeast faults (late Neogene), these two main faults were active again in the Tertiary era [19].

The method used in this research is the well logging method and the data used includes log data consisting of gamma ray logs, resistivity logs, neutron logs and density logs. Gamma ray (GR) log data from the AI-1 well is used to identify the lithology of the target zone, resistivity log data is used to identify the type of fluid present in the target zone, and neutron logs and density logs are used to identify the target zone by looking at the crossover results of the two the log data.

This research uses 1 (one) well logging data, namely the AI-1 well, which is then processed using Paradigm Geolog v.7 software. Apart from well logging data, this research also uses well report data which is used as formation boundaries which will be used as the object of discussion in this research.

B. Method

The target zone is a zone identified as a hydrocarbon producing zone. In determining the target zone, it is necessary to carry out qualitative analysis of the log data, namely by looking at the response of each log from the triple combo model. The types of logs used in qualitative analysis of hydrocarbon target zones are as follows.

According to Schlumberger (1998), Gamma ray logs generally indicate the presence of shale content in a formation, this is because radioactive elements tend to be concentrated in shale and clay. Clean formations generally have less radioactive content, such as sandstone (low GR log). Therefore, GR logs are usually used as initial justification for determining the type of shale or sandstone layer [21].

According to Harsono (1997), a resistivity log is an electrical log that is used to determine indications of the presence of hydrocarbon zones [12]. As is known, rock grains and matrices are considered non-conductive, so the ability of rocks to conduct electric current depends on the fluid that fills the rock pores. If the resistivity curve value shows a low value, it reflects the presence

of fluid with a high salinity value or water. Meanwhile, high resistivity values tend to indicate the presence of hydrocarbon content [11].

According to Harsono (1997) density logs are used to measure the porosity of rock formations. In principle, the density log will emit gamma rays into the rock formation [12].

Neutron logs are logs that measure the concentration of hydrogen content in a formation. The principle of use is by shooting neutron particles from a CNT (Compensated Neutron Tool) source, the neutron particles fired will spread throughout the formation and interact with the atomic nucleus. Neutrons are found in all elements except hydrogen and have almost the same mass as a hydrogen atom [11].

Determining the reservoir target area can be done by looking at the gamma ray log response with a small value (sandstone or carbonate lithology) then the separation between the neutron and density logs and the high resistivity log response. Therefore, geological interpretation can be stated as a reservoir target area.

C. Petrophysical analysis

Petrophysical analysis of rocks is an analysis that uses the physical properties of rocks as a function of the rock's response during the logging process. Petrophysics is the study of the physical properties of rocks. Petrophysical analysis is very important to determine the productive zone, depth and thickness of a zone, type of fluid in the reservoir, and estimate hydrocarbon reserves [4].

Shale volume is defined as the ratio of clay contained in a formation. The large amount of shale contained in a rock will inhibit fluid movement in the rock, so that it will be less good as a reservoir rock [27]. Shale volume calculations can use gamma ray values with the following equation.

$$I_{GR} = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}} \quad (1)$$

$$V_{sh} = I_{GR} \quad (2)$$

With the following information:

- I_{GR} = GR Index
- GR_{log} = GR value in the log
- GR_{min} = Minimum GR value in the log
- GR_{max} = Maximum GR value in the log

Porosity is the ratio between the volume of rock pores that are not filled with fluid and the volume of the rock as a whole. There are two types of porosity known in the reservoir characterization process, namely effective porosity and total porosity [12]. The

calculation of total and effective porosity values can be seen in equations 3 and 4 below.

$$\phi_{total} = \frac{pore\ volume}{rock\ volume} \times 100\% \quad (3)$$

$$\phi_{effective} = \frac{connected\ pore\ volume}{rock\ volume} \times 100\% \quad (4)$$

According to Koesoemadinata (1978), determining whether the porosity value of a reservoir is good or not is as shown in Table 1 [15].

Table 1. Scale for determining whether the quality of rock porosity values in a reservoir is good or not [15].

Porosity Value (%)	Scale
0-5	Ignore
5-10	Bad
10-15	Enough
15-20	Good
20-25	Very Good
>25	Excellent

Water saturation describes the amount of water fluid that fills the rock volume. Harsono (1997) stated that the volume of rock that is filled with hydrocarbons is called hydrocarbon saturation (Sh) where the value is $1 - S_w$ [12]. In this study, the water saturation value was calculated using the Archie equation because the overall shale volume value in the target zone is relatively low or generally below 30%. The Archie equation is as shown in the equation below [3].

$$S_w = \frac{n \sqrt{aR_w}}{\sqrt{\phi^m R_t}} \quad (5)$$

Information:

- S_w = Water saturation
- a = Tortuosity factor
- m = Cementation exponent
- n = Saturation exponent
- R_w = Water resistivity
- R_t = Actual resistivity

Determination of the type of content in the reservoir (water, oil and gas) is obtained from the results of water saturation (S_w) calculations in the general limits of S_w prices as below:

Table 2. Interpretation of Fluid Saturation [1]

So Average	Sw Average	Approximate Type Reservoir
< 3%	<40%	Gas
2-5%	<60%	Oil + Gas

>5%	<50-70%	Oil
<1%	>70-75%	Water

The final stage in petrophysical analysis which is the goal of interpretation is estimating the thickness of the net pay after carrying out the cut-off process. According to Singh and Joshi (2020), the cut off process is the process of eliminating rock volumes that are estimated not to contain or produce hydrocarbons, by applying several parameter limits. In simple terms, net pay is determining the depth interval that can economically produce hydrocarbons [16] by applying a cut off [14].

III. RESULTS AND DISCUSSIONS

This research uses 1 (one) well data, namely the AI-1 well which is then processed using Paradigm Geolog v.7 software. Apart from log data, this research also uses well report data which is used as formation boundaries which will be used as the object of discussion in this research.

Data preparation is a preparatory stage that will be used in carrying out calculations and further processing to obtain final results in the form of a pay summary. Data preparation will later produce various processing, namely depth references, drill hole temperature calculations, pre-calculations, and badhole flags.

