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Detection of Gas Reservoir at Banyuasin Field by using Amplitude versus Offset (AVO) Analysis

Andiani Latania[1], Eleonora Agustine[1], Humbang Purba[2], Ricky A Tampubolon[3]
[1]Department of Geophysics, Universitas Padjadaran
[2]PPPTMG Lemigas
[3]Odira Energy Karang Agung

andianilatania55@gmail.com

Abstract

Banyuasin Field is indicated to have gaseous hydrocarbons based on well data. The purpose of this study is to examine the distribution of gas hydrocarbons in the Telisa and Talang Akar Formation, which are reservoir rocks that are dominated by sandstone lithology. Amplitude versus Offset (AVO) analysis is used as a method in this study, based on the response to changes in amplitude at the offset/angle. To determine AVO responses towards seismic data, gradient analysis and AVO product were performed using the intercept and gradient attributes. Gradient analysis is made by making intercept-gradient graphs in determining the type of fluid based on the AVO class. The AVO product is a result of multiplication between the intercept and gradient so that the distribution of gas hydrocarbons on a seismic cross-section can be seen. Based on the results of the analysis on the Telisa Top Formation in Zone 1, AVO response of class III was obtained, which indicated the presence of gas hydrocarbon and Zone 2 AVO response of class II P and I was obtained which indicated the presence of wet sand. The top of the Talang Akar Formation in both target zones is identified as an AVO class IV response, indicating the presence of coal. The difference in response is caused by the impedance contrast of the sandstone in the target zone. For gas hydrocarbons, the impedance response of sandstone is small because the layer of porous sandstone is filled with gas. This causes magnitude of Vp to become smaller than Vs which causes the amplitude to increase as the offset/angle increases and AVO product has positive value on the seismic section.

Keywords: AVO, gas, intercept, gradient

Introduction

The Banyuasin field is located in the South Sumatra Basin which is a field with gas hydrocarbon potential (Figure 1). The existence well production wells have proven the presence of hydrocarbon (Figure 2 and Figure 3). However, it is still necessary to conduct field development studies to find new potentials and optimize the distribution of gaseous hydrocarbons laterally through a reservoir characterization approach. In the study area, the reservoirs targeted for gas production are the sandstones of the Telisa formation and the sandstones of the Talang Akar formation. Laterally, the gas-saturated reservoir can be identified quantitatively.

Amplitude versus Offset (AVO) is one of the seismic interpretation methods that can characterize gas hydrocarbon reservoirs by amplitude response to the offset. The Reservoir saturated gaseous hydrocarbons cause Vp response to get decreased and the Vs tends to have a constant velocity. This gives the effect of increasing the amplitude (bright spot) and the response provides information that the reservoir is saturated with gaseous hydrocarbons (Castanga and Swan, 1997).

Data and Method

1. Data

In this study, the data used include: 2D Pre-stack gather seismic data with preserve amplitude, well recordings (gamma ray, sonic, density) and petrophysics data (water saturation) as validators for the presence of gaseous hydrocarbons.

2. Geological Regional

Banyuasin Field is located in the South Sumatera Basin with formed the early Tertiary from the Eocene to Oligocene. Where Telisa Formation as a cap rock and reservoir rock. The Talang Akar Formation is the main reservoir to produce hydrocarbons. Both formations are dominated by sandstone lithology.

3. Method

3.1. Gradient Analysis

The conditioned seismic data were used in classifying the AVO class as has been done by Rutherford and William (1989) are divided into three classes later developed by Ross and Kinmann (1995) and Castagna, et al (1997). Picking data is carried out in the target zone adjacent to the well. So that it will be plotted in the intercept and gradient graph that is adjusted to the AVO class classification. In the graph, the point distribution will be obtained as an amplitude response for each angle change and the graph formed is a response model based on velocity data. Detection of the presence of gas can be shown from the amplitude response which is getting stronger for each angle shown in the class 3 AVO response.

