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CHARACTERIZATION AND CORRELATION STUDY OF SOURCE ROCKS AND OILS IN KUANG AREA, SOUTH SUMATRA BASIN: THE POTENTIAL OF LEMAT FORMATION AS HYDROCARBON SOURCE ROCKS

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ABSTRACT

This study was conducted in Kuang area, South Sumatra Basin, where three oil fields: Air Serdang, Mandala, and Kuang are situated. The Kuang area is surrounded by five sub basins (Cintamani, Jantung, Tanjung Miring, Meraksa, and Lematang). Talangakar Formation has been known as a source rock in the area, however the characteristics of the formation is different in each sub basin. It is therefore necessary to find out the most possible sub basin(s) that may be the source of hydrocarbons.

Forty two sediment (cuttings) and fifteen crude oil samples have been geochemically analyzed. The basic source rock analysis comprised of screening, kerogen typing, and maturation. Further analysis, such as correlation between source rock and crude oil as well as crude oil to crude oil, has been done by using more sophisticated techniques, i.e. carbon isotope and biomarkers.

Based on the geochemistry analysis above, it is indicated that:

- Characteristics of the Lemat and Talangakar Formations in Tanjung Miring and Cintamani Subbasins basically show a fluvio-deltaic characters with a slight different: more oxic in Cintamani rather than in Tanjung Miring Subbasin.

- Source rocks of Lemat and Talangakar Formations in Lematang Subbasin are interpreted to have shallow marine characters.

- Crude oils in Kuang area shows the fluvio-deltaic characteristic.

The result of correlation shows that crude oils in Kuang area were most probably derived from source rocks of the Lemat and Talangakar Formations in Tanjung Miring Subbasin.

Keywords: Biomarker, correlation, fluvio-deltaic, shallow marine.

INTRODUCTION

Lemat and Talangakar Formations have been considered as source rocks in the South Sumatra Basin (Sarjono & Sardjito, 1989; ten Haven and Schiefelbein, 1995; Ginger and Fielding, 2005; Noble et al., 2009; Rashid et al., 1998; Suseno et al., 1992; Ryacudu, 2008). In general, Lemat Formation found in the basin has been interpreted to be deposited in the lacustrine environment due to its tectonic history that the formation was deposited during syn-rift time (Ryacudu, 2008). However, in this study area, Lemat Formation is likely to have fluvio-deltaic environment, trending to the landward. Talangakar Formation, on the other hand, has only one opinion, i.e. more deltaic with a tendency to basinward (Ryacudu, 2008). Gumai Formation were deposited in a shallow marine depositional environment, was also regarded as a hydrocarbon source rocks in the South Sumatra Basin, particularly in Lematang Subbasin (Sarjono & Sardjito, 1989). Lemat, Talangakar and Gumai Formations (in Lematang Subbasin), other than reported to contain relatively rich organic matter, they are also regarded to be mature.

From the regional tectonic framework, the study area is surrounded by five subbasins, i.e. Cintamani, Jantung, Tanjung Miring, Meraksa, and Lematang. Talangakar Formation is observed in the five subbasin, while Lemat only in the three subbasins, with Meraksa and Lematang were the only subbasins where Lemat were not present. Even though Talangakar sediments are found in all sub-basins, their character is somehow specific in each subbasin.

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So is the Lemat Formation. The difference in characters is most likely due to the variation of the depositional position, e.g. one is more oxic than the others and the difference in the organic input (algae vs higher plants).

Study area is located in Kuang area (Figure 1). Oil fields in study area, are Air Serdang, Mandala and Kuang. The existing publications show that oils produced in Kuang-Air Serdang area are interpreted as derived from fluvio-deltaic sediments of Talangakar Formation (Suseno et al., 1992). This study attempts to prove the sub-basin(s) that are responsible to generate crude oils found in the Kuang area by implementing some sophisticated geochemical synthesis, such as correlation based on isotope and biomarkers.

RESEARCH METHODS

This paper emphasizes on geochemistry methods. Source rock analysis, consist of 25 samples for carbon isotope and 42 samples for biomarker, while oil analysis, and consist of 2 samples for carbon isotope and 15 samples for biomarker. Characterization has been based on qualitative and quantitative data. Qualitative data comprise the evaluation based on mass-fragmentograms m/z 191 and m/z 217, whereas quantitative data consists of a series of cross plots, eg. crossplot of carbon isotope ^{13}C saturates-aromatics, distribution of C_{27}-C_{28}-C_{29} sterane, Pr/nC_{17}-Ph/nC_{18}, Pr/Ph-Pr/nC_{17}, carbon isotope $\delta^{13}C$ saturates-Pr/Ph, Pr/Ph-total hopane/ total sterane, and ratio of C_{26}/C_{25} (tricyclic).

The results of this study are expected to be able to explain the characters of the oils in the Kuang-Air Serdang area and the source rocks in Tanjung Miring, Cintamani, Jantung, Meraksa and Lematang Subbasin, including the possibility of possible presence of lacustrine source rock and determine the correlation between the source rocks and the crude oils contained in this area, so it can be known whether Lemat Formation source rocks also contributes to produce oil in this study area. In addition, it is expected to provide a new opportunity in the exploration of hydrocarbons in this study area which can be considered as a mature basin exploration.