Depth reference is a step used to calculate TVD (true vertical depth) and TVDSS (true vertical depth subsea) values because not all wells are vertical, but there are also wells that are tilted or deviated, so calculating vertical depth is very important. TVD is the vertical depth of the drilled well from the ground surface to the TD (terminal depth). Meanwhile, TVDSS is the vertical depth of the drilled well which is calculated from sea level. It can be seen that the TVD response has a deeper depth, namely 6714 feet, compared to the TVDSS response, namely 6520 feet. Making references to this

will later be used to calculate the pay summary.

The drill hole temperature value is calculated to correct the resistivity log value, because the resistivity log is greatly influenced by temperature and the characteristics of the drilling mud. With this correction, valid resistivity log values are obtained in the hole diameter zone which is not affected by drilling mud. Temperature calculations use the Top Log Interval (TLI) and Bottom Log Interval (BLI) methods. Based on Figure 2 and Figure 3, the top log temperature values for run 1 and run 2 can be produced as shown in Table 3.

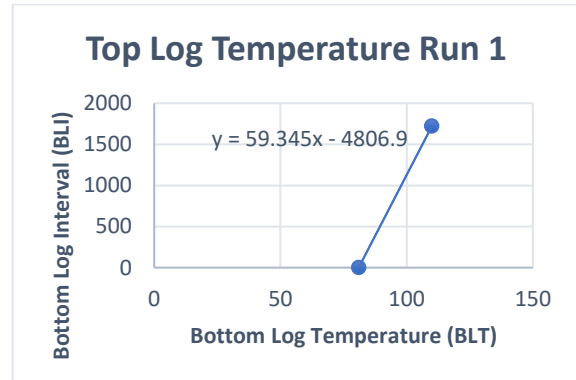


Figure 2. Trend line top log temperature run 1

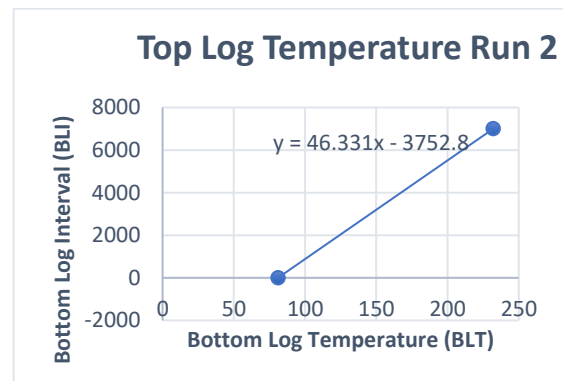


Figure 3. Trend line top log temperature run 2

Table 3. Borehole temperature data

Well Name	Depth FT	TLI FT	BLI FT	BLT DEGF	TLT DEGF	RMS OHMM	RMFS OHMM	RMCS OHMM	MST DEGF	MFST DEGF	MCST DEGF
AI-1	30	30	1721	110	81.50	12.4	12.9	9.18	110	92	88
AI-1	6996	1714	6996	232	117.99	0.88	0.81	0.77	102	96	92

Pre-calculation is a stage for converting rock physics data units obtained during logging. Pre-calculation is used to calculate formation temperature values, formation pressure, and calculate mud properties. The principle of this calculation uses the temperature gradient principle by entering the bitsize, TVD, BHT (borehole temperature), mud type, mud weight, mud properties and temperature values. From the results of pre-calculations, formation temperature values were obtained which ranged from 202° – 226° F and

formation pressure values ranged from 3499 – 3557 psi. From the pre-calculation results, it can be seen that the temperature and pressure values of the formation are directly proportional to the depth, where the greater the depth, the higher the temperature and pressure values of the formation.

Badhole calculations are carried out to determine the quality or condition of a drilled hole. The results of the badhole flag calculation can be seen in Figures 7 and 8. Based on figures 7 and 8, it can be seen that areas that

have poor drill hole conditions are marked with blue columns. This is because there is a red stripe which states it is a flag. The drill hole condition can be identified as a bedhole if the value is greater than the bitsize. If the drill hole condition is good, the value will be relatively the same as the bitsize. Conditions where the drill hole diameter is greater than the bitsize will cause tunneling and cause the reading on the gamma ray log to be smaller than the actual condition. Meanwhile, if the drill hole diameter is smaller than the bitsize, it will cause the reading of the gamma ray value to be greater than it actually is. Apart from that, to determine the condition of the drill hole, it is said to be bad if the log caliper value is high or on the badhole flag there is a red stripe.

Qualitative analysis is useful for determining rock lithology, reservoir zones and hydrocarbon accumulation. This qualitative analysis was carried out by identifying the characteristics or deflection of the log curve which is very helpful in distinguishing between permeable and non-permeable rock layers, as well as identifying the reservoir filling fluid from the shape of the AI-1 Well log data curve.

Log data analysis can be done by looking at the gamma ray log, the separation of the NPHI log from the RHOB log and the resistivity value. In general, hydrocarbons are found in permeable layers which are characterized by low gamma ray log values, because in permeable layers radioactive substances are easily released from the rock and migrate to lower pressures through the rock pores, so that when recording the permeable layer produces high gamma ray values. low. Furthermore, the presence of hydrocarbons is indicated by low NPHI and RHOB log values, because the atoms emitted by these log measurements interact a lot with hydrogen atoms, so that few neutron atoms are recorded. The less that is recorded shows that the more complex the fluid composition in the rock is, which indicates that the rock contains gaseous fluids. Furthermore, layers containing hydrocarbons have high resistivity, because oil and gas are not good at conducting electricity. This is different from water which is conductive, so the resistivity value is high.

Based on qualitative analysis, four hydrocarbon prospect zones were obtained in the Menggala Formation (5956 feet - 6126 feet), including prospect zone A at a depth of 5962.32 - 5966.83 feet with a layer thickness of 4.51 feet, prospect zone B is found at a depth of 5968.5 – 6048.98 feet with a layer thickness of 80.48 feet, prospect zone C is at a depth of 6055.44 – 6082.67 feet with a layer thickness of 27.23 feet, and prospect zone D is at a depth of 6101 – 6125.03 feet with a layer thickness of 24.03 feet.

