THE EFFECT OF CHANGE IN WATER LEVEL ON THE ABUNDANCE OF LIPTINITE AND VITRINITE MACERALS IN UPPER KELESA FORMATION SHALE IN KUBURAN PANJANG, RIAU

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Abstract

Research on changes in water levels to the abundance of liptinite and vitrinite maceral has focused on Kuburan Panjang area of the Sumai sub-Basin, Central Sumatra Basin. The subject of this research is shale rock from the Eocene-Oligocene Kelesa Formation. Series of rocks from bottom to top shows repetition between shale, sandstone and mudstone strata bounded by conglomerates at the top and bottom. The composition of organic material consists of vitrinite ranging from 0.20 - 5.0%, liptinite 0.60 - 4.70%, pyrite 0.20 - 16.00%, carbonate maceral 0.20 - 24.2%, and clay mineral which is the most dominant component, ranging from 71.60 - 98.00%. Based on the results of TOC analysis, the abundant organic material of the Kelesa Formation shale has a TOC value of 1.18% to 7.17% indicating the ability of shale as a source rock is very good. The presence of organic material in the study area shows that there is a cycle of enrichment of organic material from bottom to top. The smaller the ratio of pristane/phytane (anoxic condition, high water level), the smaller the content of liptinite and the higher the content of vitrinite. Otherwise, the greater the ratio (oxic condition, low water level), the higher the content of liptinite and the lower the content of vitrinite. Change in water level during sedimentation has effect on the quality of shale as a source of unconventional hydrocarbon energy in the Kuburan Panjang area.

Keywords: Kelesa Formation, Eocene-Oligocene, Central Sumatra Basin, Vitrinite, Liptinite

INTRODUCTION
Research on changes in water levels to the abundance of liptinite and vitrinite masals has focused on Eocene-Oligocene shale rocks in the Sumai Sub-Basin, Central Sumatra Basin, Riau. This research area occupies the southern part of the Central Sumatra Basin. Administratively, the research area is included in Rengat Regency, Riau Province (Figure 1). This area is included in a 1: 250,000 scale geological map, Rengat Sheet (8,10).

The objectives of this study are:

- To know the effect of fluctuations in changes of water level within the deposition process on the content of liptinite and vitrinite.
- To understand the relationship between the quality of hydrocarbon flakes and the deposition process and the mass characteristics of constituent organic material.

The benefit of this study is to provide an overview on the dynamics of precipitation, especially in relation to fluctuations and abundance of organic material in the upper shale layer of Kelesa Formation in the Kuburan Panjang, Riau.

Based on the regional geological map of Solok Sheet (8), the oldest Tertiary rocks revealed around the Nusa Riau, Manunggal and TBS coal fields, Taluk Kuantan Regency is Lower Telisa Formation. The formation is spread and extending towards southeast-northwest in the western boundary of the basin and covers, inharmoniously, Pre-Tertiary rocks of Kuantan Formation. In a total thickness of 300 meters, the Lower Telisa Formation is composed of quartz sandstone, clay bed, andesite breccia,
stratigraphically, the Lower Telisa Formation is likely to be comparable to Pematang Formation in Central Sumatra Basin and Lakat Formation in Lembar Rengat (Suwarna et al., 1994) (Figure 2) which is consisting of a multi-material conglomerate, quartz sandstone, carbonate siltstone and claystone carbon, coal, tuff and siderite bintal. The two rock units are in the same basin, but the first unit is on the western edge of the basin and the second on the southern edge.