3.2 Product AVO

Aki-Richard made an equation that became the basis of AVO by separating Vp, Vs, and density and was able to explain the relationship with the amplitude of the physical characteristics of rocks such as the following equation.

$$R(\theta) = A + B\ sin^2\theta$$

Product AVO is an attribute that is the result of multiplication between intercept and gradient (A*B) which can be used to determine the distribution of Direct Hydrocarbon Indicator (DHI), especially bright spots (Wibowo, 2020).

Result and Discussion

Gradient Analysis

Gradient analysis by using angle gather data has aim of seeing the amplitude response at every angle change that occurs. These responses can be categorized according to AVO classification which can knowing the type of fluid contained in the target zone.

The results of gradient analysis at APOLLO-1 well have amplitude response of Telisa Formation shows an increase in the amplitude value (Figure 4). This indicates the reservoir is saturated with gaseous hydrocarbons and can be categorized as a class III AVO anomaly response. Due to the influence of Vp, which decreases drastically as it passes through the porous sandstone filled with gas. Vs response from the beginning has seen constant changes that tend to have a faster velocity than the Vp impedance response with low value, known as the bright spot.

The results of the gradient analysis in the APOLLO-4 well have amplitude response in the Telisa Formation shows that there is a polarity reversal (Figure 5). This can be caused by the difference in impedance of the upper layer which is higher than the reservoir layer, which is the response of wet sand with gas fluid which is tight. This response is categorized as an AVO class II P anomaly with a change in polarity at the mid stack angle.

Top Talang Akar Formation for APOLLO-1 and APOLLO 2 have AVO response is decrease in amplitude at each change of angle because of their dimming effect. This indicates the presence of a coal seam that has a low density and velocity so that the ratio of Vp and Vs is not very significant. Such a response can be categorized as class IV response AVO anomalies.

The results of the overall gradient analysis of the wells in the study area are as shown in table 1.

Product AVO

AVO product is used to detect the distribution of gaseous hydrocarbons in the target reservoir. In zone 1 of the Telisa Formation, it indicates the presence of gaseous hydrocarbons with a positive anomaly response of 0.7-1 (Figure 6). In Zone 2, the Talang Akar Formation gives a positive anomaly response of 0.6-0.9 (Figure 7). Based on the AVO analysis that has been carried out, it can be seen that the two target reservoirs have a stronger amplitude anomaly response (brightspot) as the angle increases.

AVO product can show the distribution of gas on a seismic cross section with a positive AVO product value. Zone 1 has a range value of 0.6 – 1 and Zone 2 has a value of 0.6 – 0.9. This is influenced by the depth of the reservoir. Because the deeper the level of rock compaction, the greater the value of the acoustic impedance will increase. This is evident in Zone 1 which has a depth of about 220-240 m providing a greater AVO product response value compared to Zone 2 which has a depth of 1100-1360 m.

Conclusions

The gaseous hydrocarbon saturated reservoir is known from the increase in the amplitude value for each angle can be classified as AVO class III response. The response was obtained in the Top Telisa Formation in Zone 1 and in the Talang Talang Akar Formation in Zone 2 of the study area. Distribution of gaseous hydrocarbon saturated reservoirs is laterally in the Top Telisa Formation in Zone 1 and Talang Akar Formation in Zone 2 with a positive AVO product response shown.