REGIONAL GEOLOGY

The evolution of the South Sumatra Basin started since Mesozoic (Pulunggono et al., 1992) as a back-arc basin (Figure 2). Back-arc basins in Indonesia are generally hydrocarbon prolific basins. Mechanism involved in the basin formation is generally rifting that formed a graben or half graben. This basin was formed in two phases, rifting phase during Paleogene and sagging in the Neogene. Rifting phase is characterized by the thinning of crust forming graben or half graben, whereas characteristic in the sagging phase is a stable tectonic, and even a change into compression tectonic and ended by volcanic activities, shown by the occurrence of tuff that appeared in Air Benakat Formation. The rifting phase was filled by Lahat Group comprising Benakat and Lemat Formations, whereas the sagging phase was filled by sediments of Talangakar Formation up to the youngest formation, i.e. Kasai Formation (Figure 3).

CORRELATION OF SOURCE ROCKS IN TANJUNG MIRING, CINTAMANI, JANTUNG, MERAKSA SUB-BASIN, AND LEMATANG DEEP WITH OILS IN KUANG-AIR SERDANG AREA

Quantitative Methods

(Figure 4) shows a cross plot of Pr/nC_{17} vs Ph/nC_{18} for the source rock and the crude oil samples in the study area. This figure shows the source rock samples in Tanjung Miring, Cintamani Sub-Basins, and the crude oil samples in Kuang-Air Serdang area consists of humic kerogen whereas in Jantung, Meraksa and Lematang Subbasins consist of mixed kerogen.

(Figure 5) shows a cross plot of Pr/Ph vs Pr/nC_{17} for the source rock and the crude oil samples in the study area. This image shows the source rock samples in Tanjung Miring and Cintamani Subbasins are predominated by higher plant in anoxic-suboxic to oxic condition, but most of them are in oxic condition, whereas the crude oil samples in Kuang-Air Serdang area are in anoxic-suboxic condition. Source rock samples in Jantung, Meraksa. and Lematang Subbasins are dominated by algae, in anoxic-suboxic to highly anoxic condition.

The cross plot of carbon isotope $\delta^{13}C$ saturates vs $\delta^{13}C$ aromatics and carbon isotope $\delta^{13}C$ saturates vs Pr/Ph for the source rock and the crude oil samples in study area can be seen in (Figure 6). These figures show the source rock samples in Tanjung Miring Subbasin consist of mixed material and algae, the source rock samples in Meraksa and Lematang Subbasin consist of algae, and the crude oil samples in Kuang-Air Serdang area consist of mixed material. The source rock samples in Tanjung Miring Sub-basin are in anoxic-suboxic, to oxic condition, but

most of them are in oxic condition, the source rock samples in Meraksa and Lematang Sub-basin are in anoxic-suboxic to highly anoxic, whereas the crude oil samples in Kuang-Air Serdang area are in anoxic-suboxic condition.

Qualitative Methods

(Figure 7) is the comparison of biomarker characterization qualitatively between the source rock samples in Cintamani, Jantung, and Lematang Subbasin and the crude oil samples in Kuang-Air Serdang area. From this picture it shows that the source rock samples in Cintamani, Jantung, and Lematang Subbasins and the crude oil samples in Kuang-Air Serdang area, according to ten Haven and Schiefelbein (1995), and Peters et al. (2005), are not lacustrine sediments because C_{26}/C_{25}(tricyclic) is smaller than 1. Based on the tricyclic data (Figure 7), according to Price et al. (1987), the source rock samples in Cintamani Sub-basin, and the crude oil samples in Kuang-Air Serdang area showed terrestrial pattern. The source rock samples in Jantung, and Lematang Sub-basin didn't show a specific pattern.

Based on the data of ^{29}H and ^{30}H (hopane) distribution (Figure 7), it shows that the source rock samples in Jantung and Lematang Sub-basin and the crude oil samples in Kuang-Air Serdang areas are marine clastic sediments because it shows a pattern^{29}H<^{30}H, while the source rock samples in Cintamani Sub-basin beside show ^{29}H<^{30}H, also show ^{29}H>^{30}H, are evaporate-carbonate sediment (Zumberge (1984), Connan et al. (1988), Price et al. (1987), all in Waples and Machihara (1991).

From the data of homohopane distribution (Figure 7) which decreased regularly from C_{31} to C_{35}, the source rock samples in Cintamani, Jantung, and Lematang Subbasin and the crude oil samples in Kuang-Air Serdang area are interpreted depositional environment which associated with clastic (Waples and Machihara, 1991) or more oxidizing conditions (Peters and Moldowan, 1993).