Furthermore, other Lower Members of Telisa Formation (Tml) in the coal mining area of PT Karbindo (Kiliranjau) consists of Light gray mudstone, brownish, greenish with conglomerate sandstone lenses; coal-carbon rocks, and brown/gray flakes. Some researchers claim that the rock deposits in the area are Paleocene – Eocene – Oligocene Dike Groups. Some researchers contend that brown Eo-Oligocene flakes on the coal are deposited in a lake where organic-ric laminates are
formed during the dry season, whereas clay-rich laminates are formed during the rainy season. This means that the rock units in Kiliranjau area should be correlated to Kelesa Formasi (Teok) in Lembar Rengat consisting of conglomerate or sandstone conglomerate, claystone, siltstone, and coal deposited in fluviatile to lascustrine formations (Suwarna et.al., 1994) and Upper Sangkarewang Formation or Lower Sawahlunto in Ombilin Basin. In line with characteristics of lithology, age, and depositional area, the Shale unit in the research area can be compared to the Brown Shale Formation of Pematang Group (Heidrick and Aulia, 1993) or Eocene-Oligocene Kelesa Formation (Teok) (Suwarna, et.al., 1994).

**METHODOLOGY**

**Laboratory Data**

After activities in the field have been completed, the laboratory analysis of selected samples is performed in the Geological Survey Center laboratory and other institutions, including:

a. **Organic Petrographic Analysis**

Organic petrologic analysis was performed using a microscope on the basis of the optical method of reflected light with and without fluorescence. This examination aims to describe differences in types of organic material and mineral, measure the evolution of thermal ratings of organic material (level of maturity) based on the measurement of reflectance indexes on vitrinite, especially DOM (disseminated
organic material) to support the determination of depositional environment and rock maturity.

b. Gas Chromatograph (GC) and Gas Chromatograph Mass Spectrometry (GC-MS) Analysis

Bitumen fraction analysis is referred to, generally, as biomarker (biological marker) analysis. Compounds and classes of compounds found in oil and bitumen are called biomarker. Biomarker is useful to know the origin of organisms where bitumen or oil is located, as a parameter of diagenesis during the process of accumulation of organic material which is related to the maturity level of a rock. Determination of maturity with bitumen fraction can use the results of gas chromatographic analysis and GC-MS in the form of normal alkanes, sterane, and triterpane.

Some biomarkers used in source rock analysis are normal alkane, sterane, and triterpane. Biomarker is compound derived from pioneering biogenic molecule, so-called molecular fossil. Basically, certain precursor or molecule can be identified, but sometimes it can only be limited to the precursor to a few types. This molecular fossil cannot be used as index fossil for certain organisms.

Normal Alkane

Normal alkanes are the simplest series of hydrocarbons, having a straight chain structure caused by saturated hydrocarbon molecules. Normal alkanes arises in bitumen and oil due to the presence in fat and algae and the catagenic formation of long chain compounds such as fatty acids and alcohols.
Waples (11) explains that most of normal alkanes in higher plants have odd numbered carbon atoms especially on carbon atoms 23, 25, 27, 29 and 31, whereas marine algae produce normal alkanes having a maximum distribution only on carbon atoms 17 or 22, according to the current species. The appearance on the chromatography diagram shows a very sharp distribution and tends to have no odd or even numbers on the carbon atom (Table 1). Most of sediments receive normal alkane contribution from two sources, land and sea, so the chromatographic diagram will reflect a mixture of the two.

Table 1. Four important classes of biomarkers and their prazats (Waples, 1985)

| Biomarker   | Prazat                                      |
|-------------|---------------------------------------------|
| Normal Alkane|Normal Alkane (> 22) higher plant wax       |
|             |Normal Alkane (< 22) Algal fat               |
| Isoprenoid  |Isoprenoid (< 20) A variety of chlorophylls |
|             |Isoprenoid (> 20) Fat or chlorophyll from hipersaline algae |
| Triterpane  |Triterpenoid                                  |
| Sterane     |Steroid                                      |