References

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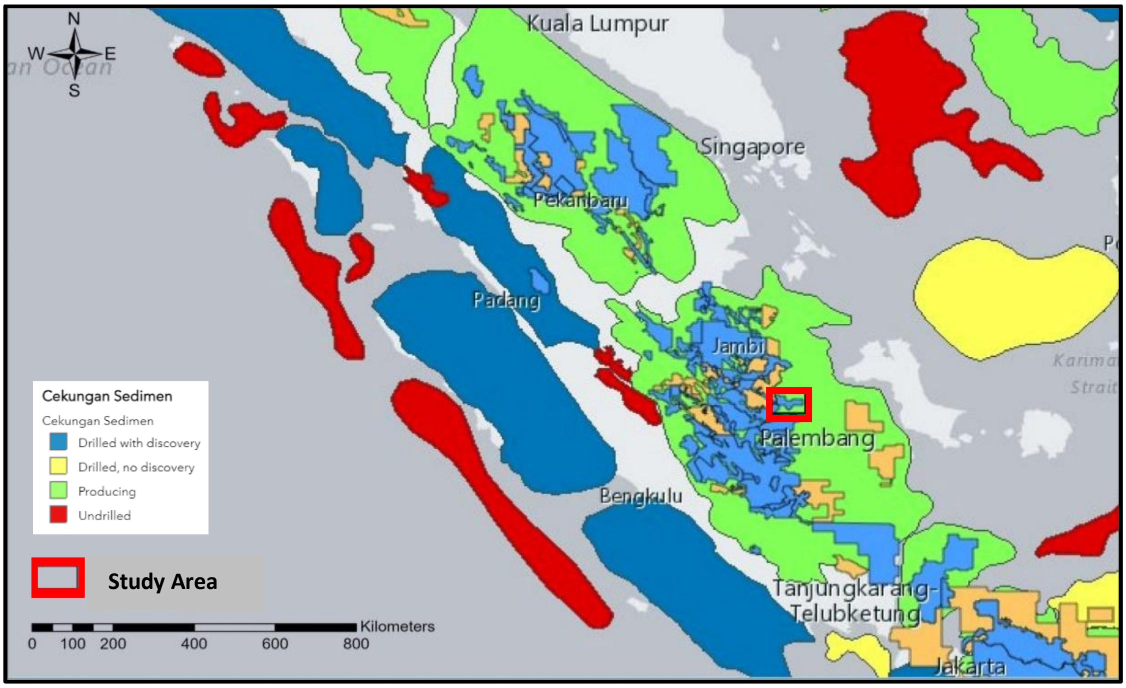

Figure 1: Location of Banyuasin Field Research Area, South Sumatra Basin (Basemap ESDM One Map, 2020)

