SOURCE ROCK POTENTIAL AND DEPOSITIONAL ENVIRONMENT OF OIL SHALE BASED ON PETROGRAPHY CHARACTERISTICS AND ORGANIC GEOCHEMISTRY IN KAPUR IX, WEST SUMATRA

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ABSTRACT

The research area were located in the Kapur IX District, Lima Puluh Kota Regency, West Sumatra Province. The research focused on Kapur IX Intramontane Sub-basin filled with oil shale. The analysis was carried out on shale samples of the Kapur IX Intramontane Sub-basin collected from outcrops to evaluate the source rock characteristics, including type of oil shale, depositional environment, and dispersed organic matter. Geochemical analyses include total organic carbon (TOC) and Rock-Eval Pyrolysis, while organic petrographic analysis comprises organic material composition and vitrinite reflectance. Based on the results the oil shale of the study area has low to excellent quality and richness, type II and II kerogen content, with the maturity level of late immature to early mature. The dominant lamalginite maceral content in the sample tends to indicate the oil shale in the research area is a Green River type. The liptinite maceral group is directly proportional to the value of Potential Yield (PY) indicating that the maceral group, especially alginite plays a role in producing hydrocarbons in the oil shale of the study area. Based on the composition of maceral data, the depositional environment of oil shale of the Kapur IX Intramontane Sub-basin is interpreted to be a lacustrine environment with brackish water condition.

Keywords: *geochemical, organic petrography, oil shale, Kapur IX Intramontane Sub-basin*

INTRODUCTION

West Sumatra Province is one of the regions that has considerable natural wealth in the field of mining mineral resources, including oil and gas, coal, lead, granite, quartz sand, and so on. Since the pre-independence era, some of the mining materials (such as oil) have been used as main commodities from West Sumatra Province.

One of the developments in the oil and gas sector is the use of oil shale as a source of producing hydroarbon compounds. Oil shale is fine-sized sedimentary rock (clay) that contains high organic material and can produce flammable oil and gas through a distillation process (Dyni, 2006). The existence of oil shale around the area of West Sumatra has been reported by several Dutch researchers, such as Steiger (1920), as well as subsequent research. The area is located in the Central Sumatra region which is known to have high number of oil and gas. Until now, exploration in Indonesia still uses conventional methods so that the concept of applying oil shale as a substitute for oil and gas is still not developed. Therefore, a more in-depth study is needed regarding the exploration of oil shale in Indonesia.

The research location, which is in Kapur IX District, Lima Puluh Kota Regency, West Sumatra Province (Figure 1), is geographically located at coordinates 100° 22'34 "to 100° 34 '17" East Longitude and 0° 7' 33 "to 0° 23 '34' South Latitude.

LITERATURE REVIEW

Oil shale is a variety of sedimentary rocks containing organic minerals and materials; Organic material in oil shale can come from terrestrial organisms, lacustrine, and the sea (Hutton, 1987), and is generally deposited in association with coal depositional environments (Dyni, 2006). To determine the ability of an oil shale to produce hydrocarbons, there are three parameters that must be met, namely the quantity of organic material, the quality of organic material, and the maturity of organic material.

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The quantity or amount of organic material wealth contained in a rock is expressed as total organic carbon (TOC) in units of percent. All compounds containing carbon atoms, except carbon dioxide, carbonate, and metal carbide, are termed organic (Waples, 1985). Then the organic material in the host rock is basically divided into two, namely kerogen and bitumen. the quality of organic material can determine what hydrocarbons will be produced.

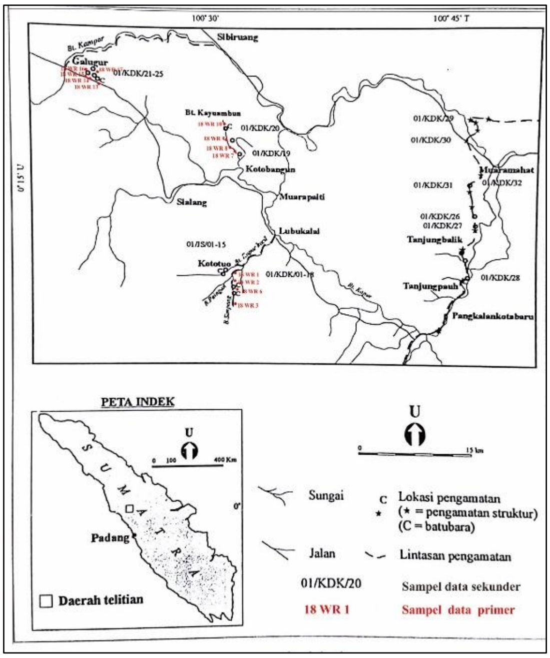

Figure 1. Research Location

Maturity of organic material is carried out to determine whether the host rock has produced hydrocarbons and to determine the maturity phase of the source rock.

