2D source rock maturity model with integrated geology, geophysics and geochemistry data in HL field Jambi Sub Basin, South Sumatra Basin

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Abstract. South Sumatra basin is one of the back arc tertiary basin in western part of Indonesia. It consists of 31 grabens and 2 grabens complexes which are divided into three general basin systems. Modeling of maturity generation has been performed in Jambi sub basin with Talang Akar formation as source rock target from 5 well along in HL field. This study aims to examine their hydrocarbon generation and expulsion history. Geochemical evaluation showed that Talang Akar formation is very potential as a source rock, with an average TOC value of around 1–8 wt %. The reconstruction of 2D modeling and thermal show that HL field evolved initially as a rift basin in Miocene with uplift in the Oligocene. The present-day calculation of heat flow in HL Field shows 7.27 HFU. The differences in the present-day heat flow with paleo heat flow have been corrected using vitrinite reflectance to know validate the paleo heat flow. In Paleo heat flow increased since the main rifting form late Oligocene until early Miocene. Erupting back, paleo heat flow will indirectly reduce the heat. During Middle Miocene there was a post rift phase which considered as influence on source rock maturation and hydrocarbon generation as quite Talang Akar formation is currently passing oil generation window. Thermal maturation model indicated that Talang Akar formation ware passed late oil generation stage and generated with oils to convert dry gas with the result % Ro is 2 %. The hydrocarbon explosion got result from transformation ratio model that source rock unit have probably completed all potential hydrocarbon since Pleistocene that in regional Sumatra has even inversion stage.

Keywords: South Sumatra basin, maturity generation model, basin modeling

1. Introduction
The HL field in this study is on the depressions in the south Sumatra basin and lies in the northern part of south Sumatra. This depression is bounded to the north by the cratonic Sundaland, and to the northwest by the basement area of the Tiga Puluh Mountain which form a basement ridge between the central and south Sumatra basins Talang Akar and Gumai formation are presumed to be the main source rock for paraffinic oil in the Jambi sub basin. Geological setting determines that Gumai shale and Talang Akar formation depositional in anoxic to subtoxic environment. Using the result of acoustic impedance...
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and TOC Predict, will give overview of the distribution source rock, which can be used in modeling 2D of source rock maturity in Jambi sub basin. The relationship between well logging information and organic carbon content (TOC) to calculate the organic carbon content of the hydrocarbon source rock [1].

2. Data and method

The data consists of 2D seismic data with final processing in the form of pre-stack time migration and there are three well data with complete geochemistry data and also other log data. source rock target is Talang Akar formation and Gumai formation. The first stage in the interpretation of a symmetry is to do seismic conditioning to equalize the amplitude value. The difference in amplitude values can occurs due to differences in the years of seismic data collection. The results of the balancing process are shown in figure 1 with quite good results, where the trend of structure and lamination more apparent from the reflection between two different vintages seismic.

The interpretation of the whole horizon to create a depth structure map. Depth structure map obtained by carrying out the process of gridding on the horizon Gumai, Talang Akar and basement formation. The process of depth structure map with conversion time structure map using velocity model. The velocity model is obtained from sonic which has previously been corrected using check shot data. depth structure maps with the conversion results in formation Gumai, Talang Akar and basements can be seen in figure 2.

The next step of this research is analysis inversion using based model method. Principle of this method is to determine the value of the reflection coefficient the well data using wavelet, after while make a synthetic amplitude model that is compared with seismic data close to well data. The smallest error percent calculation is performed to obtain maximum results and applied to each cross section of seismic data. The resulting value is the acoustic impedance value or commonly called AI. The result from AI will show the relationship between AI and TOC.