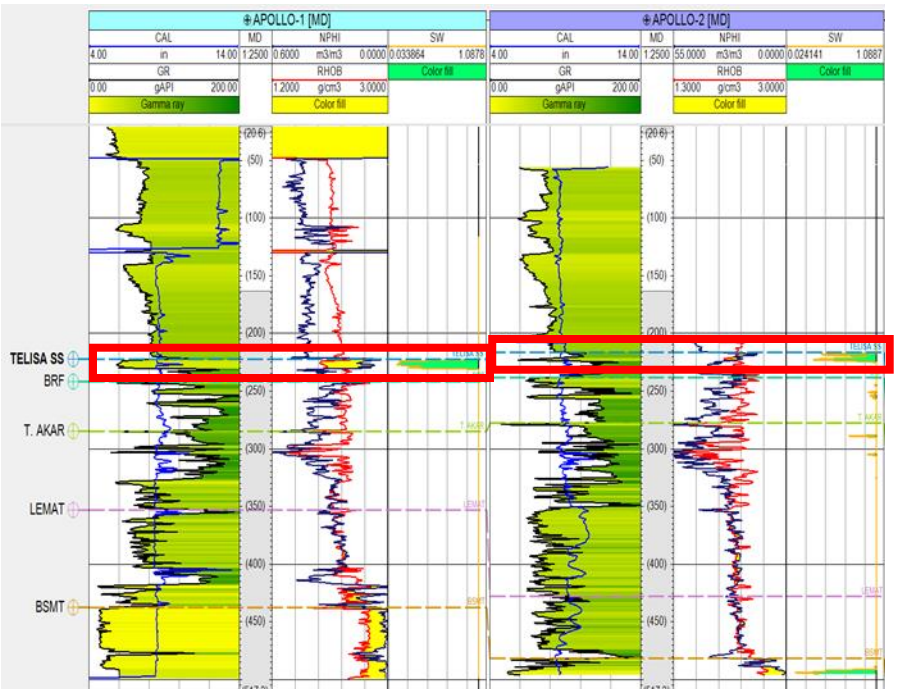

Figure 2: Well Information in Zone 1, Banyuasin Field

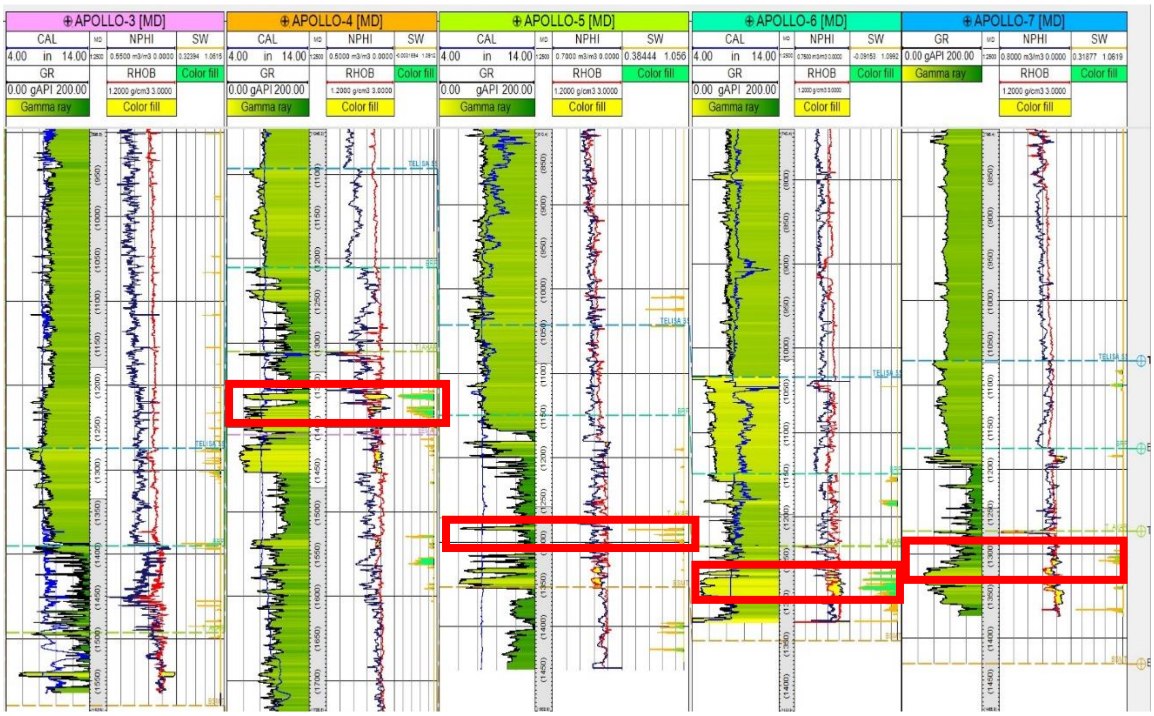

Figure 3: Well Information in Zone 2, Banyuasin Field

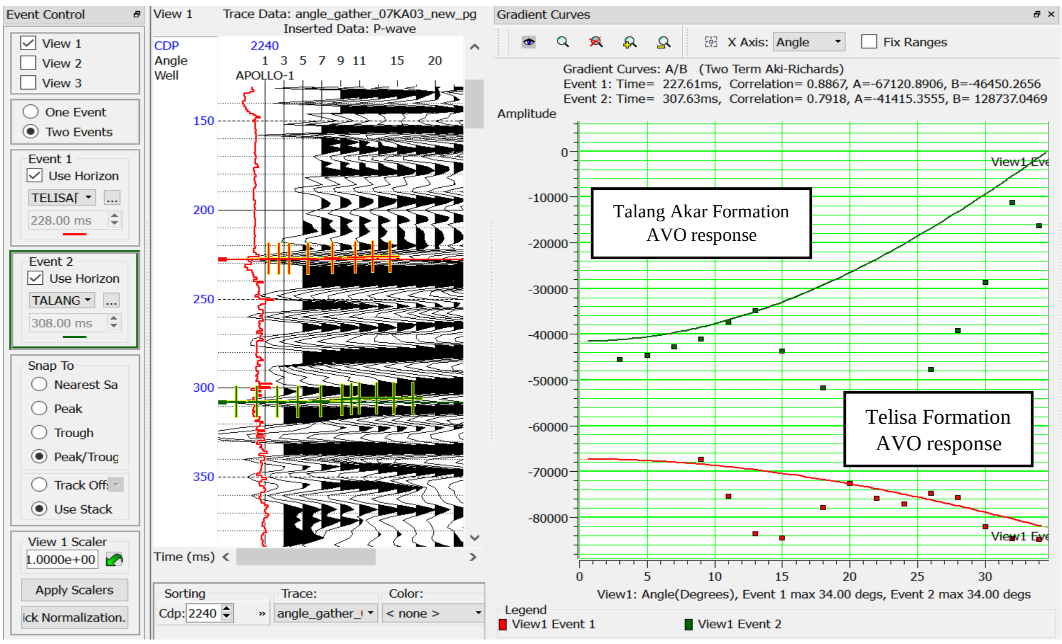

Figure 4: Gradient Analysis in APOLLO-1, Zone 1

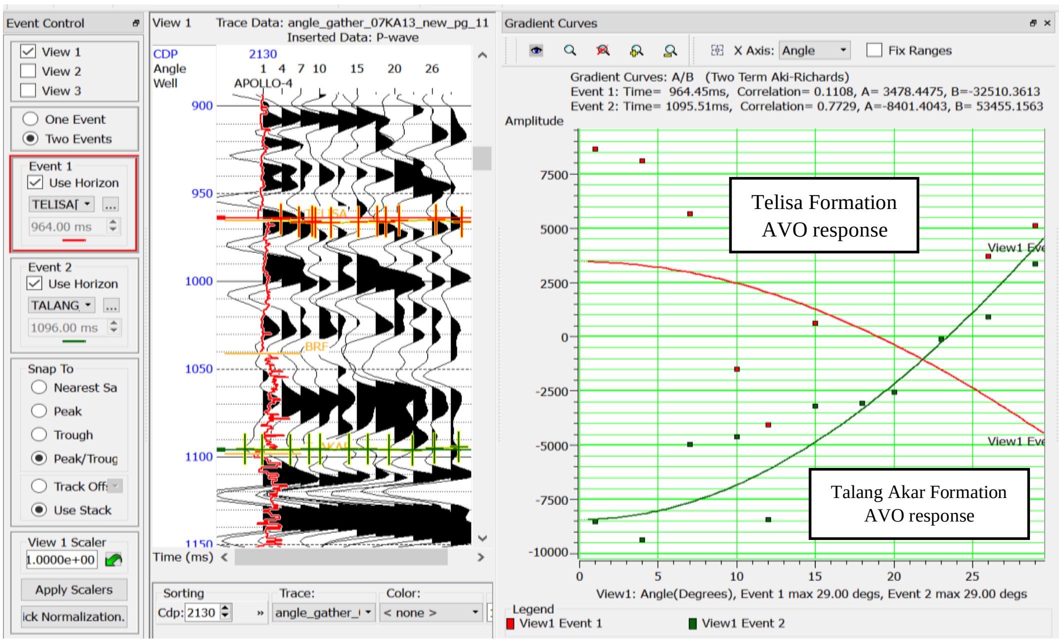

Figure 5: Gradient Analysis in APOLLO-4, Zone 2

Seismic Trace	Well	AVO Class	
		Telisa	Talang Akar
07KA03	APOLLO-1	III	IV
07KA04	APOLLO-2	III	IV
07KA07	APOLLO-3	II P	IV
07KA13	APOLLO-4	II P	IV
07KA14	APOLLO-5	II P	IV
07KA15	APOLLO-6	II P	IV
07KA18	APOLLO-7	I	IV

Table 1: AVO class classification results based on gradient analysis of wells in the study area

