# Analysis of the Effect of Lithology to Maximum Temperature (Tmax) of Oil Shale on the Change of Organic Substances into Oil or Gas at Source Rock Using SEM and TGA

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**ABSTRACT**

Several preliminary studies on oil shale have motivated researchers to find out several methods and parameters that underlie the process of converting oil shale into fuel. This process requires several appropriate parameters so that the reaction of physical and chemical changes can occur as desired. One that related to organic maturity in oil and shale is Tmax, maximum temperature to release hydrocarbon from cracking process of oil shale during pyrolysis. Tmax value is used to determine the maturity level of oil shale turning into oil fluid. Time needed to obtain Tmax value and the character of this converting are influeced by lithology.

The purpose of this study is to determine the effect of lithology on Tmax in oil shale. This study begins by selecting type of oil shale according to the purpose, clay and nature carbonate at a certain depth. After obtaining several samples of oil shale, characterization and several tests were carried out using SEM and TGA tools. By knowing the value of Tmax, type of carbonate oil shale and clay in oil shale, the conversion of oil shale into oil in term of termperature control can be determinded as needed, so there are no errors during the heating process.

Keywords: oil shale, Tmax, SEM, and TGA

## 1. INTRODUCTIONi

In the context of new energy exploration, oil shale is a renewable energy that is expected to be used as an future alternative energy (Mulyanto et al, 2018). Oil shale is a clay or carbonate material containing immature organics, when heated to a certain temperature, it can produce energy substances such as oil and gas (Kantsler et al, 1980; Dewanto et al, 2017). Currently, oil shale is an energy source that is being developed so that it can be used as alternative energy in the future. Kogerman (2001) mentions that oil shale research became a research center in the Soviet Union. The establishment of this research institute saw the development of research in the field of oil shale quite rapidly.

The discovery of oil shale by the United States is considered the cause of the shock in world oil prices. The United States, which was originally only a consumer of crude oil, is now a producer. The latest analysis also shows that shale gas could provide up to half of the US gas supply by 2020. Oil shale reserves in Indonesia have begun to be mapped at 53 locations in Indonesia.

In response to this, Indonesian researchers began to conduct research on these new energy sources, in order to be able to help overcome the oil and gas crisis. In this study, researchers are trying to find new theories and methods in processing oil shale, so that it can be used as the basis for converting oil shale into fuel oil or gas. The theoretical basis used is the level of maturation of hydrocarbons. The temperature required for the conversion of oil shale into oil and gas is called Tmax. This value is influenced by oil shale

lithology, therefore it is necessary to analyze these parameters. The specific objectives of this study were: To analyze the effect of lithology on Tmax in oil shale.

Oil shale is clay or carbonate material that contains organic matter, an energy source that produces oil and gas (Dewanto et al, 2017, 2019). Oil shale processing residue is also very useful in agriculture and industry (Barkia et al, 2004; AL-Hasan, 2006; Al-Hamaiedh et al, 2010). Kogerman (2001) mentions that oil shale research became a research center in the Soviet Union. Berraja et al (1988) initiated a study on thermal analysis studies on the combustion of oil shale at Tarfaya. Although the method used is not efficient, the research resulted in a heating theory of the pyrolysis method.

Research by Bartis et al (2005) stated that exploitation of oil shale that has been collected is sent to a processing site by burning the shale directly to be used as a source of electrical energy. Bartis also performs underground oil shale mining using the chamber and pillar method. Then Burnham et al (2006) extracted the results of the processing of oil shale, which was carried out above ground, even though it was underground *in- situ*.

Determination of temperature on pyrolysis to find out the maturity level and reaction rate analysis (Pogaku et al, 2012). Determination of temperature at the maturation stage and reaction speed from TGA analysis refers to several research results: Katarzyna et al (2011), Himawanto et al (2013), Himawanto (2013), Riyanto (2009), Emam (2013), Marnoto (2012), Yan (2014), Sugondo (2012), Sukma (2012), Malika et al 2014, Martono et al (2012), Cantrell et al (2010), Suyitno (2009), Kholisoh (2011), Minarsih (2011), Jiang et al (2014)

The urgency of this research is that oil shale gets attention as a new energy source because the price of conventional oil is increasing and its quantity is limited. Indonesia has many new energy sources, oil shale, and has begun to be mapped. The development of research for alternative energy is expected to be used commercially, as a fuel and as a producer of electrical energy and is relatively cheap for industry and human needs

This research is a theoretical technology developed to be applied experimentally analytically. This research will produce new theories and methods to be applied in the conversion of oil shale to fuel oil or gas, which is expected to help overcome the oil and gas crisis.