The depositional environment of oil shale is similar to the coal depositional environment. A good oil shale depositional environment includes an environment with anaerobic conditions or reduced and low deposition energy levels. Organic material deposited under anaerobic conditions or reduction, is less likely to experience decay compared to organic material deposited in oxygen-rich conditions. Determination of organic material content in oil shale can be determined using petrographic analysis of organic material using the Australian Standard classification (AS 2856-1986). Then the type of oil shale can determine a depositional environment based on the presence of liptinite maceral (Hutton, 1987).

METHODS

The research began with a literature study of the Geological Map of Pekanbaru Sheet and Lubuk attitude, as well as the preparation of fieldwork procedures. Next is the sampling of oil shale in the area of Kapur IX, West Sumatra. Sampling was carried out on oil shale outcrops found in the research field.

The next stage is data processing which includes petrographic analysis and geochemical analysis. Petrographic analysis was carried out to determine the composition of maceral contained in the shale in the form of dispersed organic matter (DOM) and the value of vitrinite reflectance (RV). Organic petrographic analysis is carried out quantitatively to determine organic and inorganic components in shale with the aid of a microscope. Then, to determine the organic component consisting of three main compositions, namely: vitrinite, liptinite, and inertinite and inorganic components of minerals in the form of clay minerals, carbonates, sulfides, silica, and other minerals, used maceral classification according to Australian Standards (AS 2856 - 1986). After that, the determination of the type of oil shale was carried out using the Hutton classification (1987) to determine the depositional environment of oil shale.

In the geochemical analysis, data in the form of TOC and Rock-Eval Pyrolysis values were used to see the maturity level of shale, hydrocarbon content, kerogen type, and wealth of hydrocarbon-forming organic material, which was present in samples of the Intramontane Sub-Basin Kapur IX, West Sumatra. TOC values can be obtained from the LECO method that uses carbon analyzers. Determination of kerogen type by the second method, namely the Pyrolysis method of Rock-Eval Hydrogen Index (HI).

The next stage is the determination of the settling area, referring to the results of the petrographic analysis of organic material.

RESULTS AND DISCUSSION

Petrographic Analysis

The petrographic results of the organic material carried out showed a predominance of lamalginite maceral alginite which had a pale brown color to dark gray brown (Figure 2) associated with clay minerals. Lamalginite is derived from lacustrine and other phytoplankton algae. This indicates the type of oil shale in the study area is the Lamosite with the depositional environment of lacustrine (Hutton, 1987 in Dyni, 2006). With

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reference to Hutton (1987), this type of lamalginite belongs to the type of Green River.

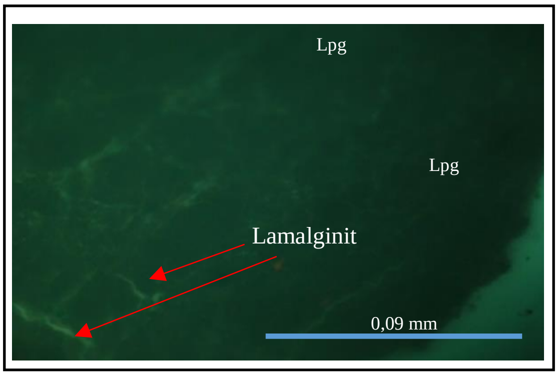

Figure 2. Photomicrograph in the form of Green River Lamalginite which is associated with clay minerals (Lpg); found in sample 18 WR 14B (light fluorescent reflection).

The mineral matter content in the study area is clay and pyrite, which in this case clay minerals predominate (Figure 3). Meanwhile the pyrite mineral is dominated by framboidal type, which is formed from the results of chemical reactions of iron (Fe) minerals found in mud with sulfur (S) minerals found in brackish water. This chemical reaction produces framboidal pyrite (FeS_2) which is aided by the presence of Desulfovibrio bacteria (Speight, 1994).