(Figure 8) is the comparison of biomarker characterization qualitatively between the source rock samples in Tanjung Miring Subbasin and the crude oil samples in Kuang-Air Serdang area. From this picture it shows that the source rock samples in Tanjung Miring Subbasin and the crude oil samples in Kuang-Air Serdang area, are not lacustrine sediments because C_{26}/C_{25}(tricyclic) is smaller than 1. Based on the tricyclic data (Figure 8), the source rock samples in Tanjung Miring Sub-basin (Lemat and Talangakar Formations) and the crude oil samples in Kuang-Air Serdang area showed terrestrial pattern. Based on the data of ^{29}H and ^{30}H (hopane) distribution (Figure 8), it shows that the source rock samples of Talangakar Formation in Tanjung Miring Subbasin and the crude oil samples in Kuang-Air Serdang areas are marine clastic sediments because it shows a pattern^{29}H<^{30}H, while the source rock samples of Lemat Formation in Tanjung Miring Sub-basin beside show ^{29}H<^{30}H, also show ^{29}H>^{30}H, are evaporate-carbonate sediment. From the data of homohopane distribution (Figure 8) which decreased regularly from C_{31} to C_{35}, the source rock samples of lemat and Talangakar Formations in Tanjung Miring Sub-basin, and the crude oil samples in Kuang-Air Serdang area are interpreted depositional environment which associated with clastic.

Based on these data, the crude oil samples in the Kuang-Air Serdang area are interpreted originated from fluvio-deltaic source rocks, and have correlation with lemat and also Talangakar Formations derived from Tanjung Miring Sub-basin.

CONCLUSION

- The source rocks in Tanjung Miring Sub-basin and crude oils in Kuang-Air Serdang area, are not lacustrine sediments. The source rocks in Tanjung Miring, Cintamani Sub-Basins, and crude oils in Kuang-Air Serdang area consist of humic kerogen,whereas in Jantung and Lematang Sub-basins consist of mixed kerogen.

- The source rocks in Tanjung Miring and Cintamani Sub-basin are predominated by higher plant in anoxic-suboxic to oxic condition, but most of them are in oxic condition, whereas crude oils in Kuang-Air Serdang area are in anoxic-suboxic condition. The source rocks in Jantung and Lematang Sub-basins are dominated by algae, in anoxic-suboxic to highly anoxic condition.

- The source rocks in Tanjung Miring Sub-basin consist of mixed material and algae, the source rocks in Lematang Sub-basin consist of algae, and the crude oils in Kuang-Air Serdang area consist of mixed material.

- Based on the tricyclic data, the source rocks in Tanjung Miring Sub-basin (Lemat and Talangakar Formation) and crude oils in Kuang-Air Serdang area show terrestrial pattern.

- Based on these data, the crude oils in the Kuang-Air Serdang area are interpreted originated from fluvio-deltaic source rocks, and have correlation with lemat and also Talangakar Formations derived from Tanjung Miring Sub-basin.

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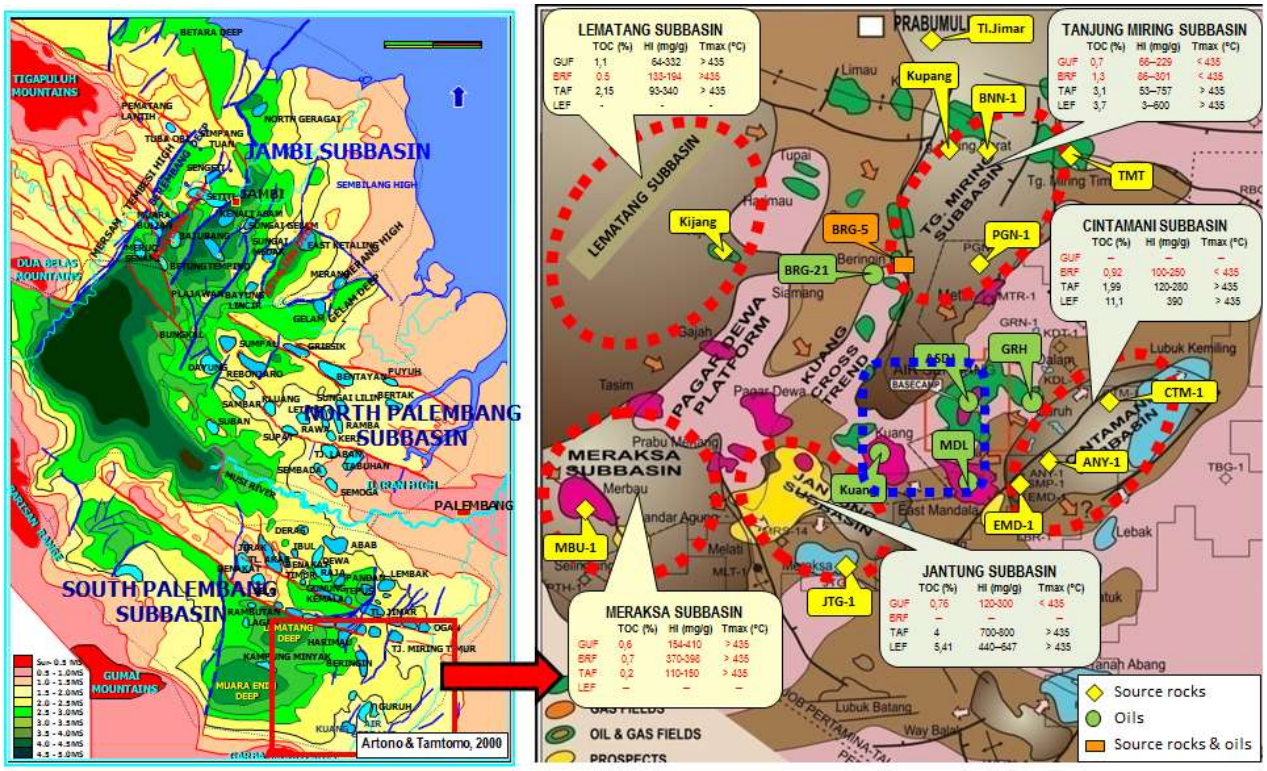

Figure 1 - Location map of the study area.

