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Oil and Gas Potential of Sihapas Formation, Central Sumatra Basin Based on Water Saturation (Sw) and TOC

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A B S T R A C T

The potential of oil and gas in the Sihapas Formation has not been extensively studied, especially in terms of reservoirs based on water saturation (Sw). Few researchers have examined the source rock potential in the Sihapas Formation. To address this, researchers conducted a study on two wells to determine the potential of oil and gas in the Sihapas Formation using Sw values and source rock identification. The target areas and oil and gas content were identified using the logging method based on Sw values. For source rock identification, the logging method determined the TOC value, which was then compared with TOC core data from other researchers. Additionally, kerogen type and maturation in other wells in the Central Sumatra Basin were considered. The results showed several target areas in the Sihapas Formation with Sw values ranging from 10% to 62%, indicating the presence of oil and gas. The source rock areas in the Sihapas and Pematang Formations were found to be in good condition based on TOC calculation results, with TOC values of 1.94%-3.53% in the Sihapas Formation and 5.58%-18.54% in the Pematang Formation. These TOC results were consistent with TOC cores from other researchers in the Central Sumatra Basin. The kerogen type was identified as I/II and immature. The study concluded that the Sihapas Formation has potential oil and gas reservoirs, with good source rock conditions indicated by Sw values, TOC, kerogen type, and maturation data.

1. Introduction

The Central Sumatra Basin is located on the island of Sumatra, Indonesia, and is considered a productive basin that produces heavy oil and has been studied using satellite imagery and gravity data (Susantoro et al., 2002). Reservoirs in oil and gas wells in the Central Sumatra Basin have the potential to produce oil and gas, and there are host rocks that are origin of oil and gas for source rock in formations in the Central Sumatra Basin. The potential of oil and gas in the Sihapas Formation has not been studied too much by researchers and even if there are those who examine it, there are still very few who examine the potential of reservoirs in the Sihapas Formation based on Sw value. Some water saturation models can provide more accurate water saturation values for a rock formation (Shahrin et al., 2002). Predicting water saturation (Sw) in oil and gas reservoirs from well log data is a very important job because core data is usually not available for all wells drilled (Wood, 2020). Accurate determination of hydrocarbon saturation depends on the accuracy of the estimation of Archie parameters, namely cementation factor, tortuosity factor and saturation exponent (Soleymanzadeh et al., 2021). Then the identification of source rocks in the Sihapas and Pematang Formations as

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sources of oil and gas in the source rock has also not been carried out by many researcher.

Looking at this background, researchers tried to conduct research on two wells in the X field of the Central Sumatra Basin. The objectives of this research are: first, to determine the reservoir target area and source rock; second, to determine the oil and gas potential in Sihapas Formation based on Sw value and source rock identification in Sihapas and Pematang Formations. In this study, the method used is the Well Logging method, which is a qualitative petrophysical analysis by looking at the resistivity value (lld) and quantitatively by looking at the water saturation value (Sw). Then determine the source rock area using the logging method as well, namely by determining the TOC value and then comparing it with the TOC value of core data.

There are several literatures that mention that the Central Sumatra Basin has the potential to produce oil and gas. Among them is research Susantoro et al. (2023) which examines the utilization of random forest classification for oil and gas exploration in the Central Sumatra Basin based on subsurface and surface data. The data used include gravity data, basement structure maps, seismic interpretation maps and surface data. Then research Widarsono et al. (2021) is identifying the geological position of oil and gas potential by analyzing qualitative and quantitative well logs supported by well test data and laboratory measurements with the aim of identifying reservoirs/traps containing oil and gas. Then research Buntoro et al. (2020) conducted research on Brownshale which is a lithological unit that is in the middle of the Pematang Formation as the main parent rock in the Central Sumatra Basin. The brown shale is spread in several troughs, namely the Balam, Aman, Rangau, Kiri, and Bengkalis Troughs, where the Bengkalis Trough is the most extensive. Furthermore, research Koning et al. (2021) examined the status of oil and gas exploration in naturally fractured and weathered basements through out Sumatra, and also reviewed the status of oil and gas production from Sumatra basements. Furthermore, research Kurniawan et al. (2022) conducted reservoir pressure maintenance in the field, existing production wells with high water cut, and inactive horizontal wells that have released water in the Permata field located in the Rokan block, Central Sumatra Basin. Then research Putra et al. (2022) managed the dynamic and geological uncertainties in the TLN field which is one of the productive oil fields in the Rokan Block, Central Sumatra Basin. This led to the successful production of thousands of BOPD in the 2020-2021 drilling campaign, by developing certain strategies that are suitable for the TLN field. From the geological aspect, and re-utilizing fault interpretation to mitigate damage at the development and execution stages using seismic reprocessing, seismic enhancement, and seismic attributes. Furthermore, Muhammad Adinur et al. (2019) found reservoirs based on petrophysical analysis with Sw=0.24-0.25%. Then Diria et al. (2018) found potential oil and gas areas with a Sw value of 30%40%. Then Corbafo Siki et al. (2016) found an area of oil and gas potential with a Sw value of 19-60% and there are two infill well points to be proposed. And there are still some researchers that I don't mention here.