In the Pematang Formation (6126 feet - 6714 feet)

there are 5 (five) hydrocarbon prospect zones, including prospect zone A at a depth of 6142.39 - 6162.04 feet with a layer thickness of 19.65 feet, prospect zone B at a depth of 6169 feet.33 – 6194.06 feet with a layer thickness of 24.73 feet, prospect zone C is at a depth of 6198.64 – 6253.08 feet with a layer thickness of 54.44 feet, prospect zone D is at a depth of 6272.25 – 6299.12 feet with a layer thickness of 26.87 feet, and prospect zone E is at a depth of 6415.38 – 6444.12 feet with a layer thickness of 28.74 feet.

Parameter picking is a step carried out to determine the clay content in the well data and to determine the porosity of the well data. Picking shale volume is done by looking at the gamma ray values in the gamma ray histogram, where the lowest value is indicated as matrix and the highest value is indicated as shale. Meanwhile, porosity picking is carried out using the relationship of four parameters, namely matrix (MA), fluid (FL), dry clay (DC), and wet clay (WC) which are then connected with a ternary diagram. The results of this porosity picking will later be used to calculate porosity values for the AI-1 Well in the Central Sumatra Basin.

Shale volume is the amount of clay mineral content that fills the pores of the rock. The purpose of calculating shale volume is to correct the porosity value.

Calculation of shale volume begins with creating a gamma ray log histogram from Well AI_1 in the Menggala Formation and Pematang Formation. From the gamma ray histogram graph, information is obtained regarding the GRmax (183.24 GAPI) and GRmin (29.6 GAPI) values which are obtained from the maximum value and minimum value which will later be used in calculating the shale volume (Vsh). To calculate the shale volume in this study, a linear calculation method was used because the linear calculation method takes into account all types of lithology that exist in the formation of the research area. The histogram of the gamma ray log is shown in Figure 4.

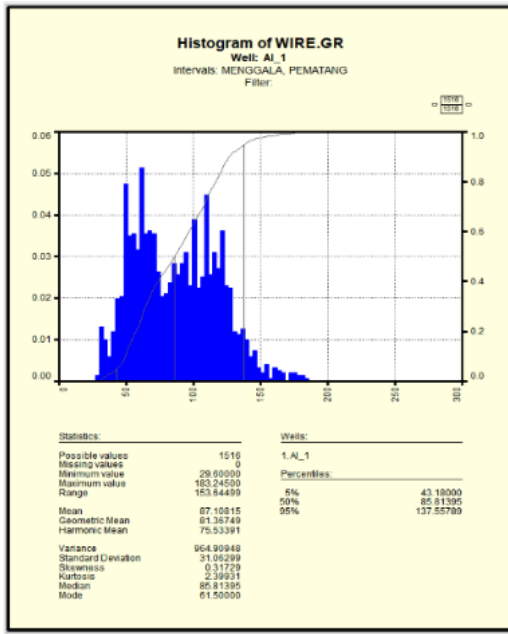


Figure 4. Gamma Ray Histogram.

Based on the calculation results, shale volume values were obtained in each hydrocarbon prospect zone in the Menggala Formation, including in prospect zone A the shale volume value (Vsh) was obtained at 16.91%, in prospect zone B the shale volume value (Vsh) was obtained at 15.1%. %, in prospect zone C the shale volume value (Vsh) was obtained at 23.66%, and in prospect zone D the shale volume value (Vsh) was 24.7%.

Based on the calculation results, shale volume values were obtained in each hydrocarbon prospect zone in the Pematang Formation, including in prospect zone A the shale volume value (Vsh) was obtained at 18.75%, in prospect zone B the shale volume value (Vsh) was obtained at 21.72%, in prospect zone C the shale volume value (Vsh) was obtained at 20.53%, in prospect zone D the shale volume value (Vsh) was obtained at 14.94%, and in prospect zone E the shale volume value (Vsh) was obtained. amounting to 4.13%.

Based on the shale volume calculation results in the hydrocarbon prospect zone in the Menggala Formation and Pematang Formation, it can be indicated that the Menggala Formation and Pematang Formation are shaly-sand formation layers because the shale volume calculation results are quite large, indicating that the layers are polluted by clay minerals. The results of calculating shale volume values in the Menggala Formation and Pematang Formation can be seen in tables 4 and 5.

The picking parameters used to determine porosity are using a crossplot between the density log and the neutron log. Porosity calculation is a calculation that determines the size of the cavity and is filled with fluid, obtained by combining density log values, neutrons and

correcting them with Vshale to obtain effective porosity values. The neutron porosity value is used directly by reading the value on the neutron log curve.

The method used in determining porosity is Bateman-Konen which functions to minimize relative errors in determining porosity from density logs due to the influence of clay content. This picking parameter uses four crossplots, namely crossplots between NPHI log and RHOB, gamma ray log with RHOB log, gamma ray log with NPHI log, and gamma ray log with DT log. The crossplot uses the ternary diagram principle as shown in Figure 5.

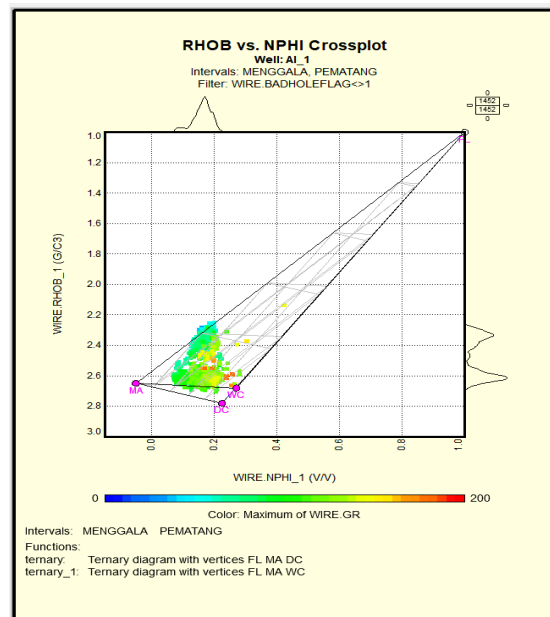


Figure 5. Crossplot of RHOB log with NPHI log

Based on the results of the crossplot of the RHOB log with the NPHI log, four parameters were obtained, namely fluid (FL), matrix (MA), dry-clay (DC), and wet-clay (WC). The density of wet clay and dry clay is used to calculate the shale porosity value which is used to determine the effective porosity value. Based on the results of the ternary diagram plot, the shale/clay density obtained is 2.68 for wet clay and 2.78 for dry clay. Apart from wet clay and dry clay, values for matrix density and formation water density are also obtained. The matrix density value obtained is 2.65 and the formation water density is 1, which indicates the density of fresh water.