**Isoprenoid**

Isoprenoid is compound consisting of carbon atoms merged in certain rules with the methyl group (CH₃) bound to each of fourth carbon atom. The common isoprenoids used are pristane (C19) and fitane (C20). Pristane is an isoprenoid having 19 carbons, while fitane has 20 carbons (Figure 2).
According to Waples (1985), isoprenoid is a good indicator to detect the biogenic origin of bitumen and hydrocarbon, however, is it very limited to certain organisms. Isoprenoid is found in only specific depositional environment. The ratio of pristane to phytane can be used as an indicator to detect the oxygen level at the time of diagenesis; a high pristane/phytane ratio characterizes the environment under oxidation condition (Table 2), while according to Illich (3) the high ratio reflects association with sediment affected by terrestrial environment.

| Structure | Number of Carbon Atoms | Name  |
|-----------|------------------------|-------|
| ![Structure of pristane and phytane](image) | 19 | pristane |
|          | 20                     | fitane |

Figure 2. Structure of pristane and phytane isoprenoids.

Table 2. Comparison of pristane and phytane as indicators of depositional environment (Waples, 1985).

| Type of sediment           | Pristane/phytane |
|----------------------------|------------------|
| Anoxic marine sediment     | < 1              |
| Oxic marine sediment       | 1 – 3            |
| Coal                       | > 3              |

RESULTS

Stratigraphy of Research Area
The study area is located in the Sumai Sub-Basin, Central Sumatra Basin which is, administratively, included in the Rengat Regency area. Geologically, the study area is included in Geological Map at Scale 1: 250,000 of Lembar Rengat and Lembar Solok (Figure 3).

The rocks composing Kelesa Formation (Figures 3 and 4) in the study area are composed of conglomerate, sandstone, mudstone and shale. Overall in Kuburan Panjang, the thickness of rocks composing Kelesa Formation on the Punti Kayu River is approximately 80 meters. Series of rocks from bottom to the top shows the
repetition between layers of shale, sandstone and mudstone bounded by conglomerates at the top and bottom.

Figure 4. Exposure of the upper Kelesa Formation showing shale rock, conglomerate on the Punti Kayu river.

The most dominant layer is shale having a thickness about 27 meters. Shale, dark brown, grayish, soft, plastic, lamination alternated with mudstone, flaggy, gray, compact, having well coat of 1-1.5 cm.

Sandstone, brown to gray, moldy, consolidated, fine granulous, fragmentary composition was dominated by quartz and feldspar. Conglomerate, polimic, compact, bad sortation, halfway angled, halfway spherical, sand matrix, fragment was dominated by basalt, quartzite and andesite. Mudstone is in interlude with very fine sandstone, brown sandstone with light gray insert, platy-flaggy, soft-hard, well laminar, parallel layers.
Stratigraphically, there is a cycle of repetition between interlude of sandstones and shale and mudstone. Starting from the bottom, we found interlude of sandstone with sandstone dominated by sandstone, to the top we found conglomerate which is boundary of a facies at shale facies having a thickness about 9 meters. In the middle section is a cross section between sandstone and mudstone and shale. The alternation shows that there is a change in current that causes repeatedly precipitation of smooth and grainy material. On the top of cross section (Figure 5) we found a depositional facies from the series of quite thick shale, approximately, 12 meters. This thick shale deposition requires a precipitation system with a calm current persisted for a long time. Based on Nichols (5), this precipitation is, generally, occurring in deeper part of freshwater lake. Based on the material, the author interprets the depositional environment of this unit is a lake (lacustrine) environment.

Broadly speaking, the precipitation system from bottom to top is a cycle from the deposition of fluviatile to lacustrine. It is a gradual change in facies in the river system towards lacustrine. Lacustrine can be formed when there is an large abundance of water, so that the area that was originally a river is turned into a lake. Specifically for the fluviatile environment in the center of cross section, we found thin repetition between sandstone and fine rock (shale and mudstone) constituting a product or particularly rapid change in current. This can happen at the curve of river or meandering river.
Figure 5. Stratigraphic cross section of the upper Kelesa Formation on the Puntikayu River

Organic Matter

The results of organic petrographic analysis show that the upper Kelesa Formation shale is arranged by organic material such as vitrinite and liptinite. Vertically (Figures 6), there is fluctuation in the presence of liptinite and vitrinite.
Liptinite appear to be more dominant than vitrinite which are, vertically, present in all rock samples.