In this study using petrophysical analysis qualitatively by looking at the resistivity value (lld) and quantitatively by looking at the water saturation value (Sw). The calculation of water resistivity will show that the reservoir zone filled with water has a low resistivity value compared to the hydrocarbon zone because water can conduct electricity better than hydrocarbons, so that the visible log graph will show a curve deflection to the left or to a low value (Camyra et al., 2022). Some studies Pratami et al. (2023), Julikah et al. (2021), Situngkir (2020), Al-Obaidi et al. (2021), Elhossainy et al. (2021), Nadhifah (2022), Ordas et al. (2023), Ge, X et al. (2023) can identify the type of fluid according to the water saturation value, so they could determine the potential of oil and gas in Sihapas Formation based on Sw value. To support the oil and gas potential of the Sihapas Formation, source rocks in the Sihapas and Pematang Formations are also required, which are sources of oil and gas in the Sihapas Formation reservoirs. There are parent rocks that are sources of oil and gas for reservoirs in formations in the Central Sumatra Basin. To determine the source rock area, researchers also conducted research using the logging method, namely by determining the TOC value and then comparing it with the results of the TOC value of core data from other researchers (Agrarianda et al., 2020). Furthermore, looking at the type of kerogen and maturation in other wells from other researchers in the Central Sumatra Basin, namely Munafatin et al. (2024) and Riyandhani (2022).

Several studies on source rocks in the Central Sumatra Basin have been conducted by several researchers. Among them, Fiqih et al. (2024) produced research on the Kelesa Formation, which although known as a hydrocarbon source rock, can play a role in the reservoir and become a target for further exploration for synrift deposits through direct migration. Then Herlienda Elizabeth et al. (2023) conducted research on geochemical analysis methods that specifically utilize Total Organic Carbon (TOC) and Rock-Eval Pyrolysis data used to assess the quality, quantity, and maturity of source rocks in Well BO-1 Pematang Formation of Central Sumatra Basin. Then Agustiyar (2021) said that the Central Sumatra Basin is estimated to have significant oil and gas potential and the results of seismic interpretation provide information that supports the presence of heavy oil. Furthermore, Ordas et al.

(2023) identified depositional environments and petroleum systems through seismic and well stratigraphic studies. This study used seismic and log methods. The determination of the reservoir layer and source rock is reinforced by the analysis of wells located on the seismic trajectory. Hydrocarbon reservoirs are found in Bekasap, Bangko, Menggala, and some Pematang Formations, while host rocks are found in some Menggala and Pematang Formations. Then Andriyani et al. (2023) and Ordas et al. (2023) identified petrophysical parameters and fluid types based on Sw and sequence stratigraphy in the coastal basin of Central Sumatra. Then Yoza et al. (2023) characterized the source rocks such as quantity, quality, maturity, and depositional environment using geochemical analysis, then analyzed the depositional history in the study area.

Furthermore, Widada (2018) found that all intervals of the Brown Shale Formation in the Gamma Well have the potential to be rich parent rocks and have reached the level of thermal maturity (mature source rock). Then Nainggolan et al. (2023) produced research that the Sihapas Formation is thought to be the source rock of the Central Sumatra Basin. Then Buntoro et al. (2020) produced research on the Brown Shale Formation is a good formation in the parameters of potential, quality and maturity of the source rock. The Pematang Formation is the main host rock in the Central Sumatra Basin. The quality of the host rock is based on Total Organic Carbon (TOC) data, kerogen type determination, and thermal maturity of the host rock according to the Tmax value and Vitrinite Reflectance (%Ro). TOC values range from 0.2 to 42.48% by weight, and maturity parameters indicate that the Pematang Formation has reached the mature stage according to Afifah (2023).

Determining TOC content is critical in evaluating unconventional shale resources. Petrophysical approaches, such as the ΔlogR method, offer a fast, convenient, and cost-effective way to estimate TOC from well logs. This method is commonly used in conventional source rock evaluation and is applied to unconventional resource evaluation. To estimate the TOC of shale logs, the Passey equation was used on oil and gas well logs according to Ehsan et al. (2024). In this study, the method used is the logging method in the form of qualitative analysis and quantitative analysis using the calculation of petrophysical value parameters in accordance with research Irmaya et al. (2023) and Indriyani et al. (2020). The fluid system in a reservoir is usually multi-phase (water and hydrocarbons). Hydrocarbon saturation (oil or gas) can be known by first calculating the water saturation, thus determining the water saturation value (Sw=water saturation) is the key to knowing whether a reservoir internal contains predominantly water or hydrocarbons (Ibrahim et al., 2022).

Reservoir Characterization is a process to describe qualitatively or quantitatively. With reservoir characterization, we can get a complete reservoir model of the lithology, porosity, and fluid in it. One of the stages in determining the potential of oil and gas in the reservoir is water saturation (Sw). Furthermore, determining the source rock area, researchers also conducted research using the logging method, namely by determining the TOC value and then comparing it with the results of the TOC value of core data from other researchers. Furthermore, looking at the type of kerogen and maturation in other wells from other researchers in the Central Sumatra Basin. The purpose of this study is to determine the target area in Sihapas Formation, then determine the source rock in Sihapas and Pematang Formations. Furthermore, the oil and gas potential in Sihapas Formation is obtained based on Sw and TOC values.

2. Methods

2.1. Data

Log data for Reservoir (Gamma Ray, Resistivity, NPHI and RHOB), used for qualitative analysis, determining lithology, determining resistivity values, calculating clay content (Vsh), determining Rw, calculating effective porosity, and determining Sw values to determine the hydrocarbon content in the reservoir (water, oil or gas). Log data for Source Rock (Gamma Ray, Sonic and Resitivity), used for qualitative analysis, determining lithology, determining source rock layers, calculating TOC. Geochemical data (vitrinite reflectance, Ro), used for chemical analysis.

2.2. Research methods

Literature study - reservoir and source rock data collection (gamma ray log data, resistivity, porositydensity separation, resistivity-time separation; core data) - determining reservoir and source rock layers-petrophysical parameter analysis and total organic carbon (TOC) parameter analysis-reservoir potential and source rock potential in Sihapas Formation-potential analysis - Oil and Gas Potential in Sihapas Formation Central Sumatra Basin.

