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Identification of Source Rock Characteristics Based on Total Organic Carbon (TOC) Sojomerto Area and Vicinity Gemuh District, Kendal Regency Central Java Province

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ABSTRACT: The research area is in Sojomerto area and vicinity, Gemuh District, Kendal Regency, Central Java Province, about ± 107 km to the north of Yogyakarta City. The purpose of the study was to determine the characteristics of the source rock by identifying the characteristics of the source rock based on the total organic carbon (TOC) value at the research site based on TOC and REP value data using descriptive methods. Based on the results of the analysis, Total Organic Carbon (TOC) in LP 1 samples has a value of 0.50%, which means poor; LP 2 samples have a value of 0.56% is still classified as poor, and LP 3 samples show a smaller value of 0.27%, wich is still classified as poor. The results of TOC versus PY plotting in the analysed sample were 3 samples, predominantly occupying gas-prone and far below the oil-prone limit. The hydrogen index value shows that three samples (LP 1, LP 2, and LP 3) produce gas, and there are no samples that produce oil or oil and gas. The thermal maturity of the Kerek Formation, based on the HI versus Maximum Temperature chart, shows the immature and near-mature categoriest.

KEYWORDS: Sojomerto Kendal, source rock, total organic carbon (TOC), rock eval pyrolisis (REP).

I. INTRODUCTION

Source rock is rock that contains sufficient amounts of organic material, has reached a certain maturity, and is rich in carbon atoms obtained from fossil shells deposited in the rock, so that it becomes the raw material for the formation of hydrocarbons. TOC is the quantity of organic carbon deposited in rocks. The higher the organic carbon (OC) value, the better the source rock and the higher the possibility of hydrocarbon formation (Manurung and Dewanto, 2021).

Source rock oil correlation is a comparison between oil and source rock to determine whether or not there is a genetic relationship between oil and source rock (Wiloso, 2019). The object in this study is three samples of source rocks in of administrative area of Sojomerto area and vicinity, Gemuh District, Kendal Regency, Central Java Province. TOC is the amount of carbon attached to or contained in organic compounds. The carbon contained in the media consists of two types, namely organic carbon (OC) and inorganic carbon (IC). The current carbon measurement system is to convert carbon into CO2, then measure the CO2 levels as a representation of the existing carbon levels. (Fertl and Chilingar, 1988 in Jamaluddin et al, 2018).

In general, it is accepted that a TOC content of 2% is an above-average (rich) value as a source rock (Bowman, 2010 in Jamaluddin et al, 2018). The TOC is defined as the amount of organic carbon expressed as a weight percent of dry rock. The minimum TOC value is not the same according to several researchers. According to (Peters and Cassa, 1994 in Jamaluddin et al, 2018), the minimum TOC value range is 0.5-1.0%. TOC value scale for sedimentary rocks (Peters and Cassa, 1994 in Jamaluddin et al, 2018) is a standard that is generally used as an indication of the potential of the source rock. (Table 1)

Table 1. Parameters of source rock richness and hydrocarbon potential of the source rock (Peters and Cassa, 1994 in Jamaluddin et al, 2018)

Potential (Quality)	Organic Matter		
	TOC	Rock-Eval Pyrolysis	
		S1	S2
Poor	**0 - 0.5**	**0 - 0.5**	**0 - 2.5**
Fair	**0.5 - 1**	**0.5 - 1**	**2.5 - 5**
Good	**1 - 4**	**1 - 2**	**5 - 10**
Very Good	**2 - 4**	**2 - 4**	**10 - 20**
Excellent	**> 4**	**> 4**	**> 20**

Rock-Eval Pyrolysis (REP) is the analysis of the hydrocarbon components in the source rock by gradually heating the sample, in the absence of oxygen in an inert atmospheric condition at a programmed temperature. This heating separates free organic components (bitumen) and organic components that are still bound to the source rock (kerogen).

Rock Eval Pyrolysis analysis produces several parameters:

a. S1 (free hydrocarbon), S1 shows the amount of free hydrocarbons that can be evaporated without going through the kerogen breakdown process. The S1 value reflects the amount of free hydrocarbons formed in situ (indigenous

hydrocarbons) due to thermal maturity or due to the accumulation of hydrocarbons from other places (migrated hydrocarbons).

b. S2 (pyrolisable hydrocarbon), S2 shows the amount of hydrocarbons produced through the kerogen breakdown process, which represents the amount of hydrocarbons that rocks can produce during the natural ripening process. The S2 value states the potential for organic material in rocks to turn into petroleum. The prices of S1 and S2 are measured in units of mg hydrocarbons per gramme of rock (mg HC/g Rock).
c. S3, S3 shows the amount of CO2 content present in the rock. This amount of CO2 can be correlated with the amount of oxygen in the kerogen because it indicates the degree of oxidation during diagenesis.
d. Tmax, this Tmax value is one of the geochemical parameters that can be used to determine the maturity level of the source rock. The recorded Tmax price is greatly influenced by the type of organic material. Type I kerogen will form hydrocarbons later than Type III at the same temperature conditions. The Tmax value as an indicator of maturity also has several other limitations; for example, it cannot be used for rocks with a low TOC <0.5 and HI <50. The Tmax value can also indicate a level of maturity that is lower than the actual level of maturity in source rocks containing resinite, which is commonly found in source rocks with type II kerogen (Peters, 1986 in Prabowo and Wijayanti, 2020). (Figure 1)