The results of TOC analysis and “Rock Eval Pyrolysis” (REP) show, vertically, the very fluctuative content of carbon, sometimes suggesting an abundant attendance, sometimes a little (Table 3). Comparison between TOC and Index Hydrogen shows a vertical similarity of pattern in stratigraphic cross section. When TOC is large, the value of Index Hydrogen is large, as well. This shows that the content of carbon has significant effect on the value of Index Hydrogen.

Table 3. Results of organic petrographic analysis in Kuburan Panjang, Rengat, Central Sumatra Basin

| No | Sample | Injection | V | Btm | Cu | E | Py | Py | Re | Dv | Sp | Alg | Cl | MM | Sb | Exu | Carb | Rv |
|----|--------|-----------|---|-----|----|---|----|----|----|----|----|-----|----|----|----|------|------|----|
| 1  |        |           | 0.00 | 0.00 | 0.00 | 2.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 |
| 2  |        |           | 0.00 | 0.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 |
| 3  |        |           | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 4  |        |           | 0.20 | 0.20 | 0.00 | 2.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 5  |        |           | 0.40 | 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 6  |        |           | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 7  |        |           | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 8  |        |           | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 9  |        |           | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 10 |        |           | 1.00 | 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |
| 11 |        |           | 0.10 | 0.10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 52.00 | 0.00 | 5.00 | 52.00 | 0.00 |

Information:
- V : Vitrinite
- Btm : Bituminite
- Cu : Cutinite
- E : Liptinite
- Py : Pyrite
- Dv : Detrovitrinite
- Sp : Sporinite
- Alg : Alginite
- Cl : Clay
- MM : Mineral Substance
- Re : Resinite
- Sb : Suberinite
- Exu : Exudantinite
- Carb : Carbonate
- Rv : Vitrinite Reflectant

Comparison of vertical abundance patterns between liptinite maceral and TOC shows a similarity less than 100%, but suitable pattern. This rather similar pattern can reflect that the total organic carbon from the upper Kelesa Formation shale is
dominated by abundance of liptinite. The abundance of liptinite affects shale to the type of kerogene, that is, shale tends to be dominant to include in type I and type II kerogene. The presence of vitrinite is closely related to type III kerogene.

Figure 6. The content of vitrinite and liptinite macerals in shale layer in Kuburan Panjang area.

The richness of organic material in shale is not only deposited in the marine environment, but also non-marine and even the transition environment. The lacustrine facies environment is most in quantity [4]. For example, in North America the source of shale gas 1/3 is coming from shale deposited in the marine environment, while 2/3 from the transition and terrestrial environments, including lacustrine (12). Shale in the
area of the study site was deposited in the lacustrine dosource inclining to have abundant content of organic material, so that the organic material is strongly influenced by organic material from the land and the lacustrine itself.

Figure 7 shows the relationship between TOC with liptinite and vitrinite, suggesting liptinite has a more dominant content than vitrinite.

![Figure 7. The relationship between TOC, Liptinite, and Vitrinite in Upper Kelesa Formation in Kuburan Panjang area](image)

**Depositional Environment**

In this location, the continuous outcrops were found along Puti Kayu River, the tributary of Keruh River having its upper reach at Bukit Susah. The lithology compiling the rock formation in Putikayu River is dominated by shale with inserts of siltstone and sandstone which are considered as synrift deposit having identical characteristics to Sangkarewang Formation and Brani Formation in Ombilin Basin,
and overlap conglomerates are incompatible which are considered late synrift deposit having identical deposits similar to the Sangkarewang Formation and Brani Formation in Ombilin Basin, and conglomerates which overlap incompatible which are considered to be synrift deposits having identical characteristics to Sawah Tambang Formation in Ombilin Basin.