Based on the calculation results, the porosity value was obtained in each hydrocarbon prospect zone in the Menggala Formation, including in prospect zone A, the total porosity value was 18.94% and the effective porosity was 17.99%. In prospect zone B, the total porosity value was 18.92% and the effective porosity was 18.07%. In prospect zone C, the total porosity value was 17.17% and the effective porosity was 15.84%. In prospect zone D, the total porosity value was 17.29%

and the effective porosity was 15.9%.

Based on the calculation results, the porosity value was obtained in each hydrocarbon prospect zone in the Pematang Formation, including in prospect zone A, the total porosity value was 17.99% and the effective porosity was 16.93%. In prospect zone B, the total porosity value was 18.69% and the effective porosity was 17.47%. In prospect zone C, the total porosity value was 18.53% and the effective porosity was 17.37%. In prospect zone D, the total porosity value was 18.33% and the effective porosity was 17.49%. In prospect zone E, the total porosity value was 19.28% and the effective porosity was 19.04%.

Based on the table for determining whether the quality of rock porosity values in a reservoir is good or not (Koesoemadinata, 1978), it can be seen that the Menggala Formation and Pematang Formation are reservoir zones with good total porosity quality and good effective porosity quality.

Water saturation describes the water content contained in rock pores. To obtain the hydrocarbon content contained in rock pores, the water saturation is subtracted from one (1-Sw). The value (1-Sw) is known as So or oil saturation. Determining water saturation begins with creating a Pickett plot between PHIT and RT. Using the Pickett plot, the values of a (roughness factor), m (cementation factor), n (saturation factor) and Rw (water resistivity) are determined.

Water saturation was calculated using the Simandoux equation because the research area is considered a shaly-sand formation area with a fairly high shale volume content. The pickett plot between PHIT and RT is shown in Figure 6. In this pickett plot method, the Rw value is 0.223 with the values a, m, and n respectively being 1,2, and 2. The zone used for this pickett plot method is the water bearing zone. The water bearing (water saturated) zone is indicated by a small resistivity value (in the reservoir layer).

Based on the calculation results, the saturation value was obtained for each hydrocarbon prospect zone in the Menggala Formation, including in prospect zone A, the water saturation value was 35.18%. In prospect zone B, the water saturation value was 29.15%. In prospect zone C, the water saturation value was 31.06%. In prospect zone D, the water saturation value was 32.25%.

Based on the calculation results, the water saturation value was obtained in each hydrocarbon prospect zone in the Pematang Formation, including in prospect zone A, the water saturation value was 33.46%. In prospect zone B, the water saturation value was 30.38%. In prospect zone C, the water saturation value was 32.87%. In prospect zone D, the water saturation value was 34.04%. In prospect zone E, the water saturation value was 28.83%.

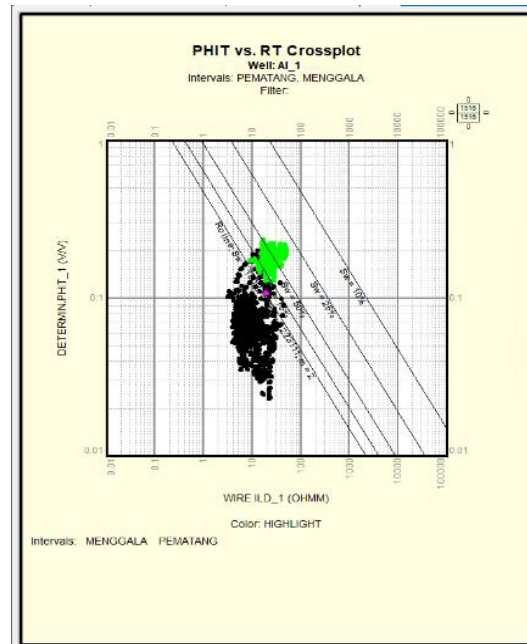


Figure 6. Pickett plot between log NPHI and RT

Based on the calculation results, the saturation value was obtained for each hydrocarbon prospect zone in the Menggala Formation, including in prospect zone A, the water saturation value was 35.18%. In prospect zone B, the water saturation value was 29.15%. In prospect zone C, the water saturation value was 31.06%. In prospect zone D, the water saturation value was 32.25%.

Based on the calculation results, the water saturation value was obtained in each hydrocarbon prospect zone in the Pematang Formation, including in prospect zone A, the water saturation value was 33.46%. In prospect zone B, the water saturation value was 30.38%. In prospect zone C, the water saturation value was 32.87%. In prospect zone D, the water saturation value was 34.04%. In prospect zone E, the water saturation value was 28.83%.

Based on the fluid saturation interpretation table (Adim, 1991), it can be seen that the Menggala Formation and Pematang Formation are reservoir zones with hydrocarbon fluid content in the form of gas. This is because the resulting saturation value from both formations is <40%.

Cut off is a value set as the threshold for a parameter in petrophysical analysis. The parameters in question are porosity (ϕ), clay volume (Vsh) and water saturation (Sw). These three parameters are used to determine the threshold of a rock formation. Cut off functions in removing shale intervals that are not reservoirs, zones with low porosity, and the percent of water contained in the reservoir.