![Figure 1](image-url)

Figure 1. Composite seismic with two different vintage and different amplitude (top) and after balancing process (bottom) with the same amplitude value.
Passey et al. developed a technique used to identify and calculate % TOC in organic matter enriched rock [2]. This method involves the overlaying of a properly scaled porosity log on a deep resistivity curve. The mathematics of TOC calculation based on Passey method are shown in equation 1 and equation 2.

\[
\Delta \log R = \log \left( \frac{R}{R_{baseline}} \right) + 0.02 \times \log \left( \frac{DT}{DT_{baseline}} \right)
\]  

TOC = \Delta \log R \times 10^{(2.97-0.168 \times LOM)}

The application of the Passey, 1990 method was carried out on several wells with good data completeness [2]. Based on equation 1 and equation 2, the data that can be used to calculate TOC prediction is well data which has complete sonic log data and resistivity logs and good geochemical laboratory samples. In this study wells that have good data are well A3 and well A6. The initial stage in conducting TOC prediction is by making LOM (level of organic maturity) with a plot between TOC and S2 which is intended to determine the maturity of the source rock. Figure 3 is the result of LOM in
wells A3 and A6 which shows LOM in A3 wells ranging between 8 and 9, while in well A6 between 9 and 10.

The initial stage in carrying out TOC prediction is by stages of analysis then followed by overlaying between DT and ILD logs by doing logarithmic scaling on resistivity curves and sonic logs so that sonic log curves and resistivity logs overlay and become baselines are obtained. After overlaying and determining the baseline to calculate the amount of separation, equation 1 is used and followed by calculating the TOC log with equation 2. Figure 4a and figure 4b are the results of the TOC prediction. The result of the AI calculation will be transformed into TOC values by making an exponential relationship. Cross plot AI and TOC prediction for A6 in figure 5 shows an exponential trend relationship. This result used to transform AI venue to TOC venue as a vertical and letteral. The equation in the cross plot between AI and TOC is mathematically transformed using a vertical cross section of AI.

Figure 4. Results of prediction log TOC well A3 and A6.

Figure 5. Cross plot AI and TOC prediction Well A6, trend toward a positive relationship where the tendency for low AI values has a low TOC value while in high AI has a high TOC.
The essential inputs of maturity modeling are paleo heat flow. The source rock has been subjected to quality and quantity of organic matter in the sediment and kinetic equations for the calculation of kerogen conversion to oil and gas [3]. The first stage in modeling process is to evaluate the geological condition such as lithology, age, bathymetry, stratigraphy and also petroleum element. The second stage is calculated paleo heat temperature and interpretation geological events (tectonic) [4]. The present temperature can reconstruct the temperature history from borehole temperature.

Composite seismic was used as the representative cross-section of the area. Subsurface reconstruction will be continued with the analysis distribution of potential source rock using AI and TOC, that the distribution of potential source rock. This model is possible to simulate time to time based on geological even, so the result shows the maturity of source rock in research area.

3. Results and discussion

Cross plot analysis conducted using data available from AI and porosity in the well data A3 and A6 is shown in figure 6. The result of a cross plot between AI and porosity in the Talang Akar and Gumai formation with the background color of the gamma ray value, where yellow refers to sandstone lithology and green refers to shale lithology.

Based on cross plot AI and porosity Gumai formation has an impedance value of 5000 to 6000 (m/s)*(g/cc) that correlates with porosity of 0.4 to 0.5%, which indicates that rocks quite good characteristics. While the Talang Akar formation has an impedance value of 6000 to 9000 (m/s)*(g/cc) correlated with porosity of 0.15 to 0.4% indicating that rocks are less porous or non-porous, with this value analogous to including shale lithology with sand intersection. Based on the result of the AI with Porosity, interpret that Talang Akar formation more dominant against non-porous rock is shale. Based on log interpretation that Talang Akar formation dominated of shale with depositional environment is deltaic fluvial.

The next cross analysis was AI and TOC prediction in the well data A3 and A6 as shown in figure 7. The Gumai formation in the well A3 has an Impedance value of 5000 to 6000 (m/s)*(g/cc) correlated with a TOC value of 0.6 to 1.4% wt which indicates that rocks with this impedance value

![Figure 6. Cross plot of AI and porosity using available data of: A. Gumai formation well A3, B. Talang Akar formation well A3, C. Gumai formation well A6, and D. Talang Akar formation well A6.](image-url)
have poor potential of source rock. Talang Akar formation with impedance of 6000 to 9000 (m/s)*(g/cc) correlates with TOC 1.4 to 3 %wt. indicates the rock with impedance value has very good potential as a source rock. The Gumai formation in the well A6 has impedance value of 5000 to 11000 (m/s)*(g/cc) correlated with TOC value of 1 to 3.4 % wt, which indicates that rocks with this impedance value have a good potential of source rock. Talang Akar formation with impedance of 12000 to 16000 (m/s)*(g/cc) indicates the rock with impedace value have a very good potential source rock. Difference in results between A3 and A6 well is influenced by either the geological aspects of each well or area. This is evidenced in 2 dimensional modeling to determine the geological concept of the research area.