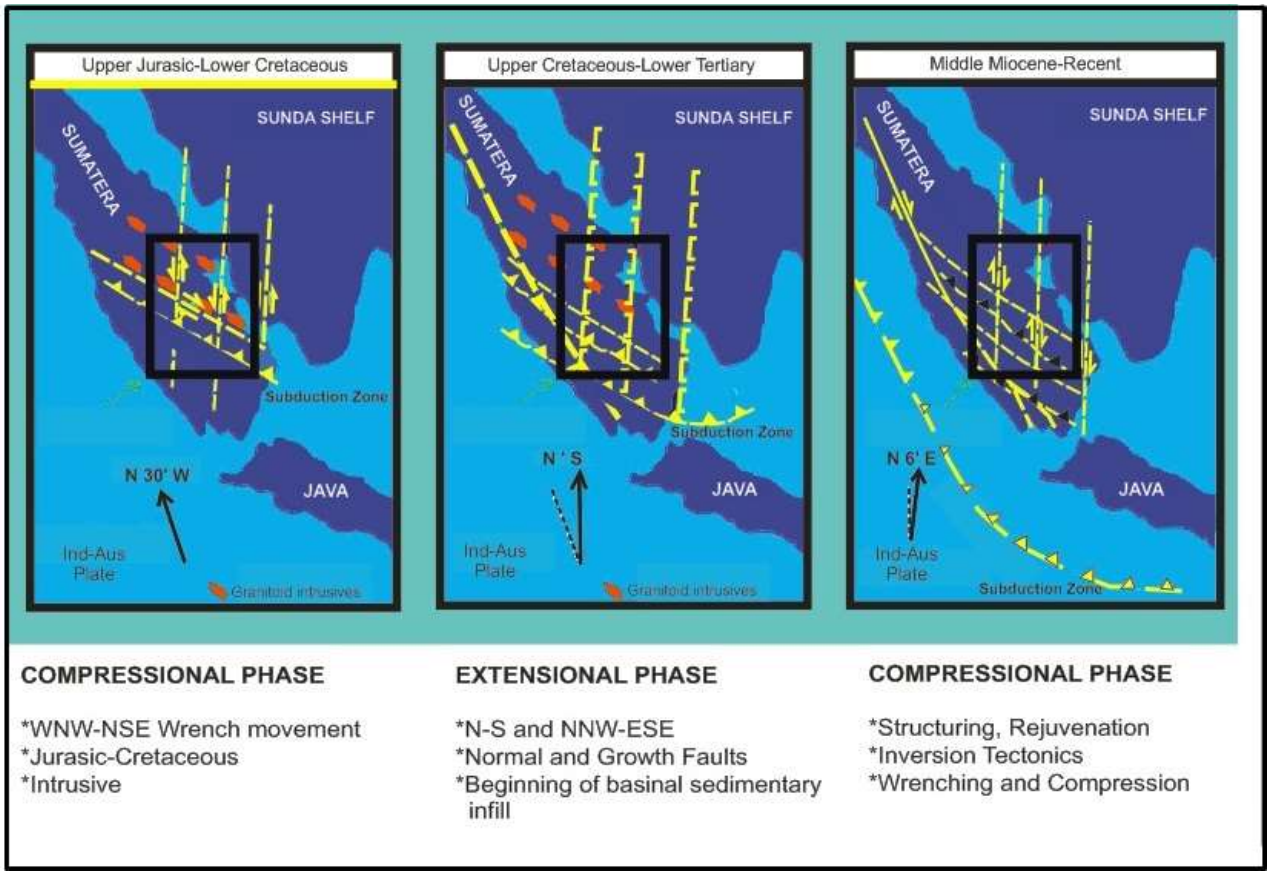

Figure 2 - Tectonic evolution of the South Sumatra Basin from Upper Jurassic-now (Pulunggono et al., 1992)