Based on the crossplot method for each parameter, the cut off value for shale volume is 0.3 or 30%, which means that a value greater than or equal to (\geq) 0.3 or

30% is not considered a sandstone thickness that is clean from the influence of shale which can be said to be as a reservoir. Likewise, the cut off value for effective porosity is 0.13 or 13%, which means that a value smaller than or equal to (\leq) 0.13 or 13% is not considered the thickness of sandstone with good porosity. And also the cut off value for effective water saturation is 0.4 or 40%, which means that a value greater than or equal to (\geq) 0.4 or 40% is not considered the thickness of sandstone that contains hydrocarbons.

Cut off is a value set as the threshold for a parameter in petrophysical analysis. The parameters in question are porosity (\emptyset), clay volume (Vsh) and water saturation (Sw). These three parameters are used to determine the threshold of a rock formation. Cut off functions in removing shale intervals that are not reservoirs, zones with low porosity, and the percent of water contained in the reservoir.

Based on the crossplot method for each parameter, the cut off value for shale volume is 0.3 or 30%, which means that a value greater than or equal to (\geq) 0.3 or 30% is not considered a sandstone thickness that is clean from the influence of shale which can be said to be as a reservoir. Likewise, the cut off value for effective porosity is 0.13 or 13%, which means that a value smaller than or equal to (\leq) 0.13 or 13% is not considered the thickness of sandstone with good porosity. And also the cut off value for effective water saturation is 0.4 or 40%, which means that a value greater than or equal to (\geq) 0.4 or 40% is not considered the thickness of sandstone that contains hydrocarbons.

From the results of determining the cut off value, results will be obtained in the form of lumping data, where this data shows the net reservoir and net pay values. Net reservoir is a determination of depth intervals that can be used to describe the reservoir body. Meanwhile, net pay is a determination of the depth interval that can economically produce hydrocarbons.

From the cut off values previously obtained, a maximum clay content of 30% and a minimum porosity of 13% were obtained in the wells in the research area which will be used to determine the net reservoir zone. The productive layer or zone (net pay) has a water saturation value of less than or equal to 40%. So, with a maximum clay content of 30%, a minimum porosity of 13% and a water saturation cut-off value of 40% in wells in the research area, a net pay zone will be obtained in each prospect zone.

Based on the results of lumping prospect zone data in the Menggala Sumur AI-1 Formation of the Central Sumatra Basin, namely zone A has a prospect zone depth of between 5962.32 – 5966.83 feet, and a prospect zone thickness of 4.51 feet, a net reservoir value and net pay of 4.51 feet, net to gross reservoir

and pay of 1, clay content of 16.91%, porosity 17.99%, and water saturation 35.18. Zone B has a depth between 5968.5 – 6048.98 feet, and a reservoir thickness of 80.48 feet, a net reservoir value of 76.32 feet and a net pay of 75.84 feet, a net to gross reservoir of 0.948 and a net to gross Pay is 0.942, clay content is 15.1%, porosity is 18.07%, and water saturation is 29.15%. Zone C has a depth of between 6055.44 – 6082.67 feet, and reservoir thickness of 27.23 feet, net reservoir value and net pay of 26.61 feet, net to gross reservoir and pay of 0.977, clay content of 23.66 %, porosity 15.84%, and water saturation 31.06%. Zone D has a depth of between 6101 – 6125.03 feet, and reservoir thickness of 24.03 feet, net reservoir value and net pay of 18.17 feet, net to gross reservoir and pay of 0.756, clay content of 24.7%, porosity 15.9%, and water saturation 32.25%. The results of lumping data on the Menggala Formation can be seen in tables 4 and 5.

Based on the lumping results in the Pematang Well AI-1 Formation of the Central Sumatra Basin, namely zone A has a depth of between 6142.39 – 6162.04 feet, and a reservoir thickness of 19.65 feet, the net reservoir value and net pay is 19.65 feet, net to gross reservoir and pay is 1, clay content is 18.75%, porosity is 16.93%, and water saturation is 33.46%. Zone B has a depth between 6169.33 – 6194.06 feet, and a reservoir thickness of 24.73 feet, a net reservoir value of 24.37 feet and a net pay of 23.53 feet, a net to gross reservoir of 0.985 and a net to gross pay of 0.951, clay content of 21.72%, porosity 17.47%, and water saturation 30.38%. Zone C has a depth between 6198.64 – 6253.08 feet, and a reservoir thickness of 54.44 feet, a net reservoir value of 53.21 feet and a net pay of 52.98 feet, a net to gross reservoir of 0.977 and a net to gross Pay is 0.973, clay content is 20.53%, porosity is 17.37%, and water saturation is 32.87%. Zone D has a depth between 6272.25 – 6299.12 feet, and a reservoir thickness of 26.87 feet, a net reservoir value of 26.87 feet and a net pay of 26.32 feet, a net to gross reservoir of 1 and a net to gross pay of 1 0.98, clay content of 14.94%, porosity 17.49%, and water saturation 34.04%. Zone E has a depth of between 6415.38 – 6444.12 feet, and reservoir thickness of 28.74 feet, net reservoir value and net pay of 28.74 feet, net to gross reservoir and pay of 1, clay content of 4.13 %, porosity 19.04%, and water saturation 28.83%.

Based on the final results of the petrophysical analysis in this research, it can be seen that the prospect zone in the Menggala Formation and Pematang Sumur AI-1 Formation of the Central Sumatra Basin as a whole is a hydrocarbon zone. This is because most prospect zones have a net gross value close to 1. Potential reservoirs with a lot of production should have a large net to gross (NTG) value as a representation of

the ratio of reservoirs that can accommodate hydrocarbons. A good net to gross is a net to gross with a ratio close to 1. This value is greatly influenced by the value of porosity, clay content and water saturation in

the reservoir. The pay summary results for the Menggala Formation and Pematang Formation can be seen in figures 7 and 8.