## 2. METHOD

### 2.1 Sites and Equipment

The equipments used are glassware for preparation purposes and rock cutting equipment available at the Chemistry Lab, FMIPA Unila and Lemigas Jakarta. TGA analysis was carried out at the Biomass Chemistry Laboratory, FMIPA Unila. SEM analysis to determine the concentration of oxide species/characteristics was carried out at the Chemical Biomass Laboratory, FMIPA Unila and Lemigas Jakarta.

### 2.2 Materials

1) Nature clay (kaolinite/illite) and carbonate ($CaCO_3$), the two have characteristics as the vessel according to the purpose, obtained from the coring at a certain depth in the area X.
2) Carbonate oil shale and clay (good quality).

### 2.3 Design

This research activity will be carried out entirely by conducting experiments in the laboratory. The detailed and complete implementation of the research is shown in the Research Flowchart in Figure 2.1.

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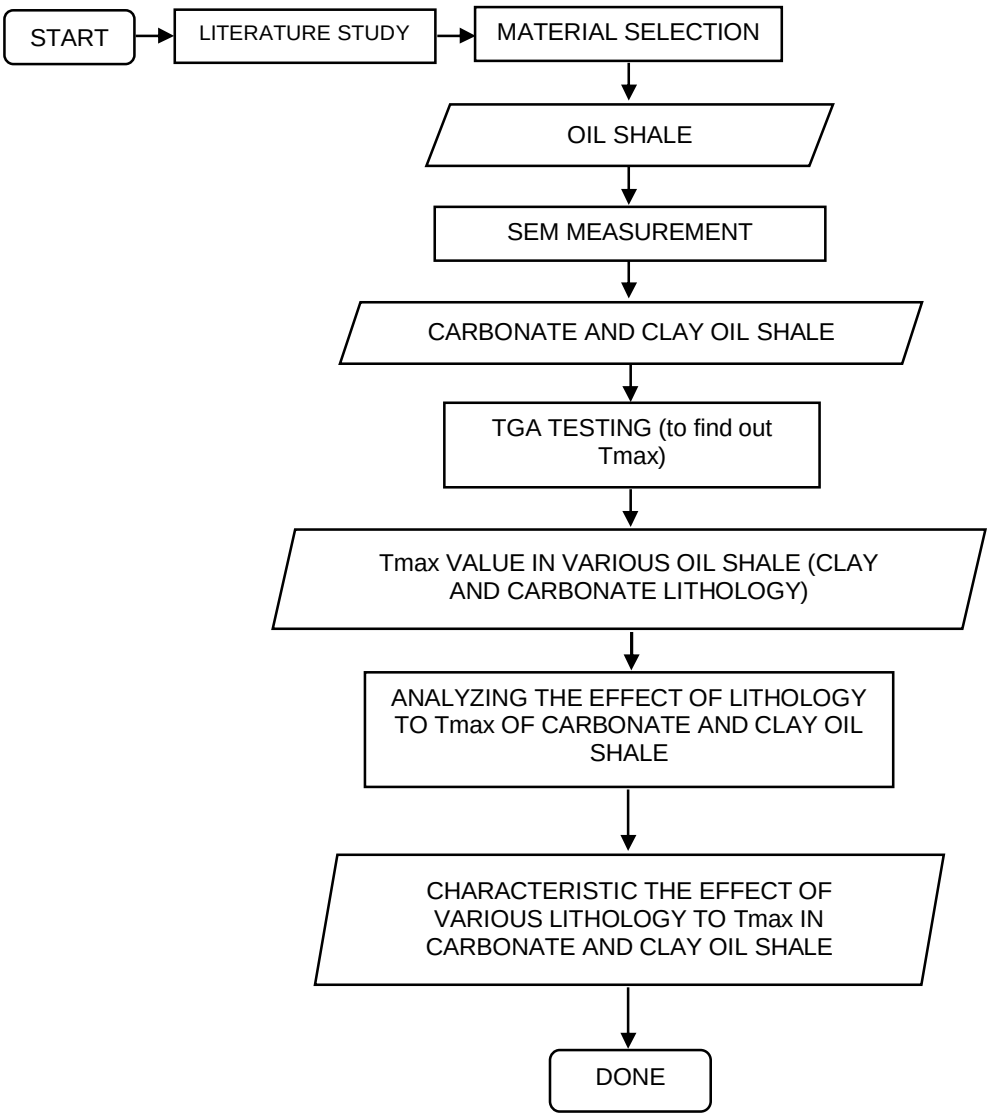