2.3. Object research

The primary focus of this research is to investigate the oil and gas reservoirs located within the Sihapas Formation, as well as the source rocks found in both the Sihapas and Pematang Formations. This study highlights the significant potential for oil and gas extraction within the Sihapas Formation, emphasizing its promising prospects. The potential for hydrocarbon reserves in this region is further supported by an examination of the type of kerogen and the maturation process observed in other wells, as documented by previous researchers in the Central Sumatra Basin. By integrating these findings, the research aims to provide a comprehensive understanding of the geological characteristics and resource potential of the Sihapas Formation, thereby contributing valuable insights into the hydrocarbon exploration and exploitation strategies in the area (Datu & Aventino (2019).

2.4. Data collection techniques and instruments data analysis

This research focuses on reservoir targets, fluid content, source rock layers and geochemical analysis, and the data required is well log data and geochemical data. Well log data for determining reservoir targets are gamma ray (GR) logs, resistivity logs, porosity logs (NPHI) and density logs (RHOB). The way to obtain this data is by drilling and coring, then inserting a gamma ray log tool to obtain the type of lithology, then inserting a resistivity log tool to measure the resistivity value of the rock. Next, enter the porosity log tool (NPHI) to get the porosity value, and the density log tool (RHOB) to measure the density value. Then you can identify the type of fluid by looking at the water saturation (Sw) value. Well log data can also determine source rock layers, namely time logs (DT) and resistivity logs (lld). Then geochemical data is used to determine hydrocarbon maturation and source rock kerogen type.

The preparation and data collection stages are the stages in collecting the data needed in this research. The data used in this research is logging data in LAS format. At this stage a pre-calculation is carried out which consists of the well header input stage, quality control data, depth matching, calculate temperature gradient and calculate the Rw value and carry out environmental correction. The stages in carrying out environmental correction are:

1. Analysis of the drilling environment (environmental correction)
   Before processing, the well data used should be corrected first. This is done because during drilling there are several parameters that can influence the results of well logging curve readings, such as drill hole geometry, casing and material configuration, and mud density. So environmental correction is needed in order to minimize the effects of the drill hole. When making log corrections on well X, this is done according to the top depth and bottom depth written in the data. This correction is carried out in accordance with a number of drilling runs, where each run of correction results is combined into one complete corrected gamma ray curve.
2. Gamma ray (GR) log analysis
   In gamma ray log analysis, the initial stage is to input the gamma ray log curve, Caliper log curve or drill hole diameter (inch). Other parameters to pay attention to are tool position (eccentered or centered), drilling mud type (non-barite and barite), drill hole type (open hole or cased hole), mud weight data, tool diameter, standoff and casing data. especially for cased holes. In well X the data was carried out in an open hole manner.
3. Analysis of density log (RHOB) and porosity log (NPHI)
   In the analysis of density logs and porosity logs, the initial stage consists of inputting density log (RHOB) and porosity (NPHI) curves. In density logs and porosity logs, the parameters that really pay attention are drilling mud and caliper data. So, correction of density logs and porosity logs requires caliper data or drill hole size and the specific gravity of the drilling mud used.
4. Resistivity log analysis (LLD) an time (DT)
   Resistivity and time log analysis is needed to determine the resistivity and time values in the original reservoir area, namely using LLD and DT logs. The aim is to determine source rock layers and analyze geochemical data.

3. Result and discussi

3.1. Reservoir target ar a and fluid content

Well A and B are located in the PRO field in the Central Sumatra Basin. The depths of wells A and B are shown in Tables 1 and 2.

Table 1. Well formation depth A.

Formation		Depth (m)
Minas		0 – 170
Petani		171 – 284
Telisa		285 – 697
Sihapas	Upper	698 – 778
	Lower	779 – 969
Pematang Group	Pmt. SS	970 – 1457
	Pmt. MS	1458 – 1719
	BRSH	1720 – 1780
	LP	1781 – 1880
Basement		1881 – 1964

Table 2. Well formation depth B.

Formation		Depth (m)
Minas		0 – 120
Petani		121 – 240
Telisa		241 – 605

Sihapas	Upper	606 – 685
	Lower	686 – 930
	Pmt. SS	931 – 1160
Pematang Group	Pmt. MS	1161 – 1318
	BRSH	1319 – 1342
	LP	1343 – 1362
Basement		1363 – 1403.8

This research is focused on the Sihapas Formation by determining the target areas of wells A and B, so that the potential of oil and gas in the Sihapas Formation can be known. The potential is also supported by source rocks in the Sihapas Formation and Pematang Formation, based on the results of TOC calculations compared to TOC cores from the results of research (Datu & Aventino, 2019).

Next, we looked at kerogen types and their maturation in other wells from other researchers in the Central Sumatra Basin. Wells A and B are known to have low resistivity values so that qualitative interpretation cannot be used to determine reservoir content (target area). The solution is to carry out a quantitative interpretation, namely by calculating the Sw value in the target area of Well A of the Sihapas Formation. Well A in the Sihapas Formation has 14 target areas. The Sw value is determined by the Archie formula because the clay content (Vsh) is small. The equation for determining water saturation according to Archie is in accordance with equation 1.

$$Sw = \sqrt{\frac{a \times Rw}{\emptyset^{m} \times Rt}} \quad (1)$$

Figure 1 shows the target area of 1 well A in the PRO field of the Sihapas formation of the Central Sumatra Basin. The overall research results of the Sihapas formation in the target area 1-14 of Well A of the Central Sumatra Basin are shown in Table 3.