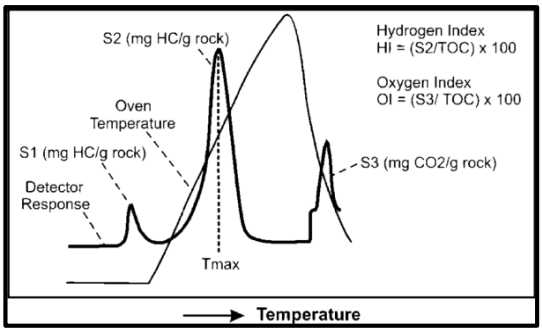

Figure 1. Reading of results rock eval pyrolysis
(Peters, 1986 in Prabowo and Wijayanti, 2020)

The combination of parameters produced by Rock-Eval Pyrolysis can be used as an indicator of the type and quality of the source rock, including:

a. Potential Yield (S1 + S2), shows the amount of hydrocarbons in the rock, both in the form of volatile components (free) and in the form of kerogen. This unit is used to indicate the maximum total amount of hydrocarbons that can be released during the maturation process of the source rock and this number represents the generation potential of the source rock.
b. Production Index (PI), value shows the amount of free hydrocarbons relative (S1) to the total amount of hydrocarbons present (S1 + S2). PI can be used as an indicator of the maturity level of the source rock. PI increases due to the breakdown of kerogen, so that S2 changes to S1.
c. Hydrogen Index (HI) and Oxygen Index (OI), HI is the result of S2 x 100/TOC, and OI is S3 x 100/TOC. These two parameters will decrease in value as the maturity level increases. A high HI value indicates that the source rock is dominated by oil prone organic material, while a high OI value indicates the dominance of gas prone organic material. (Waples, 1985 in Praptisih, 2016) states that the HI value can be used to determine the main type of hydrocarbon and the relative quantity of hydrocarbons produced. Determining the type of kerogen based on rock eval pyrolysis analysis can be done by plotting the HI and OI values on a "pseudo" van Krevelen diagram, or by using the HI – Tmax plot.

II. METHODOLOGY

A. Data collection technique

Primary data is data taken directly in the field where the research was carried out. Primary data collection is divided into 3 stages, namely:

1. Field research, including:

a) Equipment used in field research includes: RBI map of the research area, compass, geological hammer, HCl, cellphone camera, plastic sample bag, complete stationery, and field book.
b) Field orientation begins with observing the outcrop from a distance, then carrying out close observations of the outcrop which consists of, outcrop description, a location description, and outcrop photos.
c) Sampling of the source rock (Figure 2) was carried out at 3 observation locations (LP), namely LP 1, LP 2, and LP 3 respectively, at the Kerek Formation napal unit in the Sojomerto area and vicinity, Gemuh District, Kendal Regency, Central Java Province (Figure 2). Kerek napal unit consists of napal inserts of carbonate sandstones and interlude napal with carbonate sandstones. Napal greenish-gray color, massive-layered structure, has the size of silt - clay grains, rounded grain shape, closed packaging, well-disaggregated sorting, with carbonate elements and there are abundant microfossils. Interlude napal and carbonate sandstone brown color, laminate structure, medium sand-fine sand grain size, angled grain shape, open packing, poor sorting, carbonate cement, found as inserts. This unit has a spread of ±35% of the total area of the study area.

Figure 2. Samples source rock

2. Studio analysis

Analysis carried out in the studio takes the form of calculations, image editing and report preparation using CorelDraw, Microsoft Excel and Microsoft Word software. The equipment used is a laptop.

B. Data processing techniques

The data processing techniques used are data processing techniques in laboratories and studios. Data processing takes the form of TOC and REP sample analysis, as well as preparing reports on the results of analysis and research. Laboratory data processing.

The results of taking source rock samples in the field are processed in the laboratory. From the results of taking source rock samples in the field, the data is then processed using Leco and Rock Eval-6 Pyrolysis tools to determine the geochemical content and hydrocarbon components in the source rock (Table 2).