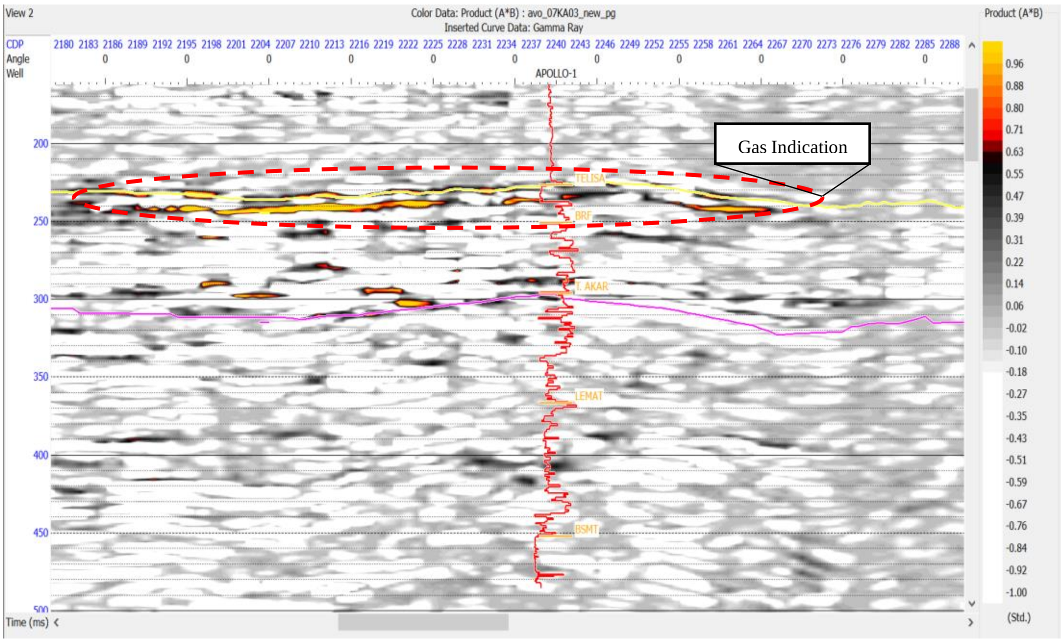

Figure 6: Product AVO in APOLLO-1, Zone 1

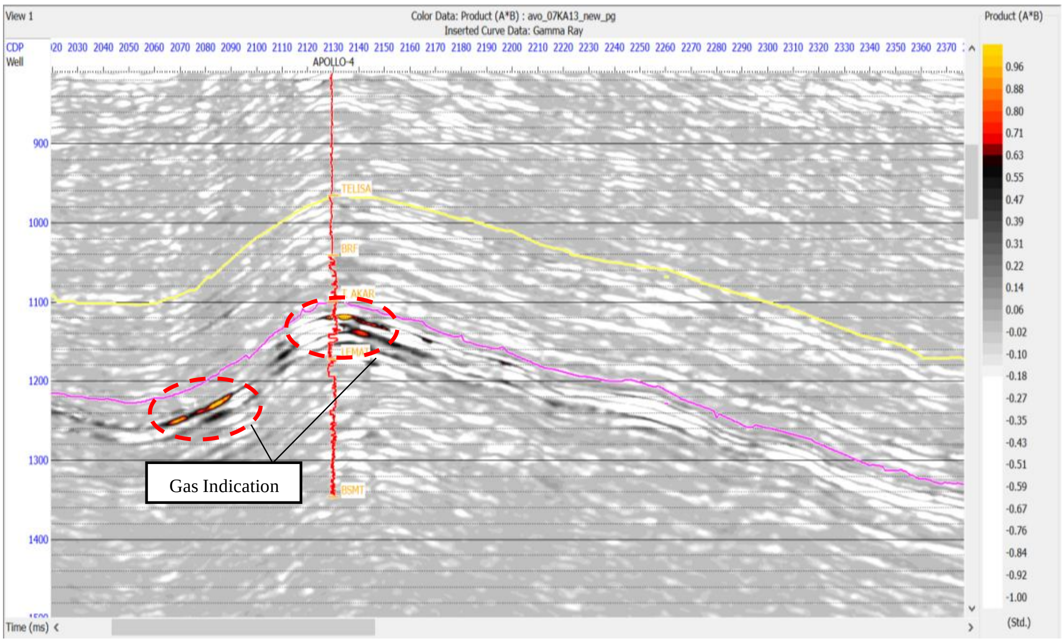

Figure 7: Product AVO in APOLLO-4, Zone 2