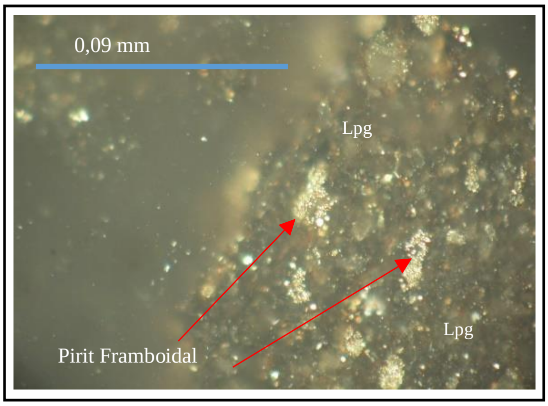

Figure 3. Photomicrograph of the framboidal pyrite mineral associated with clay minerals (Lpg); found in sample 18 WR 2. White reflection light.

Furthermore, the RV value obtained from the measurement must be corrected first because it ought to occur with vitrinite suppression. This is common in samples with a large number of liptinate content and high HI values, such as the samples used in this study. Measured RV value corrections were made with corrections from Lo (1993) (Figure 4). To correct the value of an RV, the HIo value is calculated first, namely the HI value (Hydrogen Index) of the original oil shale. To calculate HIo, a formula from Jarvie et al is used.

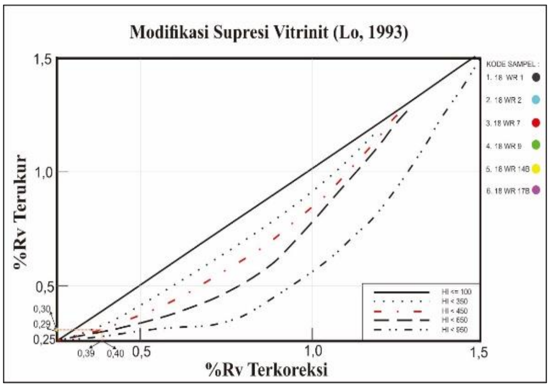

Figure 4. The results of measuring measured Rv on, Vitrinite suppression diagram (Modification of Lo, 1993).

From the results of the corrected Rv analysis (Figure 4), the maturity level in the sample research area is at the level of immature to early maturity (Peters and Cassa, 1994). This can be seen from Rv which has a range of 0.22 - 0.40%

Geochemical Analysis

Based on the results of the TOC value of HI (Figure 5) it is seen that the oil shale samples in the study area predominantly tend to be in the oil area with very good TOC values - extraordinary. In sample 18 WR 1 has a tendency to produce oil but the condition of the TOC value is at a sufficient level. In sample 18 WR 7 was in the gas area with a low TOC value.

Then, the kerogen types found in the sample (Figure 6) have Type II, and Type III, but type II kerogen is more dominant. Kerogen Type II is shown by sample 18 WR 1, 18 WR 2, 18 WR 9, 18 WR 14B, and 18 WR 17B originating from a mixture of mineral spermite, quinite, and brackish algae (lamalginite). Kerogen Type III is shown by sample 18 WR 7 which is thought to originate from humic origin.

In Rad (1984) and Tissot and Welte (1984) Classification (Figure 7), it appears that hydrocarbons in the sample have varying qualities, as in sample 18 WR 2 and 18 WR 9 are at very good levels, sample 18 WR 14B is at a good level, sample 18 WR 1 is located at a sufficient level, while sample 18 WR 7 is at a lesser level.

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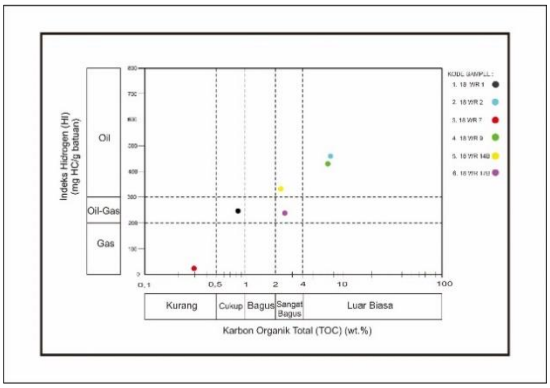

Figure 5. Relationship of the Hydrogen Index (HI) with Total Organic Carbon (TOC) (Peters and Cassa, 1994).