Table 4. Lumping Net Data for the Menggala Formation Reservoir

		Zone		Cut Off				Reservoir				
Well	Zone	Top Feet	Bottom Feet	Gross Feet	Vsh v/v	Phie v/v	Sw v/v	Net Feet	NTG	Vsh %	Phie %	Sw %
AI-1	A	5962.32	5966.83	4.51	0.3	0.13	1	4.51	1	16.91	17.99	35.18
AI-1	B	5968.5	6048.98	80.48	0.3	0.13	1	76.32	0.948	15.1	18.07	29.15
AI-1	C	6055.44	6082.67	27.23	0.3	0.13	1	26.61	0.977	23.66	15.84	31.06
AI-1	D	6101	6125.03	24.03	0.3	0.13	1	18.17	0.756	24.7	15.9	32.25

Table 5. Lumping Net Pay Data for Menggala Formation

		Zone		Cut Off				Pay				
Well	Zone	Top Feet	Bottom Feet	Gross Feet	Vsh v/v	Phie v/v	Sw v/v	Net Feet	NTG	Vsh %	Phie %	Sw %
AI-1	A	5962.32	5966.83	4.51	0.3	0.13	0.4	4.51	1	16.91	17.99	35.18
AI-1	B	5968.5	6048.98	80.48	0.3	0.13	0.4	75.84	0.942	15.1	18.07	29.15
AI-1	C	6055.44	6082.67	27.23	0.3	0.13	0.4	26.61	0.977	23.66	15.84	31.06
AI-1	D	6101	6125.03	24.03	0.3	0.13	0.4	18.17	0.756	24.7	15.9	32.25

Table 6. Lumping Net Reservoir Data of the Pematang Formation

		Zone		Cut Off				Reservoir				
Well	Zone	Top Feet	Bottom Feet	Gross Feet	Vsh v/v	Phie v/v	Sw v/v	Net Feet	NTG Feet	Vsh %	Phie %	Sw %
AI-1	A	6142.39	6162.04	19.65	0.3	0.13	1	19.65	1	18.75	16.93	33.46
AI-1	B	6169.33	6194.06	24.73	0.3	0.13	1	24.37	0.985	21.72	17.47	30.38
AI-1	C	6198.64	6253.08	54.44	0.3	0.13	1	53.21	0.977	20.53	17.37	32.87
AI-1	D	6272.25	6299.12	26.87	0.3	0.13	1	26.87	1	14.94	17.49	34.04
AI-1	E	6415.38	6444.12	28.74	0.3	0.13	1	28.74	1	4.13	19.04	28.83

Table 7. Lumping Net Pay Data for Pematang Formation

		Zona		Cut Off				Pay				
Well	Zona	Top Feet	Bottom Feet	Gross Feet	Vsh v/v	Phie v/v	Sw v/v	Net Feet	NTG Feet	Vsh %	Phie %	Sw %
AI-1	A	6142.39	6162.04	19.65	0.3	0.13	0.4	19.65	1	18.75	16.93	33.46
AI-1	B	6169.33	6194.06	24.73	0.3	0.13	0.4	23.53	0.951	21.72	17.47	30.38
AI-1	C	6198.64	6253.08	54.44	0.3	0.13	0.4	52.98	0.973	20.53	17.37	32.87
AI-1	D	6272.25	6299.12	26.87	0.3	0.13	0.4	26.32	0.98	14.94	17.49	34.04
AI-1	E	6415.38	6444.12	28.74	0.3	0.13	0.4	28.74	1	4.13	19.04	28.83