The shale has brownish to blackish grayish, rather hard characteristics, showing papery structure (Figure 8), and there were fish fossils (Figure 9). There are inserts of grayish brown to blackish sandstone, very fine sand, rather hard, medium sorting, closed packaging, conglomerate in nature, cross bedding sedimentary structure and brownish gray to blackish siltstone, rather hard, and moderate parallel lamination sedimentary structure in the shale. Based on the characteristics of rocks found in the field, it is interpreted that the papery-coated shale is a lacustrine deposit, while conglomerate sandstone found as inserts from the shale is distal alluvial fan deposit associated with border faults during rifting and contaminating with shale. Based on the character of lithology and its spread in the field, we found the mechanism of deposition is taking place under calm current condition with a suspension current system. In addition, the absence of planktonic or bentonic foraminifera, bioturbation and characteristics of non-carbonate indicates the terrestrial environment under anoxic condition. Anoxic condition can be found in quite deep and cold freshwater environments. Based on the data above and the results of stratigraphic cross section measurement, the unit is predominantly arranged by quite thick shale. This is as stated by Nichols (7) by using a depositional model in
lacustrine environment. Based on the statement of Nichols (5), this sedimentation is, generally, taking place in deeper parts of freshwater lake. Therefore, the writer interprets the unit depositional environment as lacustrine environment.

![Image of papery sediment on shale](image)

**Figure 8.** The structure of papery sediment on shale in Kuburan Panjang area.

The conglomerate found was quite thick and was seen incompatible overlapping on shale packages with insertions of sandstone and siltstone as erosional field was found. Conglomerate has blackish-gray characteristics, polomic dominated by components of basal fragments, poor sorting, components have halfway circular to angular form, matrix in the form of sandstone. This rock package is interpreted as fluvial braided channel sediment.

Historical sedimentation of rock package is initiated when there is rifting in the central basin of mountains characterized by precipitation of lacustrine sediment running around alluvial fan (Figure 10). When the intensity of the reduction of graben is decreased, the depositional environment is turning into fluvial channel (Figure 11).
Indeed, based on the appearance of outcrops in the field, the rock packages have identical resemblance to the rock packages in the Ombilin Basin, constituting the central mountain basin system. However, based on previous research by researchers, the rock packages revealed in Kuburan Panjang are those in a back arc basin system.

Change in water level can be interpreted under the oxidic and anoxic conditions during the process of sedimentation. The conditions can be detected by the ratio of several parameters, i.e., normal alkane isoprenoid. Isoprenoid commonly used is pristane/phytane (Pr/Ph). By evaluating normal alkane data, we will get information on an organic facies system. The quality of shale is related to the potential of shale as an unconventional source of hydrocarbon.
Figure 10. The shale sedimentation mechanism model with insertion of sandstone in Kuburan Panjang (cross section on the red line), modification of middle stage rifting sedimentation model in Ombilin Basin (Koesoemadinata and Matasak, 1981).

Figure 11. The conglomerate sedimentation mechanism model in Kuburan Panjang (cross section on the red line), modification of middle stage rifting sedimentation model in Ombilin Basin (Koesoemadinata and Matasak, 1981).

**Lacustrine Water Level Changes**

Table 4 illustrates the results of Gas Chromatography (GC) and Gas Chromatography - Mass Spectrometer (GCMS) analysis on shale of Kelesa Formation in the study area. Depositional environment can be interpreted based on the ratio of several isoprenoid parameters, i.e., pristane/phytane (Pr/Ph), pristane/nC17 and phytane/nC18. Powell and McKirdy, (6) stated the ratio of Pr/Ph with value of 5 - 11, the depositional environment of organic material is coming from non-marine under high wax conditions, while the low wax of marine source rock is ranging from 1 – 3. Peters and Moldowan (6) stated that the high ratio of Pr/Ph shows the depositional environment under oxidation conditions, and the lower content of
salinity. The ratio of Pr/Ph tends to be high (>1) in an oxidation environment, such as turf swamps due to the transformation of phytol into phytanoic acid is followed by decarbonization into pristane.

