Integrated analysis of spectral-decomposition, AI inversion and RMS amplitude attribute for determining sandstone reservoir distribution: A case study of ‘X’ field in Central Sumatera Basin

Suwondo1, A Haris2, A Riyanto2 and J Wiyono3

1Department of Physics, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
2Geoscience Study Program, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
3Oil and Gas Technology College (STT Migas) Balikpapan, Balikpapan 76127, Indonesia

Corresponding author’s email: aharis@sci.ui.ac.id

Abstract. The Sand A reservoir distribution in Bekasap Formation, ‘X’ Field, Central Sumatera Basin had been delineated using spectral decomposition, AI inversion, and RMS Amplitude attributes. There are onlapping feature of Bekasap Formation to the Basement High. The aim of this study is to identify the existence of oil reservoir in Bekasap Formation. The uncertainty of the subsurface model will be reduced with the integrated analysis. Spectral decomposition used frequencies of 20 Hz, 50 Hz, and 70 Hz. High amplitude with low frequency anomaly is showed by the 20 Hz frequency map and this anomaly considered as the reservoir zone. However, the amplitude anomalies are not showed by the two other frequency maps. This unique anomaly was verified by well data. The distribution of Top A reservoir was showed based on AI inversion, spectral decomposition of 20 Hz, and RMS attribute has direction of northeast-southwest on onlapping zone to the Basement High. This study concluded that combination of spectral decomposition, RMS Amplitude, and AI inversion analysis had been successful to delineate the sandstone reservoir.

Keywords: Spectral decomposition, RMS amplitude, AI, sandstone reservoir

1. Introduction

One of sedimentary basin which produces oil in Indonesia is Central Sumatra Basin. There is an ‘X’ field as an oil-producing field in the Central Sumatra. This field has several target formations, such as Bekasap Formation. The Top Bekasap onlap to the Basement in this field. The feature of onlapping become stratigraphic trap.

Based on the column stratigraphy (figure 1), the Bekasap Formation age is Early Miocene [1]. For the future development field, it is necessary for good understanding distribution reservoir. The aim of this study is to delineate the reservoir of Bekasap Formation using spectral decomposition, RMS Amplitude attribute, and AI inversion methods.
Figure 1. Bekasap formation is showed by blue box line in the general stratigraphy of Central Sumatra Basin (modified from Heidrick et al. [1]).

Spectral decomposition of seismic data qualitatively and quantitatively can help for interpretation, which can be used for seismic geomorphology analysis and net pay estimation [2]. Another application of this methods is looking for the presence of hydrocarbon [3]. Generally, this method uses continuous wavelet transform (CWT) and short time Fourier Transform (STFT). The principle of STFT method is using the width of a fixed wavelet window [4]. So, the method has a disadvantage of an unfavourable vertical resolution results at high frequency. While the CWT method can provide good resolution at low and high frequencies, the method is based on a relationship diagram of uncertainty in time-frequency [5]. In this study used the Generalized Spectral Decomposition (GSD) method, the method is a combination of STFT and CWT. The GSD method aims to get better resolution vertically and frequency resolution simultaneously.

2. Methodology
This study used 3D seismic post stack time migration (PSTM) and well data. The methodology including marker analysis of well data, well correlation, well-seismic tie, fault and horizon interpretation, spectral decomposition analysis, RMS Amplitude attribute and model based Acoustic Impedance (AI) Inversion. The spectral decomposition extraction was compared with AI Inversion and RMS amplitude attribute, which these methods were controlled by well data.
The data precondition had been done before spectral decomposition extraction. The spectral decomposition was used Generalized Spectral Decomposition (GSD) method. The information spectrum information on the reservoir target has frequency range about 20–70 Hz (figure 2). It would be this reference for quantitative interpretation of several frequencies. Based on this references, the spectral decomposition volume was extracted using frequency bands of 20 Hz, 50 Hz and 70 Hz.

3. Results and discussion

3.1. Spectral-decomposition

The spectral decomposition had been generated with a frequency band of 20 Hz. The depth structure map of Top A was overlaid by spectral decomposition 20 Hz (figure 3a). Based on figure 3a, A sandstones have high amplitude value. This method shows the distribution of sandstone A with direction of Northeast-Southwest distribution trend.

The spectral decomposition volume had been generated using frequency band 50 Hz. The depth structure map of Top A was overlaid with spectral decomposition 50 Hz (figure 3b). Based on the figure 3b, it can be seen that the high amplitude anomaly on spectral decomposition 50 Hz starts to fade than spectral decomposition 20 Hz.

The spectral decomposition volume had been extracted using frequency band 70 Hz. The depth structure map of Top A was overlaid with spectral decomposition 70 Hz (figure 3c). Based on the figure 3c, it can be seen that the high amplitude anomaly on spectral decomposition 70 starts to fade than spectral decomposition 20 Hz and 50 Hz.

Based on the analysis of the spec decomp slice (20 Hz, 50 Hz and 70 Hz), it shows that there is anomaly. The anomaly is indicated by the high amplitude value at low frequency (20 Hz), it is known as low frequency shadow. This anomaly shows that the reservoir is indicating of the hydrocarbon presence [6]. The presence of hydrocarbon can absorb seismic frequencies. The anomaly is consistent with well data.

3.2. Seismic attributes analysis

The crossplot analysis show that low gamma ray log related with high value of AI log and high value of density log [7]. Top A Sandstone has high value of AI because the layer has higher value of density than lower and the upper layers. Figure 4 shows that the Sandstone A reservoir has a high AI character value (yellow-red colour). The depth structure map of Top A was overlaid with AI inversion shows that the distribution of Sandstone A has northeast-southwest direction (figure 4).

Figure 2. The frequency spectrum information on the reservoir target is about 20–70 Hz.
Figure 3. Depth structure map of Top A was overlaid with spectral decomposition; (a) 20 Hz, (b) 50 Hz, and (c) 70 Hz.

The extraction of the RMS amplitude attribute was generated. There is high RMS amplitude anomaly is interpreted as Sandstone A reservoir. This anomaly is validated with well data. Based on depth structure map of Top A was overlaid with RMS amplitude attribute (figure 5), the distribution of sandstones A has northeast-southwest direction.
4. Conclusion
Based on spectral decomposition analysis, there is an anomaly from the frequency of 20 Hz to 70 Hz which is the weakening of the amplitude anomaly at high frequency known as low frequency shadow. The area that could become the next development target is in the northern part of this field.

The integrated methods of spectral decomposition 20 Hz, RMS amplitude attribute, and AI inversion show the Top A reservoir distribution is onlapping to the Basement High with northeast-southwest direction.

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