Kutei Basin oil bearing sand reservoirs mapping using integrated seismic methods

I M Easwara1, D S Ambarsari1, S Sukmono1, S Winardhi1, E Septama2, P D Wardaya2, V I Rossa2, B S Murdianto3, R Raguwanti2

1Geophysical Engineering Program Study, Bandung Institute of Technology, Jl. Ganesha 10 Bandung, Indonesia 40132
2PT Pertamina (Persero) Upstream Research & Technology Innovation, SopoDel Office Tower 50th Floor, Jl. Mega Kuningan Barat III, Jakarta, Indonesia 12950
3Pertamina Hulu Kalimantan Timur, CIBIS NINE Tower 9th Floor, Jl. TB Simatupang, Jakarta Selatan, Indonesia 12560

E-mail: sukmono@office.itb.ac.id

Abstract. The Lower Kutei Basin which contains several giant oil and gas fields is located on the East Kalimantan, Indonesia. This paper discusses the identification and mapping of oil-filled reservoirs and their depositional facies by integrating seismic stratigraphy, attributes, and AI (Acoustic Impedance) inversion methods. The log data cross-plots show that AI can be used to distinguish oil-sands from wet sands and shale, and to derive the total porosity of the sands. However, AI and amplitude values are greatly affected by the oil, porosity and tuning effects, hence they cannot be used to identify the facies containing the oil-bearing sands. Therefore, to map the facies containing the oil-filled sands, the AI map is combined with the variance and sweetness maps. It can be seen clearly from the variance and sweetness maps that the oil-sands suggested by the AI map are contained in a narrow and elongate meander-like geometry which is typical of channel facies. The variance and sweetness maps suggest that there are two channels in the study area. To determine which channel is thicker, spectral decomposition RGB map was made. The result suggests that the right channel is more prospective as it associates with thicker sand deposits. The combination of variance, sweetness and RGB maps strongly indicate that the channels in the study area are in upper-slope environment, and the thicker oil-sands are located in the eastward of the study area.

1. Introduction

The integration of seismic methods can become a powerful tool in hydrocarbon reservoirs identification and mapping. However, the approaches can be effective if the selected seismic attributes to be integrated match with the geological characteristics of the reservoirs. For examples, the study in [1] shows that the combination of amplitude and variance attributes can be used to map channel deposits in Melandong, NW Java basin area. On other studies for the same facies but located in different geological settings, the neural network-based attributes and the integration of amplitude and complex seismic attributes analysis were used [2], [3]. Meanwhile, for the Talang Akar channel deposits in south Sumatra basin, Indonesia, the study in [4] strongly indicates shows that seismic anisotropy is important parameters in seismic analysis. For exploration area with no well data, there are also several possibilities on seismic attributes integration to identify rocks facies and physical properties as discussed in [5]. As a common guidance,
study in [6] discussed the general seismic interpretation workflow for interpreting various reservoirs in Indonesia. The Kutei Basin which contains several giant oil and gas fields is located on the East Kalimantan, Indonesia (Figure 1). The prospective sand reservoirs are Eocene to present in age, and mostly deposited in upper shelf channels to basin floor fan facies. The dominant hydrocarbon trap in the basin is structural traps. The stratigraphic traps are harder to be identified as they often associate with thin layers. The study in [1]) shows that seismic inversion can be used to identify thick gas-filled reservoirs in the Sadewa field, Kutei basin. This paper discusses the identification and mapping of oil-filled reservoirs and their depositional facies by integrating seismic stratigraphy, attributes, and AI (Acoustic Impedance) inversion methods.

Figure 1. Location of the Kutei basin [1]. The study in [1] used seismic method to identify gas-sands in Sadewa field. This study focuses on the application of seismic methods to identify and map oil-sands in Kutei basin.
2. Data and Methods
In this study, the main data used are the 3D post stack time migration seismic and 3 wells data. Figure 2 displays a sample of seismic section showing the studied interval which lied between light green and white horizons. The Two-Way Time (TWT) map of the studied horizon and the wells’ locations are shown in Figure 2’ inset map. In the studied interval, the 3 wells discovered oil which associate with typical high seismic amplitude anomalies. From the log data, cross-plots of AI versus gamma-ray, oil saturation and total porosity can be made. The results show that AI can be used to distinguish oil-sands from wet sands and shale, and to derive the total porosity of the sands (Figure 3). It also explains why the porous oil-sands are reflected as high amplitude anomalies in the seismic sections.

The AI inversion was done by using the 3 wells. However, the weaknesses of using AI and amplitude attributes only to map the oil-sands are that they are not sensitive to the facies as their values are greatly affected by the oil saturation, porosity, and tuning effects. Therefore, to map the facies containing the oil-sands, AI is combined with the variance and sweetness attributes. The variance attribute measures of seismic traces similarity; therefore, it is effective to identify channel deposits. The sweetness attribute is the ratio of amplitude envelope maps to the frequency; thus, it will amplify the high-amplitude anomalies associated with oil-sands. Figure 4 shows the AI, variance, and sweetness maps of the studied interval. The variance map clearly shows the presences of narrow and elongate meander-like geometry features which are typical of channel facies. However, both AI and sweetness maps indicate that presumably oil-filled sands reflected by low-AI and high-sweetness areas are spotty and they are very likely associate with point-bar facies of the channels.

The variance and sweetness maps suggest that there are two channels in the study area. To determine which sand-filled channel is thicker, spectral decomposition RGB map was made. The result is shown in Figure 5 and suggesting that the right channel is more prospective as it associates with thicker sand deposits. The combination of variance, sweetness and RGB maps also strongly indicate that the channels in the study area are in upper-slope environment. Therefore, it can be expected that thicker oil-sands were deposited in the eastward of the study area.

**Figure 2.** A sample of seismic section showing typical high seismic amplitude anomalies of the oil-sand reservoirs. The studied interval lied light green and white horizons. Inset map shows the location of the section, wells and TWT contours of the light green horizon. Blueish and reddish colours in the TWT map related respectively to the shallower and deeper contours.
Figure 3. Cross-plots of AI versus (a) Gamma-ray, and (b) Total porosity from the studied interval in the three wells (Depths around 11000 – 13000 ft). Figure c shows a sample of AI and Gamma-ray log in Well-3.

Figure 4. The maps of AI (left), variance (middle) and sweetness (right) which are integrated to identify and map the facies containing the oil-sands. The maps present the related attribute values from the studied interval (light green to white horizons) window. The integrated maps show that the presumably oil-filled sands reflected by low-AI and high-sweetness areas are spotty and they are very-likely associate with point-bar facies of the channels.
Figure 5. The spectral decomposition RGB map showing that the sand in the right channel is relatively thicker than the sands in the left channel. The maps present the related attribute values from the studied interval (light green to white horizons) window.

3. Conclusions and Recommendations
Previous studies on the application of seismic methods for hydrocarbon identification in the Kutei basin were mostly focused on gas-sands cases. This paper shows that by using the appropriate attributes, the identification of oil-sands reservoirs and their facies are possible. In the studied area, the oil-sands were deposited in the upper slope channels. The AI and sweetness attributes can be used to identify and map the high amplitude anomalies associated with oil-filled sands. The sweetness and spectral decomposition are applicable for mapping the related facies and identifying relative thickness of the sands. The integrated attributes maps suggest that thicker oil-sands were deposited in the eastward of the study area.

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