In the reduction environment, Pr/Ph has low ratio (<1) due to the transformation of phytol into dehydrophytol and reducing pristane. In addition, the ratio of Pr/nC17 < 0.5 indicates oil is coming from marine source rock, while Pr/nC17 > 1 indicates oil coming from source rock deposited in nonmarine area (6).

Table 4. The results of Gas Chromatography (GC) and Gas Chromatography - Mass Spectrometer (GCMS) analysis

Shale in Kuburan Panjang has Pr/nC17 ranging between 4.55 - 13.90 which tends to be hydrocarbon source rock originating from source rock deposited in land area (nonmarine). The ratio of n-alkane shown by the ratio of pristane/phytane in Kelesa Formation shale ranges from 2.16 to 6.07 is classified as having a high value, that is, approximate 3 and > 3. The condition indicates that shale is deposited in the area under oxidation conditions and the lower content of salinity or the lower effect
of marine. Notwithstanding, the fluctuation in pristane/fitane value can indicate fluctuation in water level.

DISCUSSION

Figure 12 shows the relationship between the ratio of pristane/phytane and the content of vitrinite and liptinite suggesting a similarity; that is, when the ratio of pristane/phytane is high, the content of liptinite maceral is large, while vitrinite shows the opposite condition; that is, when the ratio of pristane/phytane is high, the content of vitrinite is low. The ratio of pristane/phytane illustrates fluctuation in the ratio of pristane and phytane. The ratio is related to the oxidation zone, the high oxygen zone that occurs when water level (lacustrine) is low, so it can be illustrated that when the water level is going down, the supply of organic material is rising, especially liptinite resulting in the formation of shale in a high Index Hydrogen which means it has characteristics of I and II type kerogen. The higher the ration of pristane/phytane, the higher the oxidation condition or when sedimentation occurs under high oxygen conditions. In the MH 02 K model, the ratio of pristane/fitane is lowest, it means that at that time there was a reduction in condition or anoxic; that is, a condition with the lower content of oxygen. The case may be taking place when lacustrine water level has fluctuation under high water level condition. As the fluctuation in lacustrine water level go up, it seems the ratio is high, heading to high oxygen or oxic conditions, or, in other words, the water level is getting lower.
Einsele (1) suggested difference in production of organic material in the basin under oxic and anoxic conditions. The oxic condition has a tendency to produce sedimentary rocks and the lower carbon organic content, 0.5 - 1%, as compared to anoxic conditions ranging from 2 - 10%. The potential of hydrocarbons will also be affected by the conditions; that it, the potential of hydrocarbons will be more likely to produce oil and gas 2 - 4% under anoxic conditions, while under oxidic conditions it produces only around 0.01%.

Figure 12. Relationship between pristane/phytane ratio and vitrinite and liptinite macerals in Kelesa Formation shale.

Figure 13 shows the relationship between the content of carbon (TOC) and the ratio of pristane/phytane. When MH 02 D is in motion to MH 02 E (Y), the value of TOC decreases but the value of pristane/phytane rises, then MH 02 I, MH02 J, MH 02 K and MH 02P moved to MH 02 Q (X) and the value of TOC increases but the value of pristane/phytane decreases and MH 02 S is in the opposite position of TOC and the ratio of pristane/phytane. Based on the fact, it seems the content of TOC is
related to fluctuation in water level or a process of sedimentation under oxic and anoxic conditions.

Figure 13 shows the relationship between TOC and pristane/fitane ratio showing the relationship between oxidic-anoxic conditions and abundance of TOC.

Figure 14 shows the Relationship between TOC and Potential Yield (PY) in the shale layer in Kuburan Panjang from the bottom (NS 29K) to the top (MH 02S). Although different scale, the distribution of TOC and PY has a similar pattern, the TOC is in the range of 1.18% to 7.17%, while PY ranges from 1.28 to 70.92. In MH 02 H and NS 29Q2, both TOC and PY show the lowest position. MH 02 G, MH 02 I, NS 29 O and NS 29 Q1 describes that when TOC is rising, the PY will be increasing, as well.