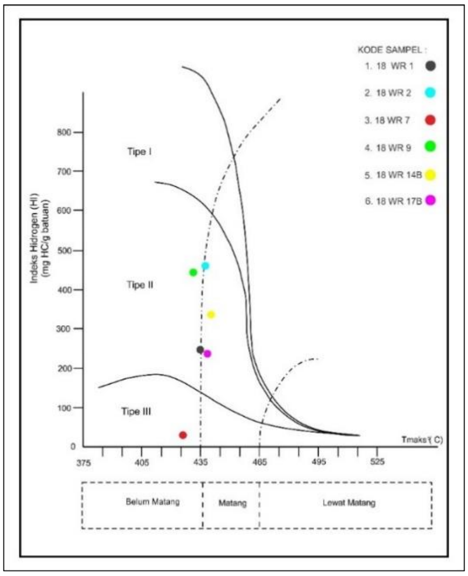

Figure 6. Relationship of the Hydrogen Index (HI) with Maturity Level (Tmaks) (Van Krevelen, 1957 in Tyson, 1995).

The tendency of samples that produce oil and gas is shown by sample 18 WR 1, 18 WR 2, 18 WR 9, 18 WR 14B, and 18 WR 17B. The tendency of samples that produce gas is shown by sample 18 WR 7.

By using Peters and Cassa (1994) diagrams that show the relationship between TOC and S2 (Figure 8), there are a number of samples, both TOC and S2 which have very good to extraordinary levels. These characteristics, indicate that the samples analyzed tend to potentially produce oil. But the sample 18 WR 1 entered the level enough. This shows that the sample has a poor potential to produce oil, while the sample 18 WR 7 is included in the low level which means it does not have the potential to produce oil.

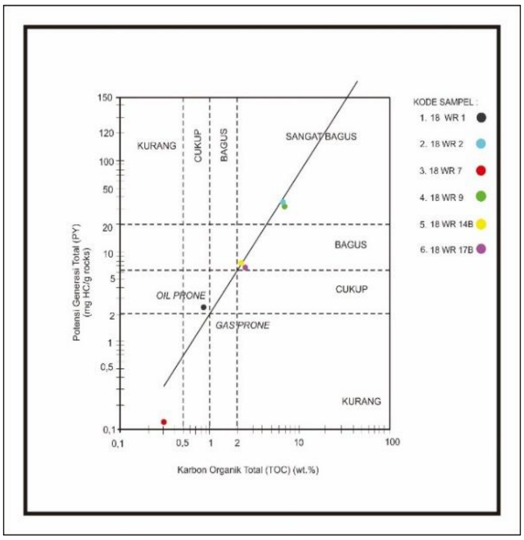

Figure 7. Relationship of Total Organic Carbon (TOC) with Total Generation Potential (PY).

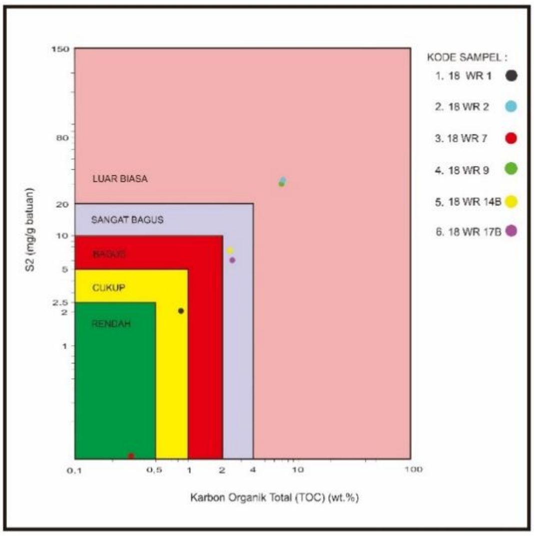

Figure 8. Relationship of Total Organic Carbon (TOC) with the amount of Kerogen released (S2) (modification from Peters, 1986; Langford and Blanc-Valleron, 1990).

In relation to the Production Index (PI) with Maturity Level (Tmaks) (Senguler et al., 2008) (Figure 9), the dominance of the immature condition appears. Meanwhile one sample that has been contaminated is sample 18 WR 7. The impurities found in the sample can be caused by high mineral matter content and contamination caused by other chemical compounds.