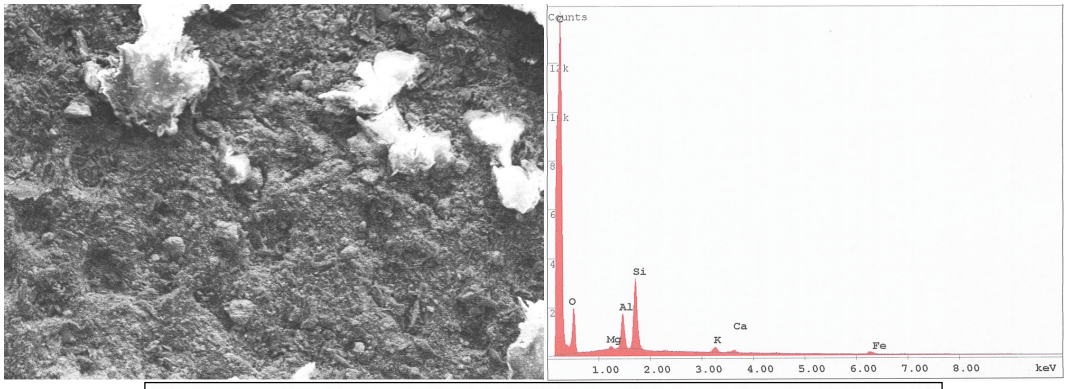

Figure 2.1. Research flow chart

## 3. RESULT AND DISCUSSION

### 3.1 Analysis Result Using SEM

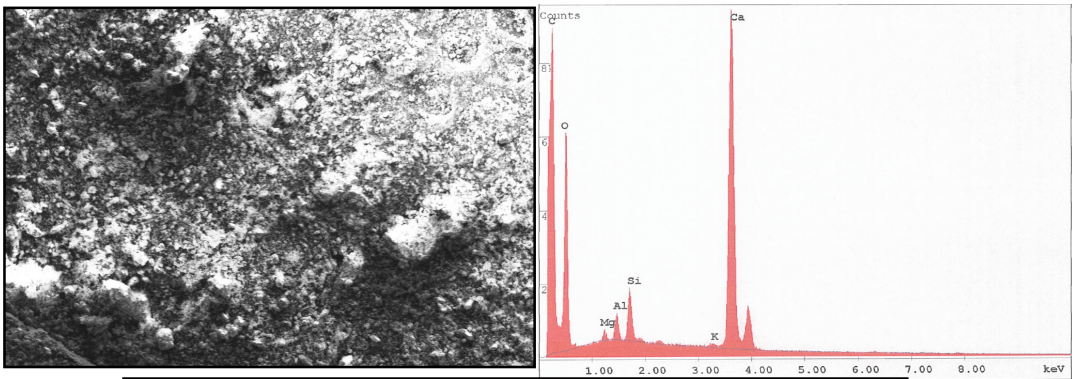
The shale material that has been selected is then characterized using SEM. The aim is to determine the morphology, particle size, material content, material pores and the elements contained.

The most important characteristic is that the shale material exhibits excellent oil shale properties according to the reference. Shale material with clay lithology (shown in Figure 3.1) and shale material with caronic lithology (shown in Figure 3.2).




| Element | Wt % | At % | K-Ratio | Z | A | F |
|---|---|---|---|---|---|---|
| C K | 75.28 | 82.41 | 0.3681 | 1.0081 | 0.4849 | 1.0001 |
| O K | 17.24 | 14.17 | 0.0286 | 0.9913 | 0.1675 | 1.0001 |
| MgK | 0.22 | 0.12 | 0.0014 | 0.9516 | 0.6684 | 1.0020 |
| AlK | 2.34 | 1.14 | 0.0174 | 0.9238 | 0.8045 | 1.0023 |
| SiK | 4.08 | 1.91 | 0.0339 | 0.9509 | 0.8728 | 1.0002 |
| K K | 0.40 | 0.13 | 0.0036 | 0.8983 | 1.0176 | 1.0008 |
| CaK | 0.15 | 0.05 | 0.0014 | 0.9200 | 1.0220 | 1.0004 |
| FeK | 0.29 | 0.07 | 0.0025 | 0.8341 | 1.0218 | 1.0000 |
| Total | 100.00 | 100.00 | | | | |

Figure 3.1. SEM photo on clay lithology oil shale




| Element | Wt % | At % | K-Ratio | Z | A | F |
|---|---|---|---|---|---|---|
| C K | 43.65 | 54.94 | 0.2018 | 1.0185 | 0.4538 | 1.0004 |
| O K | 40.81 | 38.57 | 0.0780 | 1.0015 | 0.1908 | 1.0001 |
| MgK | 0.50 | 0.31 | 0.0027 | 0.9612 | 0.5541 | 1.0013 |
| AlK | 1.13 | 0.63 | 0.0074 | 0.9330 | 0.6975 | 1.0020 |
| SiK | 1.84 | 0.99 | 0.0142 | 0.9604 | 0.8030 | 1.0024 |
| K K | 0.29 | 0.11 | 0.0027 | 0.9086 | 1.0100 | 1.0417 |
| CaK | 11.78 | 4.44 | 0.1114 | 0.9304 | 1.0169 | 1.0000 |
| Total | 100.00 | 100.00 | | | | |

Figure 3.2. SEM photo on carbonate lithology oil shale

## 3.2 Analysis Results Using TGA

Thermogravimetry is a technique for measuring the change in weight of a compound as a function of temperature or time. The result is usually a continuous recording of the diagram; one-step decomposition reaction. The sample used, weighing several milligrams, is heated at a constant rate, ranging from 1 – 2 ºC/min, maintaining its initial weight, Wi, until it begins to decompose at temperature Ti.