The quality of shale can be indicated by TOC and PY which can describe potential shale as a source of energy, either conventional or unconventional. High
TOC and PY are potential shale indicators as sources of hydrocarbon energy. The relationship between shale quality and change in water level can be seen in Figures 13 and 14. If we look at the graph between TOC, PY and pristane/phytane ratio, it seems a similar distribution pattern. When we look at MH 02 K, the ratio of pristane/phytane is lower as shown by TOC and PY.

Figure 14 shows MH 02 H, MH 02 I and MH 02 J (zone A) have the same pattern between the ratio of pristane/phytane, TOC and PY; that is, increase to decrease indicating one cycle of fluctuation. Meanwhile, from MH 02 M to MH 02 O (zone B) and from MH 02 P to MH 02 Q (zone C) shows the same pattern, i.e., the ratio of pristane/phytane, TOC and PY have the same increase. In general, there is a relationship between the three cases; that is, the ratio of pristane/phytane shows change in water level with TOC and PY as potential indicators of potential shale as sources of hydrocarbon.

Based on change in water level and potential shale as a source of hydrocarbon, it is revealed that there is a relatively significant relationship between the two things.
Figure 14. Relationship between TOC and Potential Yield (PY) showing the relationship between TOC and PY in each zone

This evidence is important to give an idea of what shale might be a potential source of hydrocarbon. Change in water level is attributable to climate factors during the process of sedimentation. The ratio of pristane/fitane tends to be high under oxic environmental conditions; otherwise, the TOC will be going down. However, when the ratio of the pristane/phytane is lower, the content of TOC will be going high under anoxic conditions. The conditions reflect that when the water level (lacustrine) is going down, the supply of organic material have relatively decrease and when the water level is going up, the organic material will have relatively increase.

Based on the results of analysis, the content of liptinite and vitrinite macerals is influenced by change in water level. When the ratio of pristane/phytane shows a small price, the water level will be high or anoxic condition. The abundance of vitrinite will be larger than the content of liptinite under noxic conditions. However, when the oxic orrr oxygen conditions are high as indicated by high ratio of
pristane/phytane, the content of liptinite shows very good, so the content of liptinite will be abundant under oxic conditions. The abundant content of liptinite may be due to organic formation and deposition in the lacustrine. Even though the water condition is low, the supply of oxygen is sufficient for the development of organisms in the lacustrine environment.

Instead, the anoxic conditions are characterized by low oxygen content and high water level. This can be interpreted organic material have not well development under those conditions due to the lower supply of oxygen so that liptinite is not abundant, while vitrinite which is a maceral originating from tall plants outside of the environment itself is formed due to transport from other places under high water level conditions.

CONCLUSION

Stratigraphically, the abundance of organic material has fluctuation from bottom to top. The abundance of organic material may be visible at the top of stratigraphic cross section in the study area. The abundance is characterized by a change in oxidation conditions. The abundance of organic material is dominated especially by liptinite and vitrinite. Change in water level in the process of sedimentation has effect on the quality of shale as a non-conventional energy source of hydrocarbon in Kuburan Panjang. It is based on difference in potential from good to perfect in the shale layer, the varying patterns of pristan/phytane ratios between shale layers showing pattern of change in water level, similar distribution patterns
between the ratio of pristane/fitane, TOC and PY, and the smaller the ratio of pristane/fitane (anoxic condition, high water level), the smaller the content of liptinite and, the higher the content of vitrinite; conversely, the greater the ratio (oxic condition, low water level), the higher the content of liptinite and the lower the content of vitrinite. In general, the development of layers from the bottom to the top gives a picture of change in water level from high to low or from a reduction condition (low oxygen) to oxidation (high oxygen) condition.

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