Bio-markers based oil to source rock correlation and paleo-environmental interpretation: A case study from Talang Akar Formation, South Sumatra Basin, Indonesia

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Abstract. Talang Akar Formation is a proven hydrocarbon source rock in South Sumatra basin. This study used 3 crude oil sample and 6 well-cutting obtained from Talang Akar Formation. Biomarkers analysis has been used to determine the depositional environment of Talang Akar Formation. The techniques utilized include gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) analysis of normal alkanes, isoprenoids, triterpene, and steranes. The most commonly used, pristine (Pr) to phytane (Ph) ratio is a good indicator of the depositional environment. The results in this research show that Pr/Ph ratios range from 5.90-10.08. Pr/Ph indicating abundant terrigenous plant input deposited under oxic to suboxic conditions. The oil/source rock correlation analysis using biomarker data shows that the oils field is correlated with the oils in source rock of Talang Akar Formation. This study concludes that the source rock in Talang Akar Formation was deposited in a transitional (Fluvio-deltaic) to marginal marine environment under oxic conditions.

1. Introduction
Hydrocarbon production in the South Sumatra Basin is ranked at the 2nd place for Indonesia after Kutei Basin in term of total productions. The primary reservoirs are within the Talang Akar, Baturaja and Gumai Formations and a smaller amount in the fractured basement [1]. Geochemical research has been carried out to increase petroleum exploration and exploitation. Starting from research on the chemical composition, oil–oil and oil–source rock correlations. Organic geochemistry is generally used to evaluate basins, plays and prospects. As a prerequisite for understanding organic geochemistry, the formation of oil and gas beneath the earth's surface must be well understood [2].

Biomarkers are used to identify compounds contained in sediments that have a clear structural relationship with compounds of biological results. One of the uses of biomarkers in petroleum exploration is to identify the depositional environment and organic material. This study aims to characterize the samples by using biomarker were obtained from gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS).
2. Stratigraphy and environment of deposition

The principal source rocks in the South Sumatra Basin are fluvio-deltaic marine, locally lacustrine and coaly facies of the Late Eocene to Middle Oligocene Lemat, and Late Oligocene to Early Miocene Talang Akar Formations. These rocks were deposited in the grabens and half grabens forms during the Late Cretaceous to Early Oligocene, and contribute to terrestrial derived oils [3]. In addition, shales of the Telisa Formation provide a marine/paralic hydrocarbon source. Talang Akar sandstones constituted the main reservoir target and the potential traps are anticlinal structure that developed in response to Plio-Pleistocene compression. The Baturaja limestones are the other prime reservoir target; the traps are structural or combined structural and stratigraphic trap potential has also been indentified in the Baturaja Formation, with the potential trap dependent on facies change from porous reefal to tight platform carbonates [4].

The Talang Akar Formation represents the second phase of Tertiary deposition in the South Sumatra Basin and contains a continental fluvial sequence composed of thickly bedded, very coarse sandstones, alternating with thin shales and some coals. The thickness of the Talang Akar Formation varies from 1500-2000 feet (about 460-610 m). The Upper part of Talang Akar Formation (TAF-TRM) was dominated by siltstone and sandstone and shale. Siltstone are dominan grey to dark grey, soft to medium hard, calcareous. Sandstone are poor to medium porosity, grey to light grey, white, fine to medium grain, medium to hard, medium sorted, sub angular to sub rounded, calcareous cemented, with oil window. Shale are dark grey, firm to medium hard, plety to sub blocky, and non-calcareous [6]. The Lower part of Talang Akar Formation (TAF-TRM) was dominated by siltstone and sandstone with shale and coal streak. Sandstone are medium porosity, grey to brown grey, medium to hard, medium sorted, sub-angular to sub-rounded, quartz, glauconite mineral, calcite cement, with oil show. Siltstone are grey to dark grey, firm to medium hard, sub-plety, sub-blocky, locally sandy, carbonate, calcareous. Coal are black, brittle and wood structure [6].
Talang Akar Formation (TAF-GRM) is a member of the lower Talang Akar Formation was dominated by conglomerate, sandstones, quartz, shales and coal. Talang Akar Formation consists of sandstones derived from delta plain, shale, silt, quartz-sandstone, carbonate, coal and conglomerate. The thickness of the Talang Akar Formation varies from 1500-2000 feet (about 460-610 m) [6].

