Burial History, Thermal Maturation, and Source Rock Evaluation of Ngimbang Formation in East Java Basin

Aditya Pradono¹, Dadali Rakasiwi²

¹Geological Engineering of Trisakti University Alumni, Indonesia
²Sele Raya Energi, Indonesia

adityapradono@live.com

Abstract. East Java Basin is the back-arc basin and it was the result of collision between the Indian Plate and Sunda Microplate. East Java Basin was formed in Early Tertiary subduction and it is related on the process in Java. In the exploration of Indonesian Basin over years, East Java is one of the successful hydrocarbon producers in Indonesia. In East Java Basin especially Rembang Zone, The Middle Eocene Ngimbang Formation is known as source rock materials. It consists of sandstone, siltstone, limestone, shale, and coal seams. The objective of this research is to determine the hydrocarbon source rock potential based on geochemical analyses and thermal maturation by making basin model. The main target source rock formation is Middle Eocene Ngimbang Formation. Log, seismic, and geochemical sample are the primary data in this research. These methods help the sense of exploring the new hydrocarbon potential. According to geochemical analyses, the source rock potential within TOC value in this area is good – very good. Fine sediments of Middle Eocene Ngimbang Formation tend to produce oil and gas originated from kerogen types II/III. Furthermore, the migration pathway started from south to north. Generation, migration, accumulation, and preservation occurred in Early Miocene.

1. Introduction
East Java Basin is one of the hydrocarbon producers in Indonesia and it consists of Rembang Zone, Randublatung Zone, Kendeng Zone, and Southern Mountain Arc [1]. In Rembang Zone, there is a well-known formation that proved to be source of hydrocarbon which is Middle Eocene Ngimbang Formation[2] (Figure 1).

Basin modeling and geochemistry source rock have been performed to reconstruct the burial histories, thermal maturation and potential of target source rock [3–6][7][8]. With integrated basin modeling and geochemistry techniques, it can be used to tell us how and when source rocks are changed to hydrocarbons and to be matured[8–10].

In this research, two wells are modeled in 1D to illustrate the difference burial history, thermal maturity, and hydrocarbon timing of generation in East Java Basin. It helps to reduce the geological exploration risk.
2. Data and Method
Log and seismic analyses have been conducted to make correlation between wells and subsurface map for analyzing the hydrocarbon migration routes. Moreover, geochemistry characteristics including TOC and Rock-Eval Pyrolysis have been analyzed by interpreting in various cross-plot diagrams [3][11].

In 1D basin modeling, these wells penetrate significant portions of geological section and maturity level in the Basin. It helps for calculating and calibrating the model and also reconstructing the burial history curves[12][6,13].

3. Result and Discussion
3.1. Source Rock Potential
TOC and Rock-Eval Pyrolysis have been used to construct in the modified Van Krevelen diagrams (Figure 2). By comparing TOC versus Tmax, both of two wells in Ngimbang Formation show that potential of source rock is good – very good. The TOC versus S2 diagram explains that X-1 well is kerogen type III/gas prone while X-2 well varied in kerogen type II (oil prone usually marine) until type III (gas prone).

3.2 Thermal Maturation
There are several modified Van Krevelen diagrams that have been used in this research including Tmax versus HI and Vitrinite Reflectance versus HI (Figure 2). In X-1 well, it shows type II and III but the source rock has not matured yet. However, X-2 well is type II and the majority of source rock has not matured but there is slightly explanation that maturity increased. Moreover, the Vitrinite Reflectance versus HI diagram illustrates X-1 well is immature and type II while X-2 well is immature-mature and type II-III.

3.3 Burial History and Basin Modeling
Burial history and thermal maturation are provided in this research (Figure 4) and (Figure 5). Both of two wells using Neglia’s bore-hole-temperature correction data for temperature fitting with burial history model. In X-1 well, it takes approximately 168-214°F (20.91-19.93 Ma) and still increasing until reached the peak of heat (217.36°F). Temperature fitting calibration is a good matched compared to
burial history. On the other hand, it takes around 186.22-261.58°F during Neogene time (23.5-18.22 Ma) and still heating until 293.6°F in 16.36 Ma. Temperature fitting is a good calibration.

**Figure 2.** (a) Source Rock Potential of Ngimbang Formation; (b) Thermal Maturation of Ngimbang Formation

**Figure 3.** Burial History and Temperature of X-1 well

**Figure 4.** Burial History and Temperature of X-2 well
The relationship between measured and modeled vitrinite reflectance of both wells have been conducted to know source rock maturity (Figure 6) and (Figure 7). The lowest maturity level (0.27% Ro) and highest maturity level (0.72% Ro) of X-1 well show good matched calibration data between vitrinite reflectance and burial history model. Otherwise, in X-2 well, the lowest maturity level at 0.29% Ro and the highest level at 1.07% Ro. The calibration indicates fair matched.

Figure 5. Burial History and Vitrinite Reflectance of X-1 well

The burial history models are superposed with oil and gas window limits for both wells (Figure 8) and (Figure 9). The hydrocarbon generation of X-1 well is expected to start in 19.66 Ma at depth 5470 ft. Moreover, the generation of hydrocarbon in X-2 well explains that started from 22.67 Ma at depth 5879 ft. As can be seen from both of the burial history models, the generation of hydrocarbon started from Early Miocene.

Figure 6. Burial History and Vitrinite Reflectance of X-2 well
3.4 Migration Pathway

With using subsurface mapping techniques, it gives an insight the deeper/the higher and the thicker/thinner of sedimentary depositions. By using isopach map as indicator to predict the hydrocarbon migration routes (Figure 10), it started from south to north of the research area.
4. Conclusion
The results of Middle Eocene Ngimbang Formation source rock characteristics between two wells indicate both wells have good-very good TOC value and divided into kerogen type III (X-1 well) and kerogen type II/III (X-2 well). Furthermore, the reconstruction of burial history models explained that both of two wells began to generate hydrocarbon from the Early Miocene (19.66 in X-1 well) and (22.67 in X-2 well) respectively. Hydrocarbon migration routes started from south to north of the research area. It will give the sense of exploring new potential and reducing risk.

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