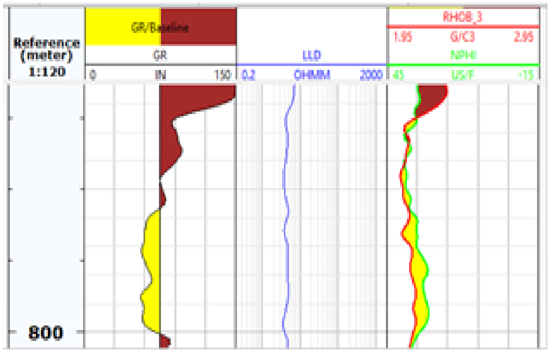

Figure 1. Target area 1 PRO field, Sihapas Formation, well A Central Sumatra Basin.

Table 3. Results of determining petrophysical parameters for target areas 1-14 of the Sihapas Formation, Well A Central Sumatra Basin.

Target	Vsh (%)	n	a	m	Rw (Ωm)	Rt (Ωm)	Ø (%)	Sw (%)	Fluid type
1	24%	2	0.62	2.15	0.07	3.55	24%	51%	Oil and gas
2	39%	2	0.62	2.15	0.07	3.95	19%	64%	Oil
3	28%	2	0.62	2.15	0.07	4.55	25%	44%	Gas
4	35%	2	0.62	2.15	0.07	4.5	19%	57%	Oil and gas
5	42%	2	0.62	2.15	0.07	4.75	17%	63%	Oil
6	36%	2	0.62	2.15	0.07	3.85	19%	62%	Oil
7	37%	2	0.62	2.15	0.07	4.83	15%	73%	Water
8	41%	2	0.62	2.15	0.07	4.1	11%	75%	Water
9	36%	2	0.62	2.15	0.07	4.6	16%	72%	Water
10	39%	2	0.62	2.15	0.07	4.97	16%	66%	Oil
11	43%	2	0.62	2.15	0.07	4.7	17%	63%	Oil
12	42%	2	0.62	2.15	0.07	5.93	13%	75%	Water
13	38%	2	0.62	2.15	0.07	5.7	17%	59%	Oil and gas
14	40%	2	0.62	2.15	0.07	5.3	15%	69%	Oil
15	39%	2	0.62	2.15	0.07	5.75	14%	74%	Water
16	43%	2	0.62	2.15	0.07	6.36	11%	75%	Water
17	43%	2	0.62	2.15	0.07	7.4	14%	63%	Oil

Table 4. Results of determining petrophysical parameters for target areas 1-17 of the Sihapas Formation, Well B Central Sumatra Basin.

Target	Vsh (%)	n	a	m	Rw (Ωm)	Rt (Ωm)	Ø (%)	Sw (%)	Fluid type
	7%	2	0.62	2.52	0.11	4.7	30%	55%	Oil and gas
1	7%	2	0.62	2.52	0.11	4.8	30%	55%	Oil and gas
	7%	2	0.62	2.52	0.11	5.0	30%	53%	Oil and gas
2	7%	2	0.62	2.52	0.11	4.4	29%	59%	Oil and gas
3	9%	2	0.62	2.52	0.11	4.6	27%	63%	Oil
4	7%	2	0.62	2.52	0.11	5.5	27%	59%	Oil and gas
5	10%	2	0.62	2.52	0.11	5.2	28%	57%	Oil and gas
6	8%	2	0.62	2.52	0.11	5.1	25%	67%	Oil
7	8%	2	0.62	2.52	0.11	5.8	25%	62%	Oil
8	10%	2	0.62	2.52	0.11	5.2	25%	65%	Oil
9	10%	2	0.62	2.52	0.11	5.7	30%	49%	Gas
10	9%	2	0.62	2.52	0.11	29.6	10%	75%	Water
11	8%	2	0.62	2.52	0.11	7.0	22%	66%	Oil
12	2%	2	0.62	2.52	0.11	7.7	21%	69%	Oil
13	7%	2	0.62	2.52	0.11	7.0	13%	75%	Water
14	3%	2	0.62	2.52	0.11	7.2	15%	75%	Water

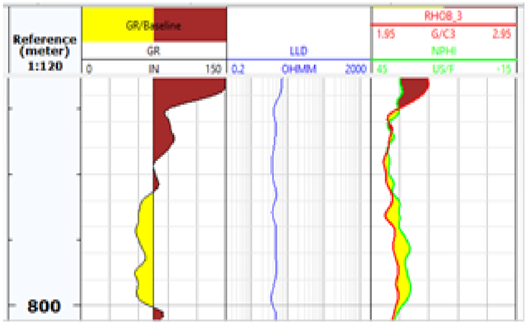

Figure 2. Target area 1 PRO field, Sihapas Formation, well B Central Sumatra Basin.

The overall research results of the Sihapas formation in the target area 1-17 of Well B of the Central Sumatra Basin are shown in Table 4. Figure 2 shows the Sw Archie Formula and target area 1 of Well B in the PRO field of Sihapas Formation of Central Sumatra Basin. Overall research results in the target area of Well B are shown in Table 4.

The results of the research in well A of Sihapas Formation, shown in table 3, the fluid content is dominated by oil and gas, while in well B table 4 the fluid content is also dominated by oil and gas. This is supported by the effective porosity value of wells A and B which is 10%-30% with sandstone lithology. While the Sw value is quite good and the fluid is dominated by hydrocarbons (oil and gas) with the type of hydrocarbons based on Adim (1991) shown in table 5.

Table 5. Interpretation Of Fluid Saturation Of Laboratory Data Results Adim (1991).