Table 2. Analysis results TOC and REP

TABEL

ROCK-EVAL PYROLYSIS DAN TOC

No	Formasi	Sampel ID	Tipe Sampel	Litologi	TOC (%)	S_1	S_2	S_3	Tmax (°C)	OPI	PY	HI	OI
						mg/g							
1	kerek	LP1		Napal	0,50	0,07	0,55	0,50	416	0,11	0,62	110	100
2		LP2		Napal	0,56	0,17	0,23	0,54	425	0,43	0,40	41	96
3		LP3		Napal	0,27	0,04	0,15	0,43	432	0,21	0,19	55	159
Remarks :													

	TOC	: Total Organic Content	Tmax	: Temperature of Maximum S_2	OI : Oxygen Index = $(S_2/TOC)*100$
	S1	: Free Hydrocarbons	OPI	: Oil Production Index = $S_1/(S_1+S_2)$	OC : Outcrop
	S2	: Pyrolysable Hydrocarbons	PY	: Potential Yield = (S_1+S_2)	
	S3	: Organic CO_2	HI	: Hydrogen Index = $(S_2/TOC) \times 100$	

III. RESULTS AND DISCUSSION

The physiology of the research area is plain to hilly. These plains and hills are composed by lithology in the form of napal carbonacetan sandstone inserts and napal interlude with carbonate sandstones. The process that works dominantly today, is exogenous processes in the form of denudational and erosional, this is what changes its formation into the morphology of plains to hills.

The constituents of the Kerek Formation in its lithology are alternating loops between claystones, napals, limestone, tuff sandstones and tufaceous sandstones. The age of this formation is Middle Miocene to Upper Miocene (Miftahussalam and Arif, 2016).

Based on the results of the Total Organic Carbon (TOC) analysis in the LP 1 sample, it has a value of 0.50%, which means poor; the LP 2 sample has a value of 0.56% which is still classified as poor, the LP 3 sample shows a value that is smaller, namely 0.27%, and is still classified as poor, then the potential of the Kerek napal unit as a hydrocarbon source rock is classified as poor.

Based on the results of the Rock Eval Pyrolysis (REP) analysis, it was carried out to determine the S1, S2, S3 and Tmax values. From the resulting data, the Potential Yield (PY) and Oil Production Index (OPI), Hydrogen Index (HI) and Oxygen Index (OI) will be known using the formula stated in Table 2.

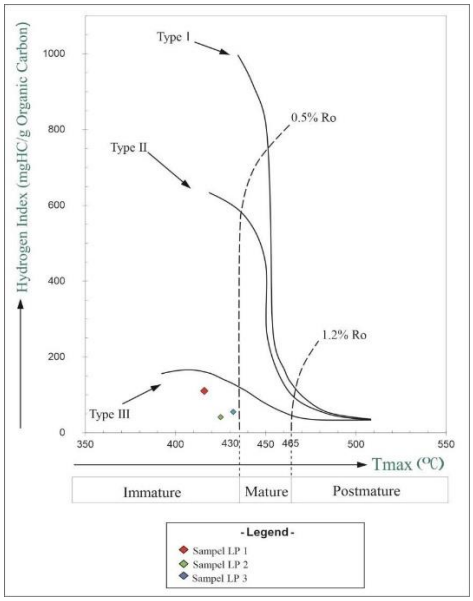

Figure 3. The thermal maturity of the Kerek Formation based on the HI versus Maximum Temperature diagram

The hydrocarbon potential of the Kerek Formation in the research area can be seen in the diagram of organic carbon content (TOC) versus Total Generation Potential (PY) figure 3 (attachment). PY values ranging from 0.19/mg HC/g rock to 0.62/mg HC/g rock are in the poor category. The results of plotting TOC versus PY in the samples analysed show that 3 samples predominantly occupy the gas prone area and are far from the oil prone boundary in Figure 3 (attachment). The source rock in the Kerek Formation has an HI value of 41/mg HC/g rock to 110/mg HC/g rock, based on classification (Petter, 1986 in Prabowo and Wijayanti, 2020) The hydrogen index value shows that 3 samples (LP 1, LP 2, and LP 3) produce gas and there are no samples that produce oil or oil and gas, showing immature and almost mature categories (Figure 3).

CONCLUSION

Based on the results of the analysis, Total Organic Carbon (TOC) in the LP 1 sample research area has a value of 0.50% which means poor, the LP 2 sample has a value of 0.56% which is still classified as poor, in the sample LP 3 shows a smaller value, namely 0.27% and is still classified as poor.

Rock Eval Pyrolysis (REP) analysis of three samples has total organic carbon values of 0.27% to 0.56%, known 3 samples are not potentially of hydrocarbon sources rock. The results of plotting TOC versus PY in the samples analysed show that three samples predominantly occupy the gas prone area and are far from the oil prone boundary. The hydrogen index value shows that 3 samples (LP 1, LP 2, and LP 3) produce gas and there are no samples that produce oil or oil and gas. The thermal maturity of the Kerek Formation based on the HI diagram versus maximum temperature shows immature and almost mature categories with reference to the TOC analysis results, which fall into the poor group, there is very little chance that hydrocarbons will be present. Based on the Tmax value and the findings of prospective yield plotting, the current potential is gas-prone and still below the maturity value.

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