3. Research Method
This study used 3 crude oil sample and 6 well-cutting from Talang Akar Formation. Based on biomarkers data to determine the depositional environment of Talang Akar Formation. The biomarkers data were obtained from gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS) analysis.
4. Results and Discussion

Biomarkers can provide information about the organic content in the source rock, environmental conditions during the formation process and diageneis, thermal maturity process with rocks or oil, the degree of biodegradation, some aspects of rock minerals and age of rocks [8]. Based on kerogen type, Talang Akar Formation was deposited in fluvial environment (terrestrial), transitional environment and shallow marine environment [9].

Figure 3. Crossplot Pr/n-C17 and Pr/Ph to identify the depositional environment.

Based on graph Pr/ nC17 versus Ph /nC18 (figure 3), it can be seen that the source rock in Talang Akar Formation was deposited in the oxic environment with organic material derived from higher plants. The presence of bicadinane is abundant with high plant biomarkers from the family angiosperms and other biomarkers. The ratio of Pristane/Phytane ratio in all samples was Pr/Ph ratios range from 5.90-10.08. Pr/Ph more than 3.0 indicates terrigenous plant input deposited under oxic to suboxic conditions, while Pr/Ph less than 0.8 indicates saline to hypersaline conditions associated with evaporate and carbonate deposition [10]. The source rock samples in Talang Akar Formation predominated by higher plant in oxic condition. The ratio of Pr/n-C17 and Ph/n-C18 in Talang Akar Formation range from 0.18-10.57 and 0.12-1.29, which reflect that most of kerogen was derived from humic source and tend towards an oxidative environment of deposition (figure 4).
Figure 4. Pr/nC17 vs Ph/nC18 cross plot maturity level.

Figure 5. Diagram of maturity of some potential source rock from Talang Akar Formation.

This condition is supported by biomarker analyses, which indicate early mature level as shown by Tm/Ts ratio (Figure 5). A high hopane/Sterane ratio can indicate anoxic to sub-oxic primarily algae and typical for marine derived petroleum [11].
Figure 6. Ratio of hopane/sterane versus Pristane/Phytane, showing anoxic to sub-oxic condition of fine sediments in Talang Akar Formation.

Lemat Formation has been considered as syn-rift sediments until now, consist of terrestrial sediment (fluvio-lacustrine), creating source rock with fluvio lacustrine characterization. While based on existing publications, showing that oil having fluvio-deltaic characterization and generated by source rock from Talang Akar Formation with fluvio-deltaic characterization. A number of potential reservoir rocks in the South Sumatra Basin occur within the regressive and transgressive sequences. The Muara Enim and Air Benakat Formations from the regressive sequences have good potential as reservoirs. The transgressive sequences are represented by the Talang Akar and Baturaja Formations [12]. Based on cross-plot of carbon-13 isotopes (δ13C) showed Talang Akar Formation began in the Late Oligocene in the form of alluvial fan and braided stream environments filling topographic lows and depressions. Therefore, the Talang Akar Formation locally occurs overlying the pre-Tertiary rocks. This sedimentation continued in Early Miocene in a fluvial, deltaic and marginal-shallow marine environment. During the time, the connection to open marine conditions became more significant and the sea gradually encroached into the basin [13].

All samples contain C27-C29 steranes. In some cases the relative abundance of C27-C29 steranes can be used as indicators of the nature of the photosynthetic biota, both terrestrial and aquatic, while triterpanes are usually indicators of depositional and diagenetic conditions [11]. Land plant inputs are usually inferred from a dominance of the C29 steranes. The C29 steranes of this type of crude were not derived from C29 sterols of land-plant origin (frequently proposed as the source of C29 steranes). The presence of these compounds shows a high contribution from terrestrial plants, especially from dipterocarpacceae species which produce resin. Biomarker compound with composition C29> C28 < C27, giving an indication of the dominant contribution of organic matter from terrestrial plants. The presence of diasterane compounds that are quite dominant indicates that the source rock of oil is deposited in an environment rich in clay minerals [14]. The composition of styrene shows C29 > C28 < C27 which gives an indication of the origin of mixed organic matter between algae and terrestrial plants.
The depositional environment of the study area is a transitional environment for oxic conditions with material organic higher plants and marine algae. Based on oil–oil and oil–source rock correlations, Talang Akar Formation those were depositional environment (transitional) and precursor (terrestrial) [15].

5. Conclusions
The main conclusions of this research are;
- The Talang Akar formation was deoposited in a transitional environment indicated by biomarkers, lithofacies and sedimentary characteristics
- The conditions were oxic to sub-oxic at the time of deposition. This is based on the relatively higher values of Pr/Ph ratios.
- The source of organic matter in Talang Akar formation is mainly higher plants as indicated by Hopane/Sterane and Pr/Ph ratios.

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