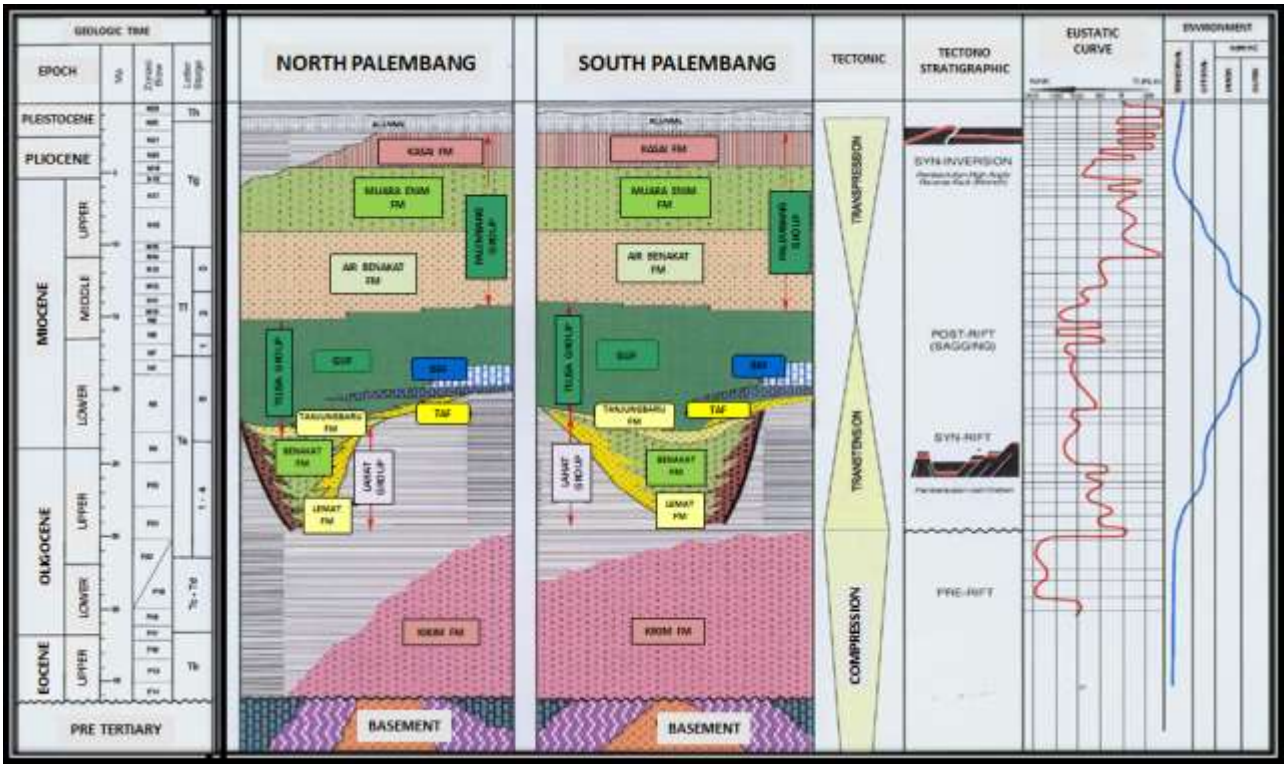

Figure 3 - Regional stratigraphy of the South Sumatra Basin (modified from Ryacudu, 2008).