Average So	Average Sw	Estimated reservoir type
< 3%	< 50%	Gas reservoir
2 – 5%	< 60%	Oil + gas reservoir
> 5%	< 50 – 70%	Oil reservoir
< 1%	> 70 – 75%	Water reservoir

So it can be said that the potential in the Sihapas Formation of the Central Sumatra Basin is dominated by oil and gas content because the value of its petrophysical parameters (porosity and Sw) is very good. This is also supported by research results from Muhammad Adinu et al. (2019), Diria et al. (2018), and Corbafo Siki et al. (2016). The potential for oil and gas in the Sihapas Formation is also supported by source rocks in the Sihapas and Pematang Formations, which are sources of oil and gas in the Sihapas Formation reservoirs. Because there are parent rocks that are sources of oil and gas for reservoirs in Formations in the Central Sumatra Basin. To determine the source rock area, researchers also conducted research using the logging method, namely by determining the TOC value and then comparing it with the results of the TOC value of core data from researchers Datu & Aventino (2019).

3.2. Maturity evaluation of the source rock layer

Figures 3 and 4 show the qualitative interpretation of the source rock layers of Wells A and B in the PRO field of the Pematang Formation, Central Sumatra Basin. Furthermore, quantitative interpretation is carried out by determining the TOC in the area. According to Passey et al. (1991) the formula for calculating logR is:

$$TOC = (\Delta LogR)\ x\ 10^{(2.297-0.2688xLOM)} \qquad (2)$$

$$LogR = Log\ 10\left(\frac{R}{R_{baseline}}\right) + 0.02\ x\ (t - t_{baseline}) \qquad (3)$$

$LogR$ = separation curve overlaying log sonic and resistivity
R = resistivity measured by the log tool (ohm-m)
t = transit time measurement (µsec/ft)
0.02 = ratio at -50µsec/ft per 1 resistivity cycle
$R_{baseline}$= the same resistivity as tbaseline

To evaluate the source rock layers of the Sihapas and Pematang formations in wells A and B, a combination of resistivity logs and sonic logs was used. The separation between resistivity and sonic log curves may indicate the presence of mature organic material-rich host rock intervals. Figures 3 and 4 can be seen to evaluate the maturity of the source rock layers in wells A and B.

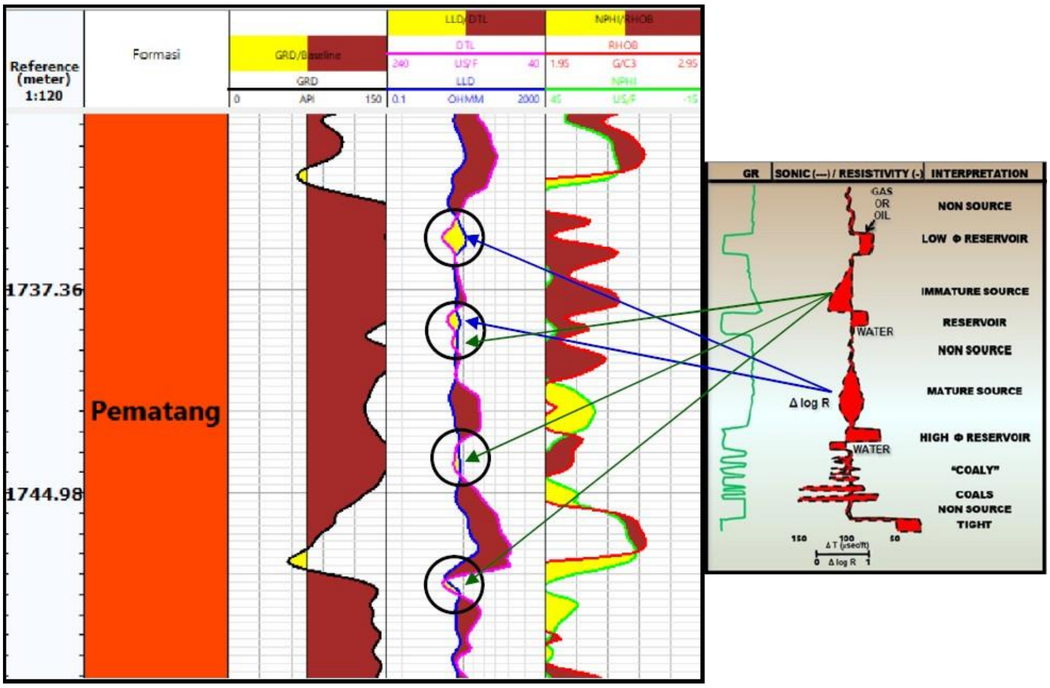

Figure 3. Qualitative interpretation of source rock layer of well A in field PRO Pematang Formation, Central Sumatra Basin.