Then the relationship between the Hydrogen Index (HI) and the Oxygen Index (OI) (Peters, 1986) can also determine the kerogen type of each study sample. Based on the plot carried

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out on the HI vs. OI diagram (Figure 10), almost all samples are kerogen Type II (Oil Prone). Whereas sample 18 WR 7 is included in Kerogen Type III (Prone Gas)

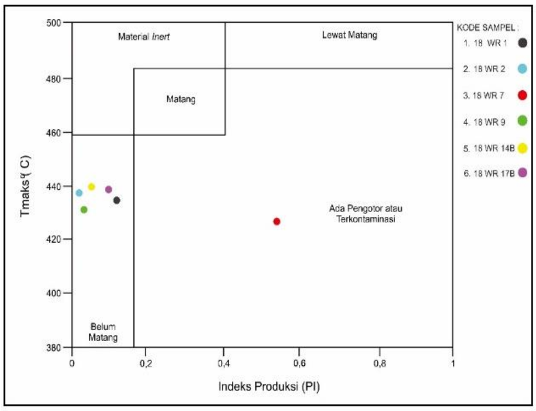

Figure 9. Relationship of Production Index (PI) with Maturity Level (Tmaks) (based on Senguler et al., 2008).

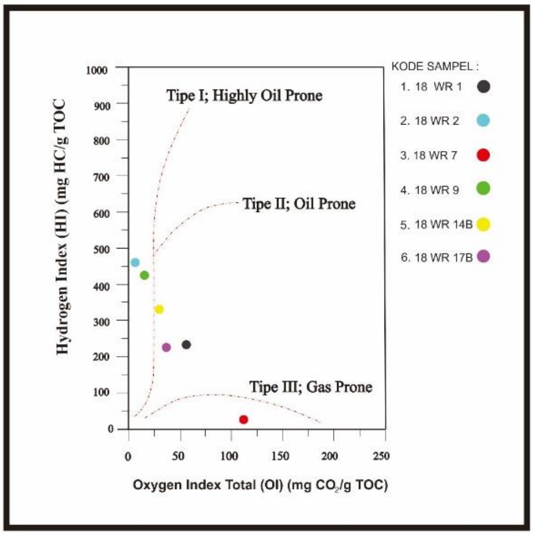

Figure 10. Relationship between Hydrogen Index (HI) and Oxygen Index (Espitalie et al., 1977; Tissot and Welte, 1978; Katz, 1983; Peters, 1986).

Next, we plot the S1 diagram against the TOC (Figure 11). This aims to ensure that samples from the study area have not been contaminated or come from a particular source. The results show all samples of the study area are autochtonous (indigenous hydrocarbon). This shows that the sample of the study area has not been contaminated and deposited in the same place.

Furthermore, the maturity data of the Flake Unit (host rock) in the form of Tmaks and Rv are plotted into the Smith and Cook diagrams (1984, Demaison modification, 1984) (Figure 12). In this diagram, the Flake Unit analyzed has the potential to produce oil and gas. This supports the results of analysis of Total Organic Carbon (TOC) with Total Generation Potential (PY) (Rad, 1984; Tissot and Welte, 1984) (Figure 6).

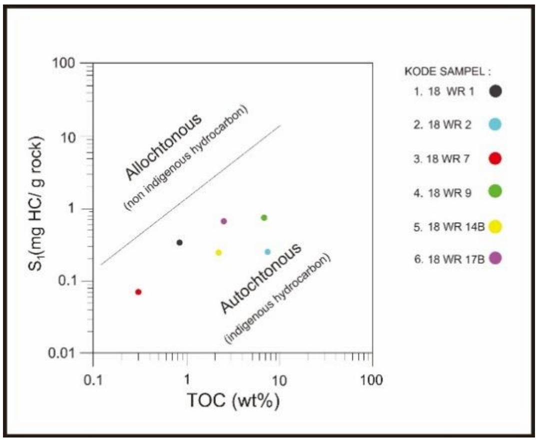

Figure 11. Relationship of S1 to TOC content (according to Hunt, 1995; Rabbani and Kamali, 2005; Ghori and Haines 2007).

Depositional Environment

The liptinite maceral group, including alginite is an important maceral and is widely found in oil shale, and is a major source of oil shale producers during the pyrolysis process (Hutton, 1987). Based on the results of the maseral analysis carried out there is a dominant liptinite maceral which is lamalginite type alginite which has a pale brown color to dark gray brown, predominantly composed of liptinite in the form of lamalginite derived from lacustrine and other phytoplankton algae. Lamosite with lacustrine depositional environment (Hutton, 1991 in Dyni, 2006).