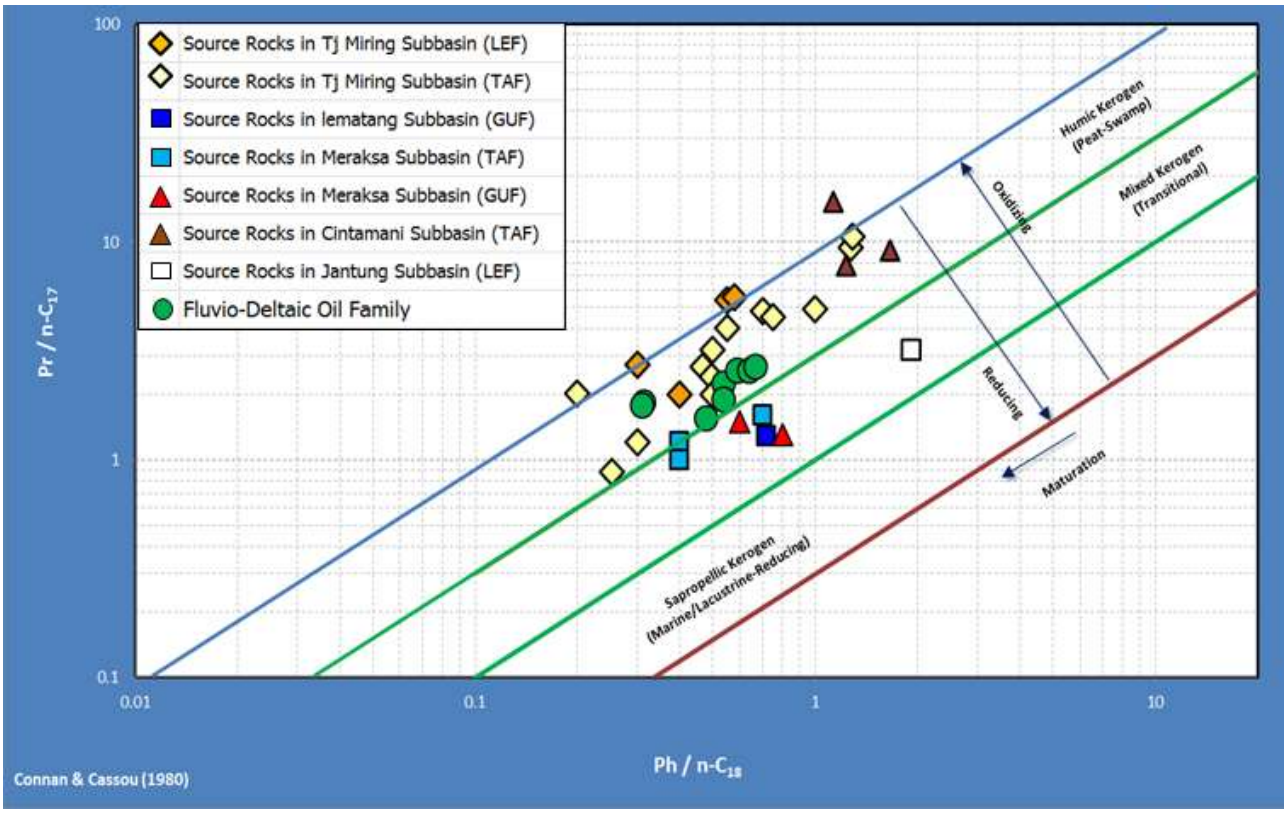

Figure 4 - The cross plot of Pr/nC_{17}-Ph/nC_{18}, samples of source rock and oil in the study area.

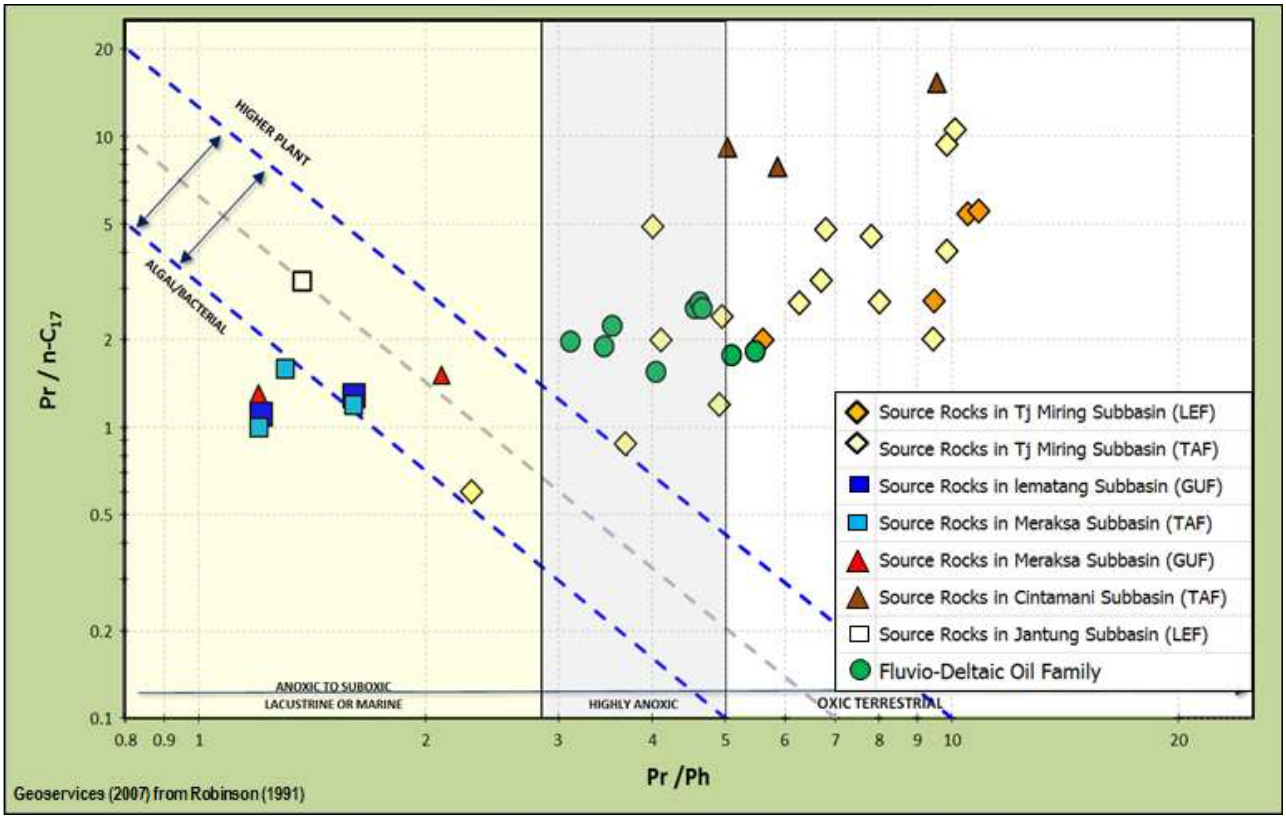

Figure 5 - The cross plot of Pr/Ph – Pr/nC_{17}, source rocks and oils in the study area.