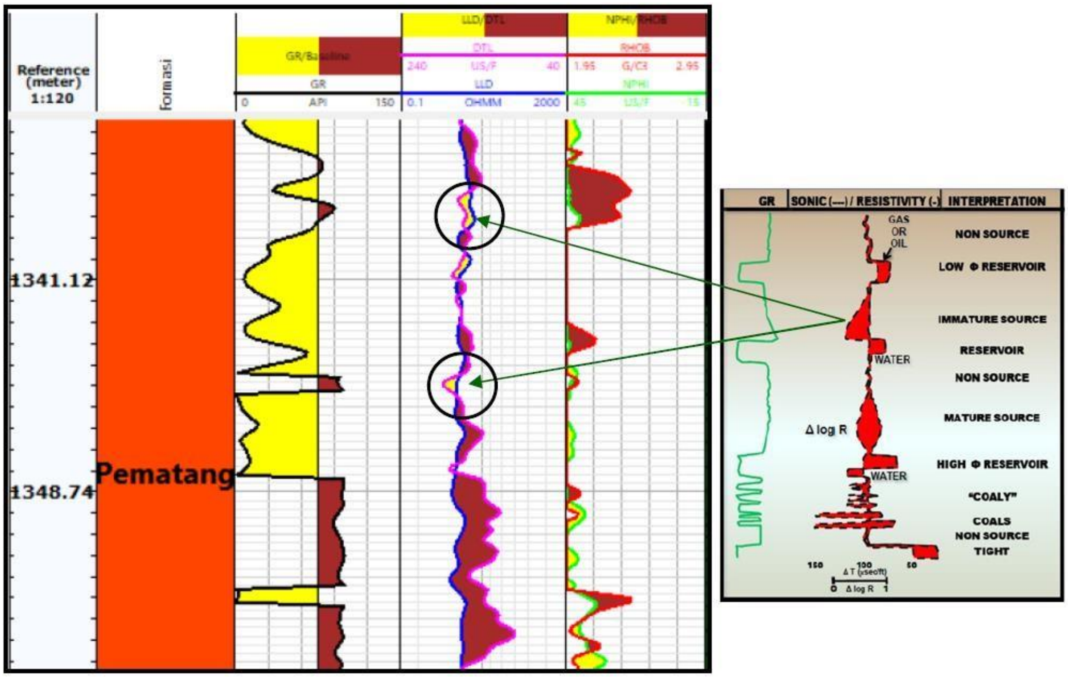

Figure 4. Qualitative interpretation of source rock layer of well B in field PRO Pematang Formation, Central Sumatra Basin.

3.3. Geochemical analysis

Figure 5a, shows the thermal maturity of well A of Sihapas formation is considered immature, and for Pematang formation is considered early mature for two rock samples of Pematang formation and late mature for one rock sample of Pematang formation well A below. Figure 5b, shows that the thermal maturity of well B of Sihapas formation is late immature, and for Pematang formation is early mature.

From the calculation of TOC value in well A of Pematang Brown Shale Formation is 1.94%-3.53% and well B of Pematang Brown Shale Formation is 5.58%18.54%. These results are compared with the results of research Ganjar Gani et al. (2017), that the TOC value in the Pematang Brown Shale Formation is 3.21%-6.06%, and according to Peters and Cassa (1994) is classified as good-special. The potential for oil and gas in the Sihapas Formation is also supported by the TOC value of core data from other researchers (Datu & Aventino, 2019). Furthermore, looking at the type of kerogen and maturation in other wells from the research results of researcher.

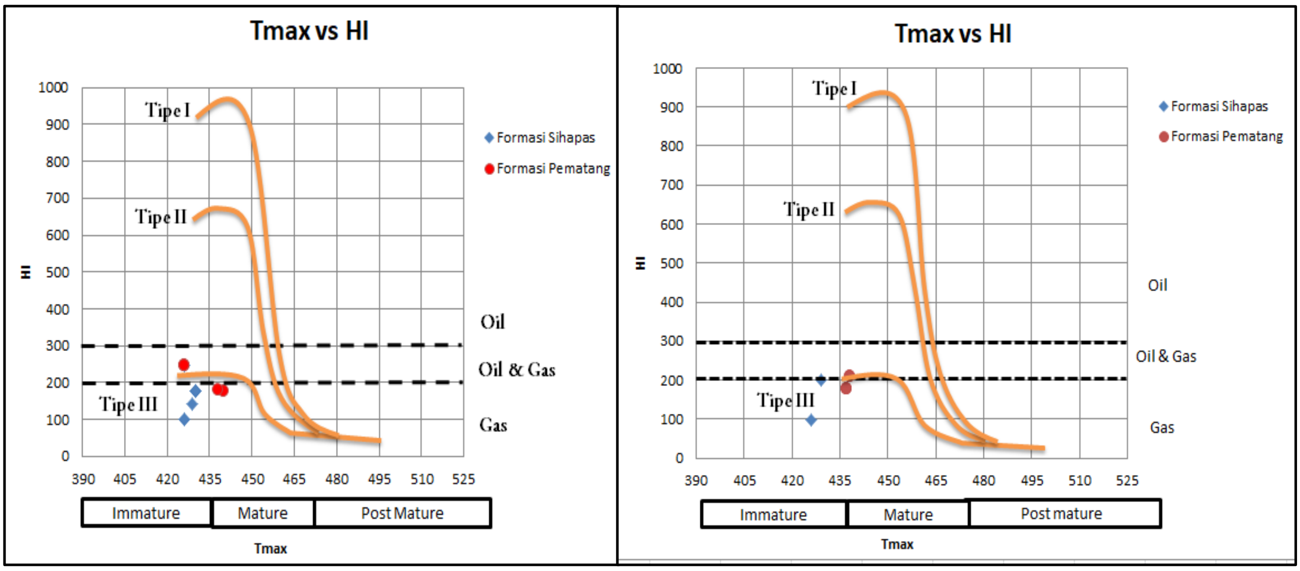

Figure 5. Cross plot between maximum temperature (Tmax) and hydrogen index (HI) values for wells A (5a) and B (5b) .

3.4. Interpretation of findings

3.4.1. Reservoir layer

The reservoir target zone can be seen from the permeable layer, the type of lithology, and the fluid that fills the formation, and with a quick look it can be seen in the triple combo which includes a gamma ray log, resistivity log, porosity log and density log. A layer can be said to be permeable if it has a low gamma ray log value range and can flow the fluid that fills the reservoir, with a high resistivity value which means the filling fluid cannot conduct electricity well, and there is separation in the neutron log and density log, then a layer can considered a layer that is a prospect for oil and gas potential. This research uses two well data, namely Well A and Well B which are located in the Central Sumatra Basin. There are 14 target reservoir target zones for oil and gas potential in well A (Table 3) and in well B there are 17 reservoir target areas (Table 4). The log images are given as examples in figures 1 and 2 for reservoir target one in wells A and B in the Sihapas formation of the Central Sumatra Basin.