The depositional thickness in basin on isopach maps overlay with AI is shown in figure 8a. The results of AI extraction are deltaic depositional environment pattern associated with the lacustrine environment with sediment supply originating from the northeast to southwest shown in figure 8b. This are identified has kerogen type III which the characterized by availability of organic material rich such as lignite and low hydrocarbon composite. The results of the TOC distribution shown in figure 8c, the highest TOC value was found in the low area associated with the deposition environment of lacustrine. In sediment supply area that associated with good porous material has TOC value is low, it can be concluded that this area has poor potential as a source rock.

Isopach map of Gumai formation is shown in figure 9. Isochore map overlay with AI, the map can be interpreted as a change to the pattern of depths that points towards east in western direction of the study. Changes in lamination of the west direction indicate a change in depositional environment leading to the northwest towards more landward direction with rocks identified as having low porosity. The result of AI extraction shows figure 9b. This extraction AI identified more porous rock that show a pattern of direction sediment supply which trends is northeast to southwest. The results of predict TOC is shown in figure 9c. The direction sediment supply which trends is Northwest towards more landward direction with 2D modeling result is shown in figure 10. The evolution basin model and maturity model source rock from time to time. The evolution of basin describe sediment deposition process and event tectonic that can change the maturity model [5]. Based on the result are location has a 3 tectonic event.

The first event is th syn-rift phase, this event occurs starting from the deposition of the Lemat formation to the Talang Akar formation during the Late Eocene to the Early Miocene (Intra N9) period.
The second phase is the sagging phase or the postrift phase. In this phase, the activation starts from the bounding fault. General passive rifting is characterized by the presence of marine deposits whose thickness is relatively constant as an example of sedimentary rocks will be deposits whose thickness is relatively constant as an example of a carbonate platform, whereas active rifting that can show the pattern of change into the passive margin basin and sedimentary rocks will be deposited with a relatively constant thickness with the depositional environment towards the open marine. The third phase is event inversion or tectonic activation, the appointment takes place. This event is the age of 5 ma (Plio-Plistosen). In this inversion event a compression force occurs which results in the activation of the old faults formed in the early tertiary and characterized by rising faults with sharp angles as a result of reactivation of normal faults.

Based on 2D maturity model shown in figure 10, the maturity pattern is known in lower basin. In this study are found the middle Miocene age with Ro value 0.6 %. The more occurrence of the subsidence process caused by the loading the sedimentation process, making the source rock will over mature. In the high area maximum Ro value is around 0.9 %, interpreted as maturity occurring only in the lower area that migrate hydrocarbon to high.

Figure 8. (a) Isopach map Gumai formation, (b) Extraction AI Gumai formation, and (c) Extraction TOC Gumai formation.

Figure 9. (a) Isopach map Talang Akar formation, (B) Extraction AI Talang Akar formation, and (c) Extraction TOC Talang akar formation.
4. Conclusion
In this study, the maturity model of a part of Jambi sub basin is characterized and modeled. In the order to accomplish this, geochemical, geophysical and geological studies are combined which include 2D seismic volume, borehole data and literature information which are used for reconstruction of the geological history of the study area. Thermal maturation history, timing hydrocarbon generation in this study are prediction from model result. The observed organic thermal maturity measurement in the study area indicate that Talang Akar source rock is at mature to overmatured stage as in the case of 2D model. The maturity of Talang Akar source rock increases gradually towards the southeast (lower basin) due to change in depth of burial. Measured maturity indices show gradual increase in thermal maturity with depth.

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