The uses of thermal analysis in solid state science are many and varied. In general, DTA is more useful than TGA; TGA detects effects involving only mass changes. DTA can also detect this effect, but can also detect other effects such as polymorphic transitions, which do not involve weight changes. For many problems, it is advantageous to use DTA

and TGA because the thermal events detected in DTA can be classified into a variety of processes involving heavy or not involving weight.

Figure 3.3 shows the weight loss before decreasing at the last temperature indicating the maximum temperature required for clay shale to start turning into oil shale. So the temperature required for the conversion process of oil shale into crude oil requires a temperature of ± (285°C-425°C).

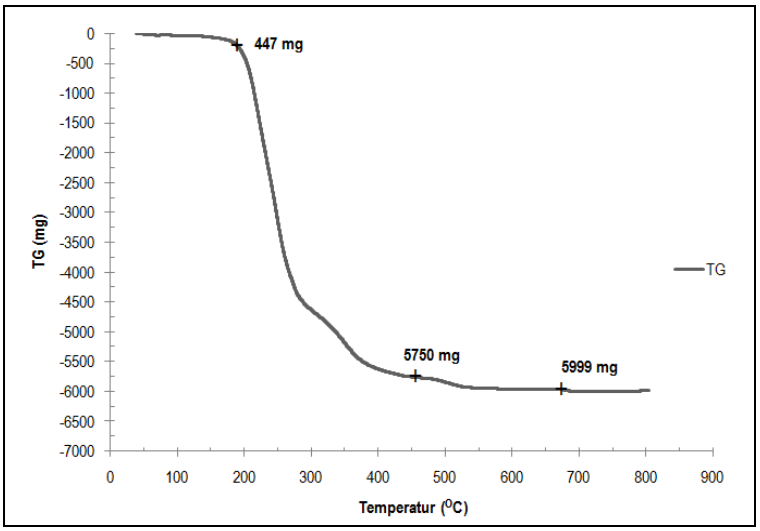



Figure 3.3.
Graph of Thermogravimetry Analysis (TGA) for clay shale (clay lithology)

From the results of the TGA test on the carbonate shale material as shown in Figure 3.4, it was found that the last phase change occurred at a temperature of around 650°C. So it was slightly higher than the last phase change in clay shale. Slightly different from clay flakes, the carbonate shale changes four times in weight. So the temperature required for the process of changing (reaction) oil shale material on carbonate shale into oil shale requires an ambient temperature of ± (320°C-455°C).

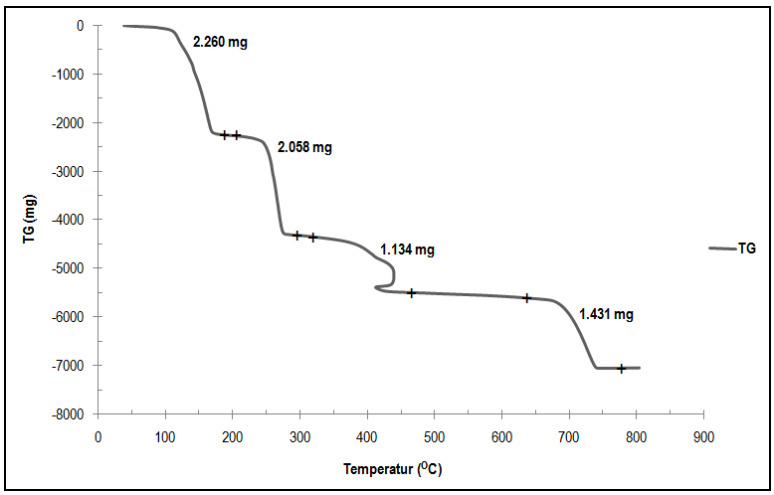



Figure 3.4.
Graph of Thermogravimetry Analysis (TGA) for clay shale (carbonate lithology)

From the results of the TGA test, oil shale with clay lithology is faster than carbonate which is means lithology greatly affects the maximum temperature of a material (Tmax) and will accelerate the reaction to change from oil shale to oil and natural gas.

## 4. CONCLUSION

1. The types of oil shale are clay oil shale and carbonate oil shale.
2. Litholgy greatly affects the maximum temperature of material which clay is more influencial that carbonate and will accelerate the reaction from oil shale to oil and natural gas.

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