3.4.2. Source rock layer

Total Organic Carbon (TOC) is a measure of organic richness that describes the amount of organic material in the parent rock consisting of bitumen and kerogen. The higher the TOC value, the higher the possibility of hydrocarbon formation and the better the source rock will be. In this research, Total Organic Carbon (TOC) analysis was carried out using two well data, namely wells A and B specifically in the Sihapas and Pematang formations.

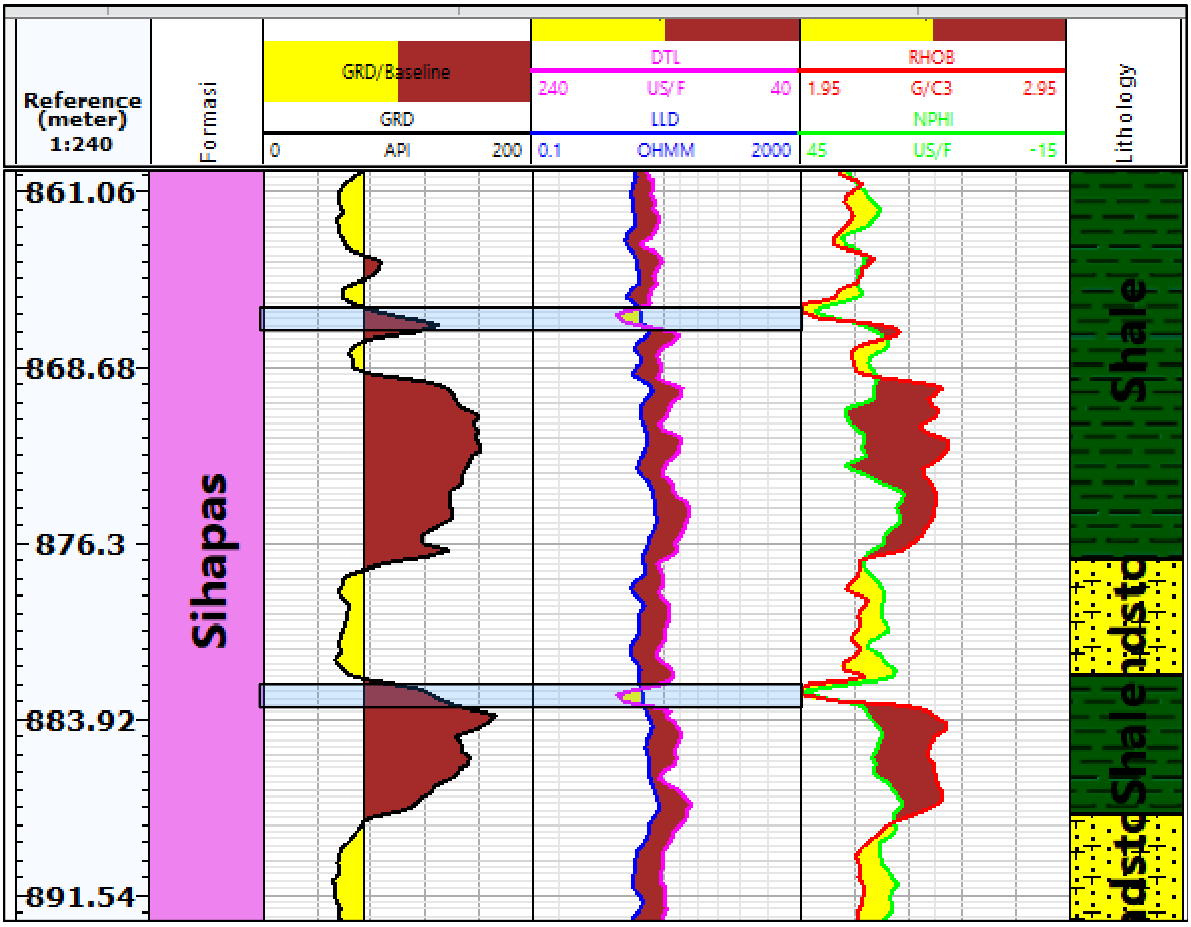

Figure 6. Source rock target area 4-5 in well A.

Table 6. Total Organic Carbon (TOC) calculation results in well A.

No	Depth (m)	LOM	TOC (%)
1	755.4	6.0	0.94
2	756.4	6.0	2.58
3	757.7	6.0	2.70
4	758.5	6.0	4.44
5	759.0	6.0	4.25
6	831.0	6.1	0.34
7	866.0	6.2	1.50
8	882.0	6.2	10.92
9	949.0	6.5	0.66
10	1735.0	9.8	1.11
11	1738.0	9.8	0.58
12	1739.0	9.8	0.27
13	1743.0	10.2	0.46
14	1757.0	10.2	0.66

Figure 6 shows the target area of Source Rock 4-5 Well A. The total organic carbon value was obtained in well A with 9 samples in the Sihapas formation and five samples in the Pematang formation. In nine samples in the Sihapas formation, the average TOC value was 3.14%, then the minimum and maximum TOC values for the Sihapas formation were 0.34% and 10.92%. The Pematang Formation obtained an average TOC value of 0.6% for the minimum and maximum values of 0.6% and 1.11%. Classification according to the TOC classification system of Peters & Cassa (1994), the source rock of well A in the Sihapas formation is a very good and excellent source rock in terms of organic richness because the TOC content on average is dominated by between 2% and 4% and some are 10.92%. While the Pematang formation includes good and moderate parent support because the TOC content varies from 1% and above 0.5%. Can be seen in Table 6.