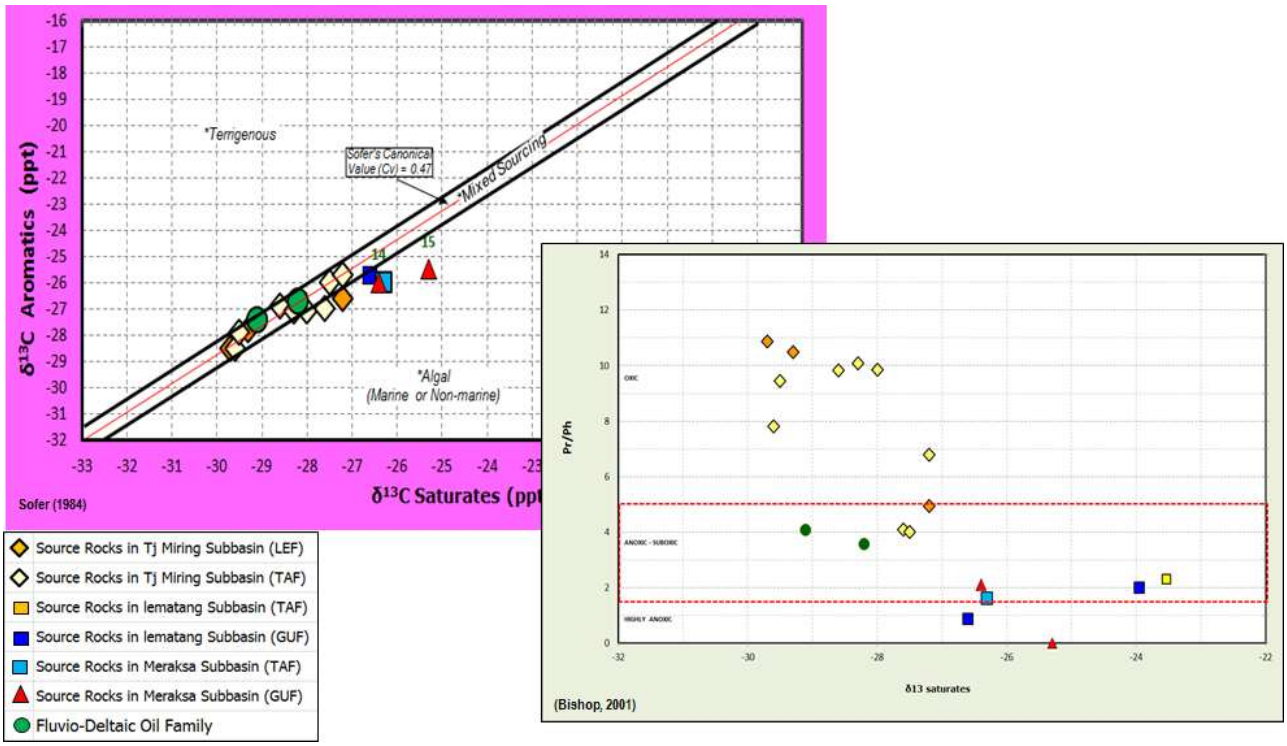

Figure 6 - The cross plot of carbon isotope $\delta^{13}C$ saturates - $\delta^{13}C$ aromatics and carbon isotope $\delta^{13}C$ saturates - Pr/Ph, source rocks and oils in the study area.

