Reservoir and Source Rock Identification Based on Geological, Geophysics and Petrophysics Analysis Study Case: South Sumatra Basin

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Abstract. Reservoir and source rock Identification has been performed to deliniate the reservoir distribution of Talangakar Formation South Sumatra Basin. This study is based on integrated geophysical, geological and petrophysical data. The aims of study to determine the characteristics of the reservoir and source rock, to differentiate reservoir and source rock in same Talangakar formation, to find out the distribution of net pay reservoir and source rock layers. The method of geophysical included seismic data interpretation using time and depth structures map, post-stack inversion, interval velocity, geological interpretations included the analysis of structures and faults, and petrophysical processing is interpret data log wells that penetrating Talangakar formation containing hydrocarbons (oil and gas). Based on seismic interpretation perform subsurface mapping on Layer A and Layer I to determine the development of structures in the Regional Research. Based on the geological interpretation, trapping in the form of regional research is anticline structure on southwest-northeast trending and bounded by normal faults on the southwest-southeast regional research structure. Based on petrophysical analysis, the main reservoir in the field of research, is a layer 1,375 m of depth and a thickness 2 to 8.3 meters.

1. Introduction

The research area localized within TalangAkar Formation, South Sumatra Basin. South Sumatra basin is a back-arc basin that have trough and graben. An altitude that has a NNE-SSW direction through the Northern Mountains of Thirty limits this basin [1]. Tertiary sedimentation in South Sumatra Basin consists of Lahat Formation, Formation Talangakar, Balfour Formation, Formation Gumai, Airbenakat Formation, Formation and Formation Muaraenim Kasai [2]. South Sumatra basin has some good field of oil and gas production, such as Abab field, Benakat, Bentayan, Jene. KenaliAsam, Limau (Niru), Musi, King, Ramba, Rambutan, Rawa, TalangAkar, JimarTalang, Tanjung Laban, Leaning TanjungTimur, TanjungTiga Barat, etc [3].

TalangAkar formation reservoir consists of quartzose sandstones, siltstones, and shales [4] deposited in a delta plain setting that changed to be open marine, nearshore, delta plain, delta, distributary channel, fluvial, and beach environments, based on sequence correlation, core analysis, and palinomorf fossil analysis [5].

Reservoir characteristics in exploration used to determine the traps of hydrocarbons, reservoir sedimentation models, etc [6]. Reservoir characteristics consist of various methods, including seismic
inversion, seismic attributes, multi-attribute seismic, petrophysics, etc [7]. In this research, analyzes crossplot is on several parameters interactively, so that a very small change of physical parameters expected to be able to show anomalies that can differentiate the reservoir and source rock. This research aims to determine the characteristics of the reservoir and source rock of the study area, to distinguish reservoir and source rock in the formation of the TalangAkar formation, and to determine the distribution of net pay reservoir.

2. Geophysics, Geology and Petrophysics Analysis Data
The research-interpreted horizons generally is not be difficult to determined, there is only the reflectors on the horizon deeper penetration as a result influenced by the level of seismic and basement. There are four horizons are interpreted and considered synonymous with surface formations.

Stages of this research are as follows:
- Identification potential reservoir area covered by analyzing well, seismic and petrophysics data (Figure 1.a).
- Well seismic tie which tied from seismic data to well data, initially it is convert well data into time domain using the checkshot data and combined with sonic data.
- Picking the horizon, rock bedding has a pattern that follows strata or deposition pattern based on composite seismic Map (Figure 1.b).

![Figure 1. Composite seismic Map A-A’ direction.](image)

- Post stack inversion, on every 2D seismic been applied.
- Identification of geological such as fault and elevation of subsurface aims to get time structure map and depth structure map.
- Using petrophysical data of well 11at the study area, its’ result is net pay value of each well.

3. Result and Discussion
The result of seismic and completeness analysis, there are four vintage seismic in research area. The differences of existence of vintage will affect the process of seismic interpretation. Therefore, the process of miss tie analysis is in order to facilitate the next process. Seismic interpretations generally generate horizons that not difficult to interpreted. There are four horizons to be analyzed that equivalent with layer A, I, D, and BRF at the well data (Figure 1.b).

Subsurface geological mapping analyzed after completion of picking horizon. In addition, several faults observed in each seismic path in the analysis of their severity, which indicate the uniformity of geological phenomenon. It is shown by time structure and depth structure map. Depth structure map obtained from time structure map and generating velocity model of the seismic cube. Further analysis of the subsurface geological mapping done on the layer I and A (Figure 2).
Layer I (Figure 2a) has northwest trending fault structure that still controls the fault pattern in this area. This fault assumed a continuation of the underlying fault that occurs after the synrifting phase ends. This phenomenon seen from the thickness and relative pattern of the relatively equal in the seismic data in the study area. The depth of this heights structure lies at 1300 msec or 1475 mss (north altitude) and 1315 msec or 1480 mss (south altitude). While the low structure is in the north of the research area with a depth of 1450 msec or 1600 mss.

Layer A (Figure 2b) is the main reservoir of the research area, stratigraphically constituting part of TalangAkar Formation. The sandstone with a fluviatile precipitation mechanism dominates from layer A. Normal fault with northeast-southwest direction still developing and controlling the sedimentation in this layer. The height structure on the structure contour map is generally still relatively in the same position as the previous layer, with a depth of 1175 msec or 1275 mss around 01 well, 02, 03, 05, 07 that indicate research area has anticline structural capture model. While the lower structure is in the north with a depth of 1250 msec or 1375 mss and 1225 msec or 1300 mss on the southern part of this area. The research-interpreted horizons generally is not be difficult to determined, there is only the reflectors on the horizon deeper penetration as a result influenced by the level of seismic and basement. There are four horizons are interpreted and considered synonymous with surface formations.