Figure 7, shows the Source Rock 3-5 Well B target. The total organic carbon value was obtained in well B with two samples in the Sihapas formation and five samples in the Pematang formation. In the two samples in the Sihapas formation, the average TOC value was 5%, then the minimum and maximum TOC values for the Sihapas formation were 7.22% and 2.78%. The Pematang Formation obtained an average TOC value of 3.57% for the minimum and maximum values of 4.28%

and 2.97%. Classification according to the TOC classification system of (Peters & Cassa, 1994), the source rock of well B in the Sihapas formation is a very good and excellent source rock in terms of organic richness because the TOC content is between 2% and 7%, while for the Pematang formation it includes parent support. very good and good because the average TOC content is dominated between 2%-4%. Can be seen in Table 7 below.

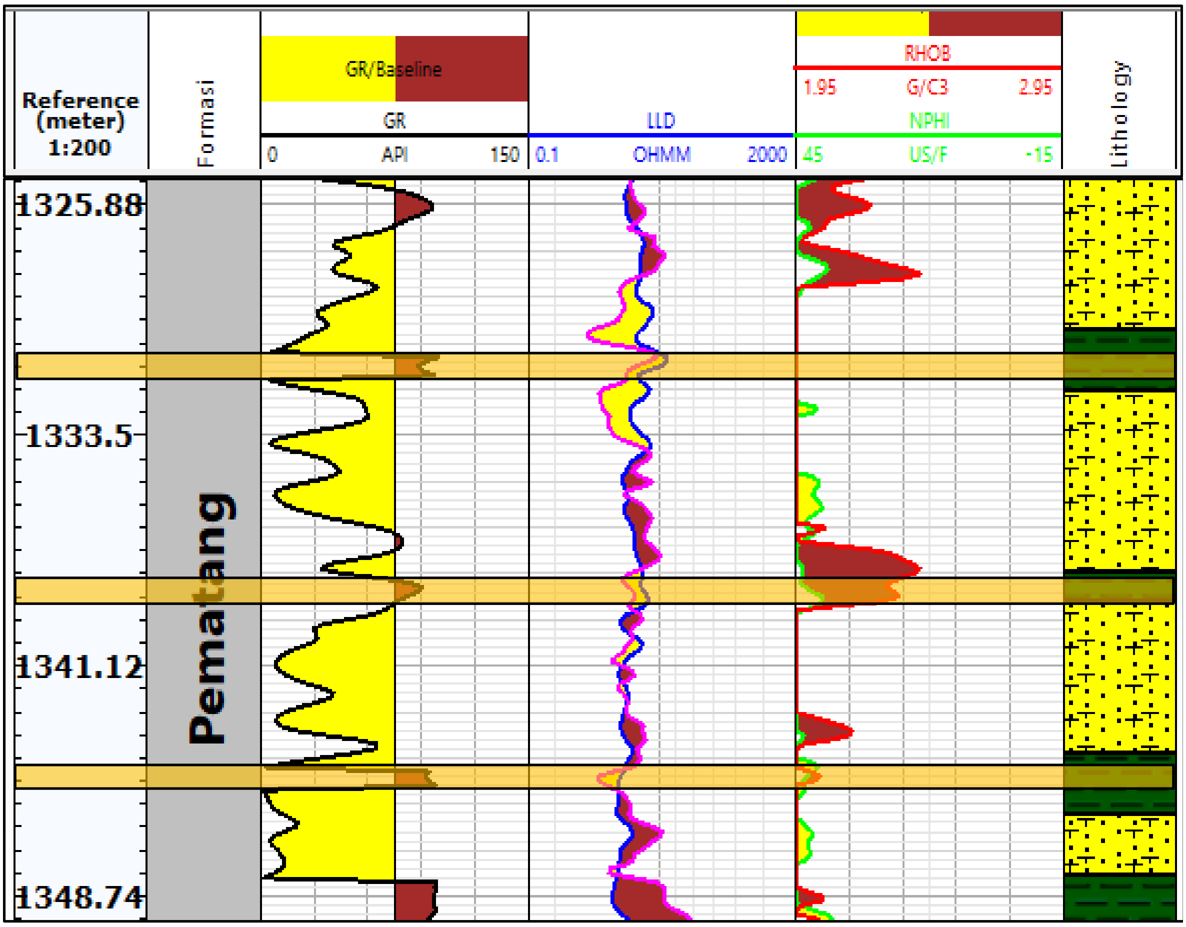

Figure 7. Source rock area 3-5 well B.

Table 7. Total Organic Carbon (TOC) calculation results in well B.

No	Depth (m)	LOM	TOC (%)
1	845.0	6.0	7.22
2	874.7	6.0	2.78
3	1330.8	6.2	2.97
4	1331.5	6.2	3.06
5	1338.0	6.4	4.28
6	1344.5	6.0	3.53
7	1345.0	6.0	4.01

Based on the calculation table above, it can be said that the total organic carbon (TOC) value in wells A and B in the Sihapas and Pematang formations is quite good, it can be said that the potential for oil and gas in the Sihapas and Pematang formations is very good, as seen in the table TOC calculation above.

Conclusions

In conclusion, this chapter summarizes the main findings, contributions and reflections of this research.

There were 14 reservoir target zones in well A and 17 reservoir target zones in well B in the Sihapas and Pematang formations, with rock porosity values between 11%-30%, water saturation values were 44%-75% and the fluid content was dominated by oil and natural gas with low shale volume values. Then 14 source rock target were obtained in well A and seven source rock target in well B in the Sihapas and Pematang formations. The total organic carbon (TOC) value in well A in the Sihapas formation is 0.34%-10.92% and in well B is 2.78%-7.22%. The total organic carbon (TOC) value in well A of the Pematang formation is 0.27%-1.11% and in well B is 2.97%-4.28%.

With the water saturation (Sw) and total organic carbon (TOC) values in wells A and B in the Sihapas and Pematang formations being quite good, it can be said that the potential for oil and natural gas in the Sihapas and Pematang formations is very good. This is also supported by the type of kerogen and the level of maturation in wells A and B in the Central Sumatra Basin.

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