Lamalginite lacustrine itself is divided into two types, namely lamalginite type Rundle (discrete) and lamalginite type Green River (layered). These two different types of lamalginite are used to distinguish two different types of lamosite flakes and in the sample area of research there is a Green River type lamalginite, meaning oil shale is deposited in environments with brackish water (Hutton, 1987). Based on the results of the analysis of mineral matter in the study area, the dominance of framboidal pyrite was indicated. This data confirms that oil shale in the study area is deposited in a Lacustrine (brackish) environment. Chemical reaction of iron (Fe) minerals found in mud with sulfur minerals (S) found in brackish water can form

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framboidal pyrite. The reaction is aided by Desulfovibrio bacteria (Speight, 1994).

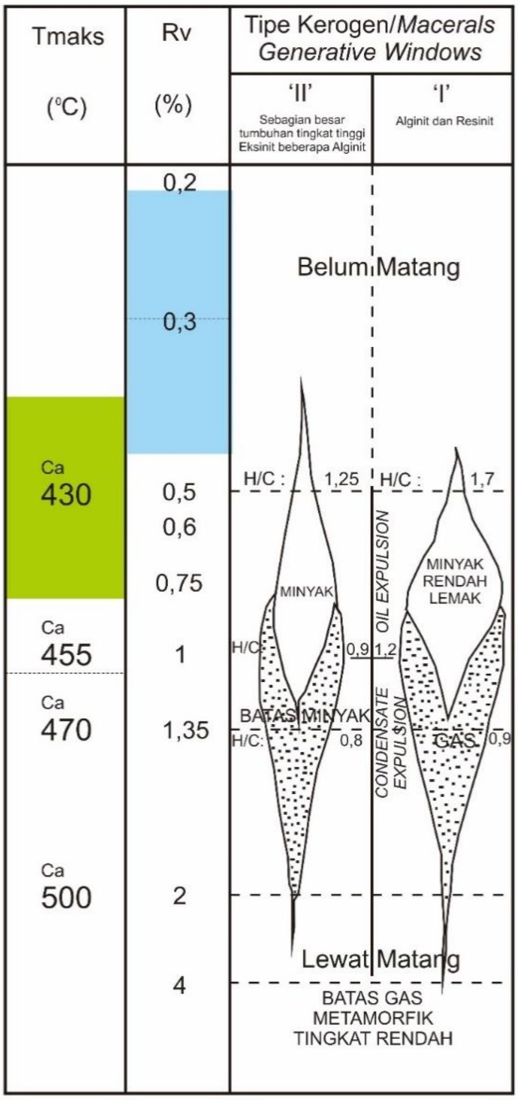

Figure 12. The Maturity Level Diagram of Smith and Cook (1984; Demaison Modification, 1984)

This bacterium colonizes, so that it forms a group pyrite (framboidal) and also becomes a catalyst in the process of chemical reactions. These bacteria can develop in the absence of atmospheric oxygen (anaerobic), in other words, these bacteria can live in environments that have no oxygen (this environment is where the oil shale is deposited).

CONCLUSION

Based on the results of research on oil shale in Kapur IX, West Sumatra as discussed in the previous chapters, we can conclude a number of things as follows:

1. On the basis petrographic analysis results, the dominant maseral is lamalginite type alginite, while the results of analysis of mineral matter in the study area indicate the dominance of framboidal pyrite
2. Most of the oil shale samples that has been analyzed have TOC content ranging from 0.30 - 7.10% and produce hydrocarbons between 0.13 - 32.92 kg / ton. The quantity of TOC and PY can be categorized as potential oil shale with low to extraordinary quality.
3. Lamalginite which is found to have a Green River type, this indicates the type of oil shale in the study area is the lamosite with the lacustrine depositional environment with brackish water quality. However, telalginite sub-masses are also found in small amounts. This shows the freshwater depositional environment. The dominant framboidal pyrite content also strengthens that oil shale in the study area is deposited especially in brackish environments.
4. Based on the corrected RV value, the maturity level in the sample research area is at the final immature level - early maturity. This can be seen from RVs that have a range of 0.22 - 0.40%.

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