The next step is post stack inversion that used acoustic impedance parameter (Figure 3). In this study used three seismic lines tied to the wells in the field of research area. The wavelet performed by the extraction of all well data using Top A and Top I of the window parameters is about 1350 - 1900 ms, 150 ms wavelet length, 20 ms taper length, 2 ms sampling rate with constant phase type. Log and seismic correlation results using statistical wavelets can be seen in (Figure 3) with an error value of 345 - 436.
Figure 3 Analysis of Acoustic Impedance inversion at line 78-p-01.

Figure 4. The result of seismic inversion at line 78-p-01
Differences of impedance values distinguished from each layer (Figure 4). There is a low value impedance anomaly on a 1420 ms - 1430 ms time scale marked in green to reddish yellow (also indicated by blue arrows) with an impedance value of 2,041 - 4200 (m / s) * (g / cc). The anomaly is continuous from the middle of the seismic line to the northeast of the field. This low anomaly interpreted a sandstone lithology that has good porosity whereas high value anomalies interpreted to the presence of strong flakes at the lower layers.

Petrophysical analysis at the last step of this study that aim to determine important parameters of reservoir rock physics properties such as shale content (Vsh), porosity (Ø) and water saturation (Sw) in relation to calculating gas and oil in place and net pay of the sandstone (Table 1).

| Table 1. Net Pay result of the well study area. |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| NET Pay (m) in Layer | WELL |
|-----------------|-----------------|-----------------|-----------------|-----------------|-----------------|
| A | I | C | D | E | K |
| 2.9 | 4 | 3 | 4 | 9 | 7.46 | 01 |
| 3.2 | 0 | 2.74 | 0.61 | 0.61 | 0 | 02 |
| 0 | 0 | 2.44 | 0 | 0 | 1.34 | 03 |
| 3.51 | 2.29 | 0 | 3.05 | 2.44 | 13.72 | 04 |
| 1.55 | 0 | 2.74 | 2.9 | 2.29 | 13.56 | 05 |
| 0 | 0 | 1.07 | 2.29 | 0 | 17.95 | 06 |
| 6.29 | 4.72 | 1.37 | 2.13 | 3.05 | 3.59 | 07 |
| 7.77 | 0.46 | 0.61 | 3 | 2.13 | 0 | 08 |
| 2.44 | 0 | 0 | 2.59 | 0 | 4.03 | 09 |
| 5.53 | 0 | 0 | 4.11 | 6.4 | 0 | 10 |
| 5.79 | 1.9S | 1.6S | 4.63 | 2.74 | 12.19 | 11 |

Based on the net pay value data (Table 1), wells have abandoned status ie 03,05,06,09 have very low value in both layer A and I about 0-2 m. While on 01, 02, 04, 07, 08, 10- wells that have a suspended status, that have better net pay value than abandon wells that about 2.5 to 8.3 m in layers A and 1.8 to 5 meters in layers I. The 11-well are located around the descendants located in the southwest of the fault section that pass through the southwest-northeast direction so that it still have production status.

Based on side wall data of well-11 (Table 2) depth of 1426.00 - 1623.50 meters is classified as medium potential - very good (TOC = 0.65 - 2.68%) as source rock, except 1386.00 m (TOC <0.5%). Petrophysical analysis got the net pay value, which generating of Layer I with thickness 1.98 m. At 1386 m depth, on side wall data cores have 0.4% TOC and 0.42 maturity level (Ro), and interpreted low relative, it is possible to be reservoir zone, whereas in petrophysical analysis it is obtained net pay value which is equivalent to Layer A with 5.79 m of thickness.

| Table 2 Potential Data of Source Rock Well-11 |
|-----------------|-------------|-------------|-------|-------|-------|-------|
| No | Dept (m) | Sample | Lithology | TOC (%) | Tmaks (°C) | HI | Ro (%) |
|-----------------|-------------|-------------|-------|-------|-------|-------|
| 1 | 1386 | SWC | Sandstone | 0.4 | 426 | 74 | 0.42 |
| 2 | 1426 | SWC | Shally Sandstone | 0.65 | 433 | 105 | 0.43 |
| 3 | 1512 | SWC | Sandy Shale | 2.23 | 435 | 145 | 0.51 |
| 4 | 1612 | SWC | Sandy Shale | 1.87 | 436 | 124 | 0.53 |
| 5 | 1623 | SWC | Sandy Shale | 2.68 | 437 | 116 | 0.54 |
4. Conclusions
Based on the results of research that is the integration of geological analysis, geophysics, and petrophysics of several things as follows, the main reservoir layer of this research is the Talang-Akar Formation consisting of Layer A and Layer I to be source rock. The research area has anticline structure trending southwest northeast, that bordered by the normal fracture in the southwest and southeast structures. Performed by petrophysical analysis, the main reservoir in the research area is the layer A with depth = 1375 m and thickness value is 2 - 8.3 meters. While validation data is using side wall cores data of well-11, the potential layer as the source rock is about 1512 m that based on geochemical data equivalent to layer I which still at the Talang-Akar.

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