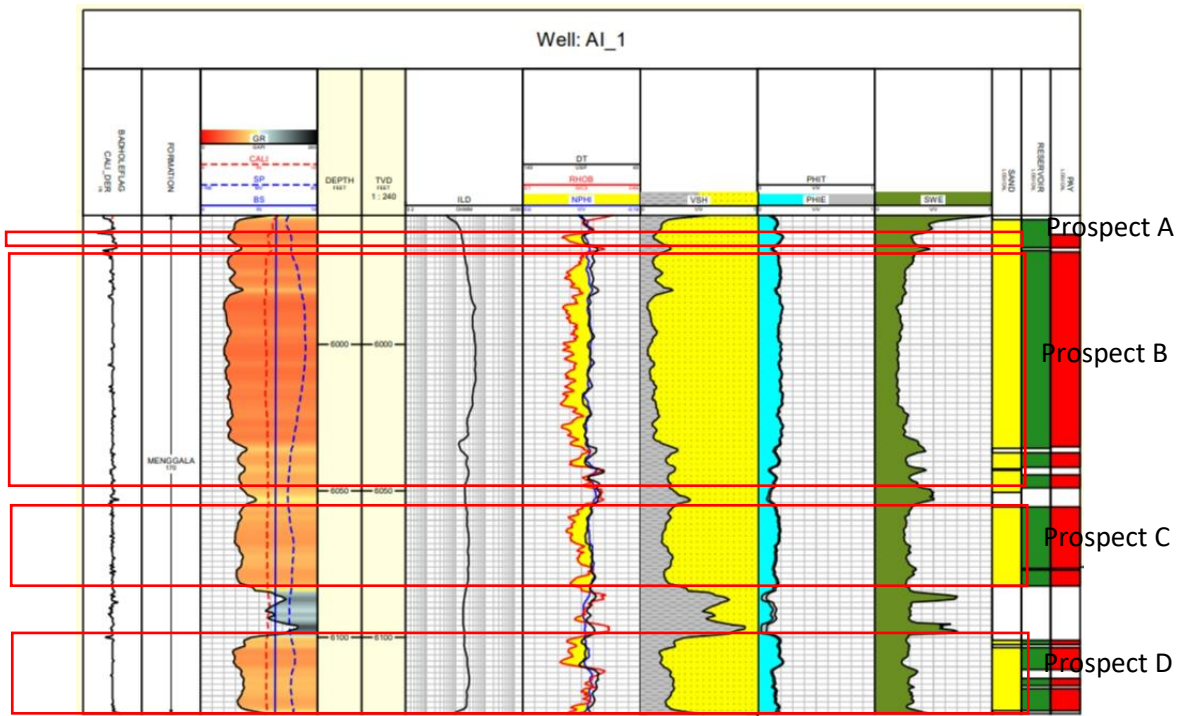


Figure 7. Mengkala Formation hydrocarbon prospect zone

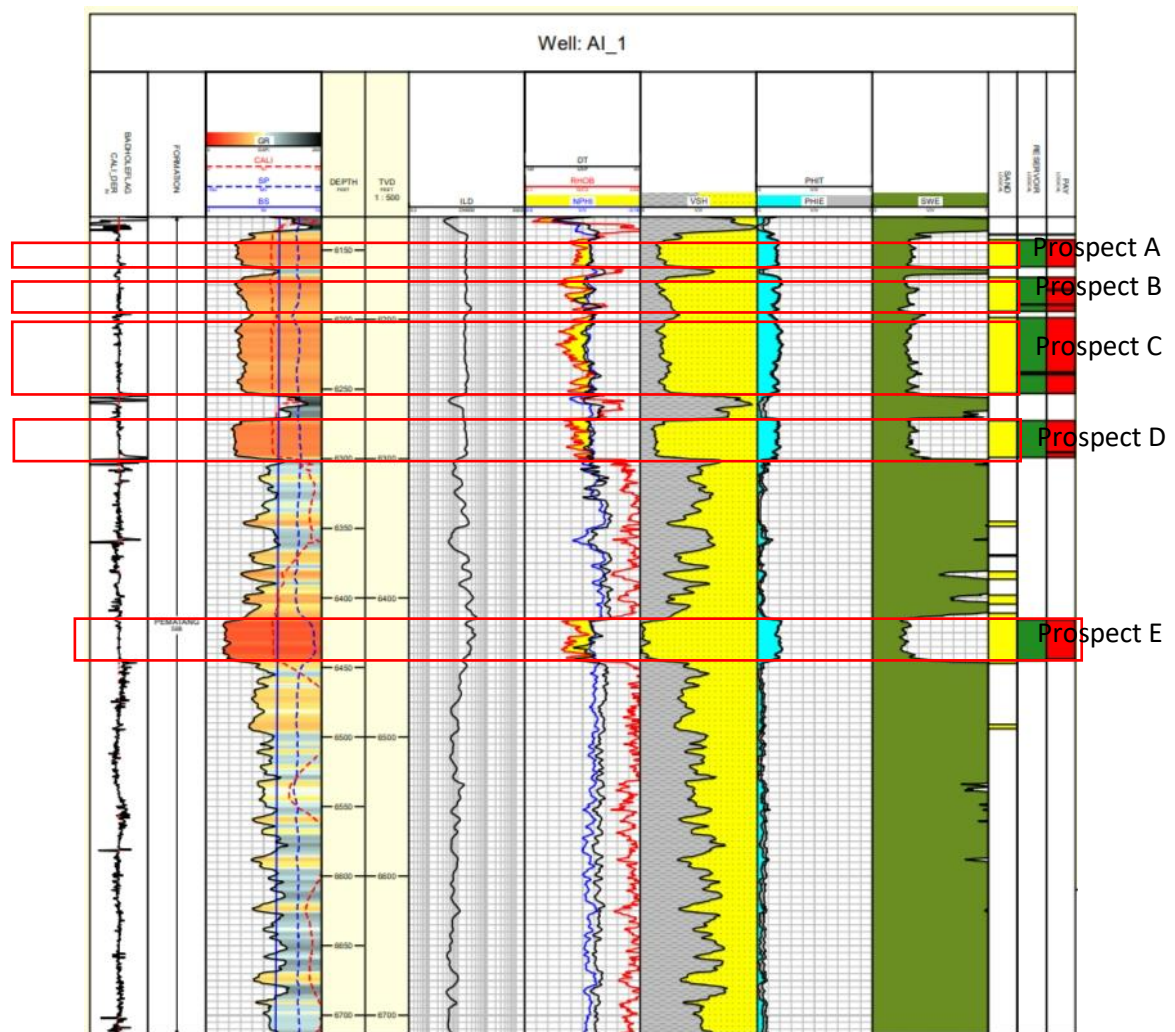


Figure 8. Pematang Formation hydrocarbon prospect zone

IV. CONCLUSIONS

1. Based on the AI-1 Well of the Central Sumatra Basin, it can be seen that in the Menggala Formation there are 4 hydrocarbon prospect zones at a depth of 5962.32 feet to 6125.03 feet and in the Pematang Formation there are 5 hydrocarbon prospect zones at a depth of 6142.39 feet to 6444.12 feet.
2. Based on petrophysical analysis in the AI-1 well of the Central Sumatra Basin in the Menggala Formation, the physical parameters obtained in each prospect zone were shale volume values of 15.1% - 24.7%, porosity 15.84% - 18.07 % with good quality, and water saturation 29.15% - 35.18% with fluid content in the form of gas. Meanwhile, in the Pematang Formation, physical parameters were obtained in each prospect zone, namely shale volume values of 4.13% - 21.72%, porosity of 16.93% - 19.04% with good quality, and water saturation of 28.83% - 34.04% with fluid content in the form of gas.
3. Base on the final results of the petrophysical analysis, it can be seen that the prospect zone in the Menggala Formation and Pematang Formation in Well AI-1 of the Central Sumatra Basin as a whole is a hydrocarbon zone. This is because most prospect zone have a net to gross value closes to 1.

V. ACKNOWLEDGMENT

The author would like to thank the relevant parties who have provided support for this research.