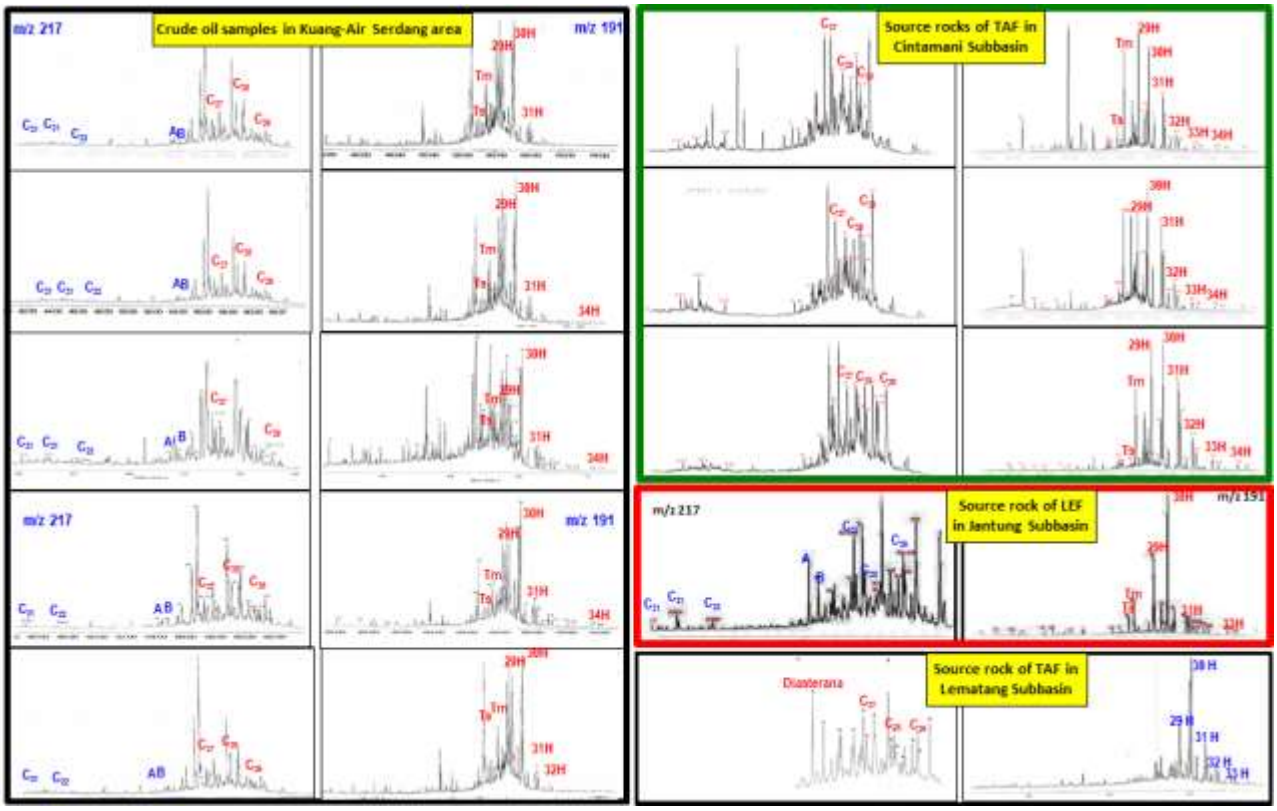

Figure 7 - The comparison of biomarker characterization qualitatively between the crude oil samples in Kuang-Air Serdang area and the source rock of Talangakar Formations in Cintamani, Lemat Formation in Jantung, and Talangakar Formation in Lematang Subbasin.

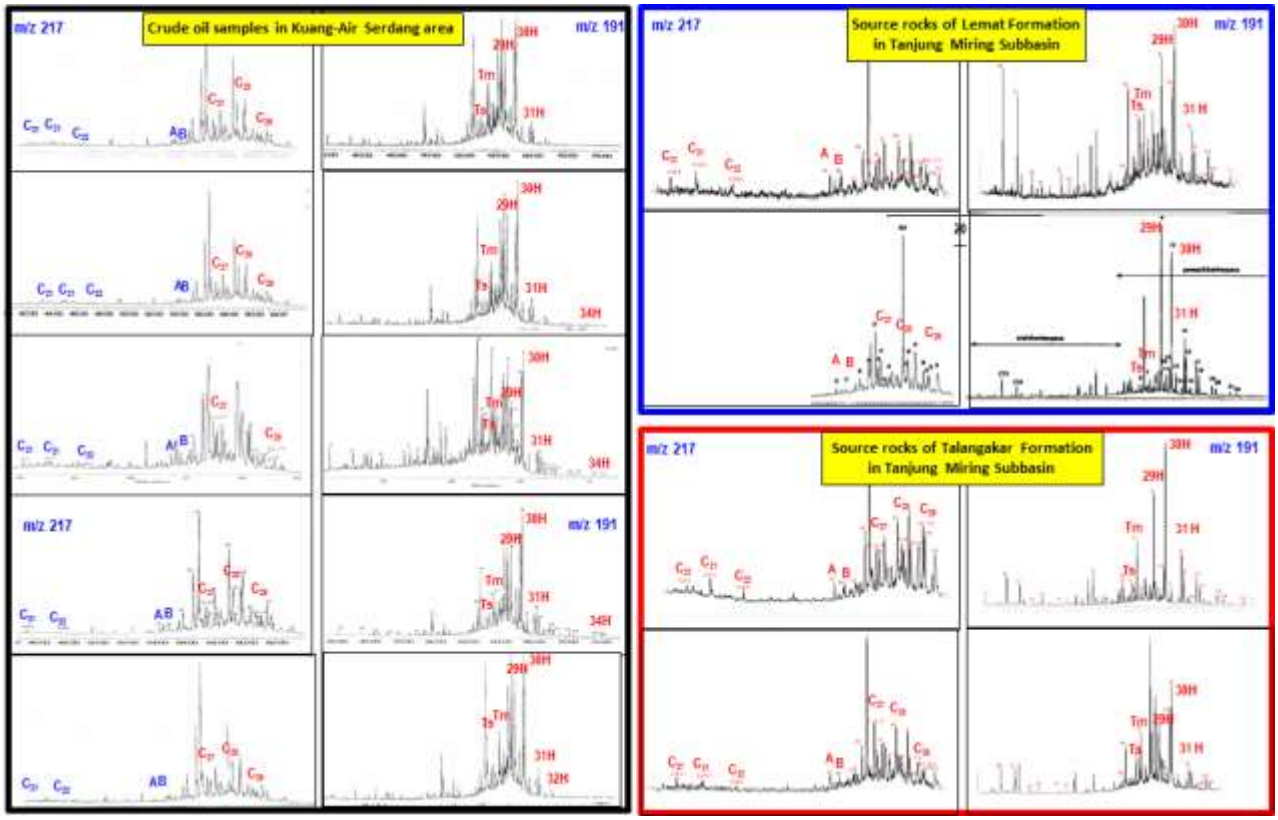

Figure 8 - The comparison of biomarker characterization qualitatively between the crude oil samples in Kuang-Air Serdang area and the source rock of Lemat and Talangakar Formations in Tanjung Miring Subbasin.