VI. REFERENCES

- [1] Adim, H. (1991). *Pengetahuan Dasar Mekanika Reservoir, Volume 1*. Badan Penelitian Dan Pengembangan Energi Dan Sumber Daya Mineral Pusat Penelitian Dan Pengembangan Teknologi Minyak Dan Gas Bumi "LEMIGAS", Jakarta.
- [2] Aprilia, R., Dewanto, O., Karyanto, K., & Ramadhan, A. (2020). Analisis Petrofisika dan Penyebab Low Resistivity Reservoir Zone Berdasarkan Data Log, SEM, XRD dan Petrografi Pada Lapangan X Sumatera Selatan. *JGE (Jurnal Geofisika Eksplorasi)*, 4(2), 144-158. doi:<https://doi.org/10.23960/jge.v4i2.13>
- [3] Archie, G. E. (1941). *The Electrical Resistivity Log as an Aid in Determining Some Reservoir Characteristics*. Trans., AIME. 146 : 54-62.
- [4] Asquith, G. & Gibson, C. (1982). *Basic Well Log Analysis For Geologist*. Tulsa: AAPG.
- [5] Bateman, R. (1985). *Open-Hole Analysis and Formation Evaluation*. Boston: IHRDC.
- [6] Chen, J., & Dickens, T. A. (2008). Effects of uncertainty in rock-physics models on reservoir parameter estimation using seismic amplitude variation with angle and controlled-source electromagnetics data. *Geophys. Prospect.*, p. 14, 2008.
- [7] Darling, T. (2005). *Well Logging and Formation Evaluation*. USA: GPP.
- [8] Dawson, W.C., Yarmanto, U. Sukanta, D. Kadar & J.B. Sangree. (1997). Regional Sequence Stratigraphic Correlation Central Sumatra Basin, Indonesia. 21st Annual Convention, *IPA Proceeding*, Jakarta.
- [9] Eubank, R. T., & Makki, A. C. (1981). Structural Geology of The Central Sumatra Back Arc-Basi. *Proceedings Indonesian Petroleum Association*, 10th Annual Convention, Vol. I, Jakarta, p. 153-196.
- [10] Fada, A. A. (2021). Evaluasi Petrofisik Berdasarkan Data Well Logging Pada Lapisan "Z", Lapangan "X" Dan Formasi "Y" Cekungan Sumatra Tengah. Skripsi. Prodi Teknik Geologi, Fakultas Teknik, Universitas Islam Riau, Pekanbaru.
- [11] Fatahillah, Y. (2016). Penentuan Potensi Batuan Induk Menggunakan Model Log TOC, Pada Formasi Ngimbang, Lapangan "ARRAZI", Cekungan Jawa Timur Utara. *Tugas Akhir*. Surabaya: Institut Teknologi Sepuluh Nopember.
- [12] Harsono, A. (1997). *Pengantar Evaluasi Log*. Jakarta: Schlumberger Oilfield Service.
- [13] Heidrick, T. L., & Aulia, K. (1993) A Structural and Tectonic Model of The Coastal Plains Block, Central Sumatra Basin, Indonesia. *Proceedings Indonesian Petroleum Association*. 22nd Annual Convention, Vol. I, Jakarta, p. 285-317.
- [14] Jooybari, H. (2016). A Structured Mobility-Based Methodology for Quantification of Net-Pay Cutoff in Petroleum Reservoirs. *SPE Reservoir Evaluation & Engineering*, (no. SPE 183643).
- [15] Koesoemadinata, R. P. (1978). *Geologi Minyak dan Gas Bumi*. Bandung: Penerbit ITB.
- [16] Mahbaz, S., Hadi, S., Namjouyan, M., & Mirzaahmadian, Y. (2011). Optimization of reservoir cut-off parameters: a case study in SW Iran. *Pet. Geosci.*, 17, 355-363. doi:, <https://doi.org/10.1144/1354-079311-005>.
- [17] Mertosono, S. & Nayoan, G. A. A. (1974). The Tertiary Basinal Area of Central Sumatra. *Proceedings Indonesian Petroleum Association*. 3rd Annual Convention, Jakarta, p. 63-76.
- [18] Nasir, M. (2014). Potret Kinerja Migas Indonesia. Diambil kembali dari <https://www.kemenkeu.go.id/sites/default/files/potret%20kinerja%20migas%20indonesia.pdf>
- [19] Potter, P.E., J. B. Maynard, & W. A. Pryor. (2012). Sedimentology of Shale: Study Guide and Reference Source. *Springer Science & Business Media*.
- [20] Priyanka, F., Mulyatno, B., & Ariffianhany, R. (2020). Klasifikasi Petrofisika Tipe Batuan Untuk Memprediksi Kualitas Reservoir Pasir Serpihan Pada Formasi Talang Akar, Cekungan Onwj. *JGE (Jurnal Geofisika Eksplorasi)*, 4(3), 255-266. doi:<https://doi.org/10.23960/jge.v4i3.39>
- [21] Schlumberger . (1998). *Schlumberger Log Interpretation Principles/Applications*. Texas: Schlumberger Wireline and Testing.
- [22] Sephiana, S., Karyanto, K., & Sinambela, R. (2023). Analisis Petrofisika Dalam Mengidentifikasi Zona Potensi Hidrokarbon Pada Formasi Tualang dan Lakat. *JGE (Jurnal Geofisika Eksplorasi)*, 9(3), 165-183. doi:<https://doi.org/10.23960/jge.v9i3.273>
- [23] Setyono, A. E., & Kiono, B. F. (2021). Dari Energi Fosil Menuju Energi Terbarukan: Potret Kondisi. *Jurnal Energi Baru & Terbarukan*, 2(3), 154-162.

- [24] Singh, K., & Joshi, R. (2020). Petro-physics and Rock Physics of Carbonate Reservoirs. *Springer Nature Singapore Pte Ltd.*
- [25] Sukanta, U. & Kadar, D. (1997). *Regional Sequence Stratigraphic Corelation Sentral Sumatra*. Intern Report. 60h.
- [26] Tarigan, F., Dewanto, O., Karyanto, K., Wibowo, R.C., & Widyasari, A. (2020). Analisis Petrofisika Untuk Menentukan Oil-Water Contact Pada Formasi Talangakar, Lapangan “FBT”, Cekungan Sumatra Selatan. *JGE (Jurnal Geofisika Eksplorasi)*, 5(1), 15-29. doi:<https://doi.org/10.23960/jge.v5i1.20>
- [27] Ulum, Y., Hastuti, E., & Herlina, W. (2012). Studi Evaluasi Data Logging dan Sifat Petrofisika Untuk Menentukan Zona Hidrokarbon Pada Lapisan Batupasir Formasi Duri Lapangan Balam South, Cekungan Sumatera Tengah. *Jurnal Universitas Sriwijaya*.