New reservoirs prediction and production effects in the a Kutai Basin using the spectral decomposition method

Afzalurrahman¹, A Haris² and A Riyanto²

¹Department of Physics, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia
²Geophysics Study Program, Faculty of Mathematics and Natural Sciences (FMIPA), Universitas Indonesia, Depok 16424, Indonesia

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

Abstract. The reservoir prospect with the play sub-thrust fault concept is new in the Kutai Basin. This basin still has many potential hydrocarbon reservoirs that have not been discovered and must continue to be explored. Prospect evaluation is one of the important stages in hydrocarbon exploration. One of ways that can accommodate prediction of reservoir distribution prospects is spectral decomposition analysis method. Prediction of reservoir distribution prospects uses spectral decomposition. The purpose of integration, blending and coordinating some processes, of this analysis is to investigate the distribution of reservoirs and trap integrity by using Spectral Decomposition analysis. In this study, low-frequency zone analysis and amplitude anomalies were observed at low frequencies and compared with the amplitude at mid and high frequencies. Amplitude analysis is used to distinguish the possibility of lithology and its filling fluid. The amplitude anomaly is seen at low frequencies and disappears at high frequencies. The spectral decomposition methods used are Continuous Wavelet Transform (CWT), Short Term Fourier Transform (STFT) and Generalized Spectral Decom (GSD). The results of the various processes are then compared to see new reservoirs and the effect of production.

Keywords: Continuous wavelet transform, Kutai Basin, low frequency, spectral decomposition

1. Introduction

The Kutai Basin is the largest and thickest Tertiary basin in the western part of Indonesia. Proven reserves currently exceed 11 billion barrels of oil equivalent (bboe), making the Kutai Basin significant on a global scale and the fourth most prolific area in Southeast Asia-Australia [1]. The prospect of the Play Subthrust Fault Concept is new in the Kutai Basin. The type of play below the fault reservoir which serves as a trap has not been found in the Kutai basin so that exploration needs to continue. Prospect evaluation is one of the important stages in hydrocarbon exploration. DHI (Direct Hydrocarbon Indicator) from seismic data is one of the methods used by exploration experts today. The presence of direct hydrocarbon indicators (DHI) on seismic data can have a significant impact on the reserve/resource calculations not only for volumes but also uncertainty levels. In 2001 a consortium of oil companies was organized to understand seismic amplitude anomalies interpreted as DHIs and their
impact on prospect risking and resource calculations [2-4]. This method is used to minimize the risk of failure in exploration. This method has background on the increasingly difficult discovery of hydrocarbon reserves that are only based on conventional interpretations of the appearance of certain structural patterns. This conventional interpretation is considered not enough to provide complete information on hydrocarbon exploration.

This research was conducted to maximize the data available in the "AA" field, Kutai Basin. The study is located in the territory of East Kalimantan Province. Research focuses on Balikpapan Formation. This formation is deposited in the fluvial-delta environment, so the layer is very thin and difficult to map with seismic good resolution. The hydrocarbons are trapped in thin sandstones which are generally difficult to recognize, therefore, special techniques are needed to predict their existence. The same problem is how to distinguish between thin reservoirs containing hydrocarbons and other rocks. Reservoir value limits using seismic data have different value standards in each field.

One method that can identify the presence of hydrocarbons in thin layers is spectral decomposition; this method can decipher seismic signals into the spectrum and frequency components. The object of research in this study is focused on the horizons C, D, E, F and G, the horizon identification is done by using several wells from two fields close to it ("CC" and "DD") with the aim of creating a horizon that will be used as a basis for predicting a new reservoir and the effect of production at the field beside it.

2. Method

This research uses this data; 3D post-stack seismic data and several well data (figure 1). Each well contains gamma-ray, density, neutron porosity, sonic, and resistivity. Overall, this project uses Schlumberger and OpendTect software to process all type of spectral decomposition methods. This research tries to compare the differences between STFT (Short Term Fourier Transform), CWT (Continuous Wavelet Transform), and GSD (Generalized Spec Decomp).

In the STFT method, a good window width is needed so that if the signal shape matches the width of the window, the STFT analysis will produce a good time-frequency domain description. The short-time Fourier transforms and the wavelet transform are the principal approaches to simultaneously decompose a signal into time and frequency components [5]. The application of WT in signal analysis in practice can be done by using continuous wavelet transform (CWT) method where this method can produce a good time-frequency map. When the time resolution increases, the frequency resolution will decrease and vice versa. In this method, wavelets are used as window and wavelet functions that are used can change for each different frequency so that the resolution will be good [6]. The Generalized Spectral Decomposition (GSD) method is a hybrid method of the existing STFT and CWT techniques. With this method, the interpreter can control the vertical resolution and frequency better simultaneously. The GSD methodology can be summarized in steps; Wavelet design, correlation, and convolution.

3. Results and discussion

The most important step in spectral decomposition is to analyze frequency. As shown in figure 1a we have the wavelet and the tuning thickness analysis result as shown in figure 1b shows us the vertical resolution of data. From the seismic, the minimum thickness that can be detected is 20 ms. Furthermore, from the amplitude spectrum information can be drawn at what frequency dominates. As shown in figure 1c there are 4 dominant frequencies, 10 Hz, 21 Hz, 30 Hz and 40 Hz, which from these values the seismic data will be decomposed.

The identification process continues at the location where hydrocarbons can be trapped. A structural trap facing the fault and an anticline trap can be suspected to be a place for hydrocarbon accumulation in the reservoir so that the frequency analysis is focused on that area. Seismic structural
Figure 1. Tuning analysis based on the 3D "A" field seismic data, (a) wavelet, (b) tuning Thickness chart and (c) frequency.

Figure 2. The seismic structural section where the trap is expected (a) anticlinal trap and (b) against the fault.

section from inline 2454 in figure 2, IL2454, indicates that there are two dominant frequencies in the area, mainly at 10 Hz and 20 Hz.

STFT results show frequency anomalies in reservoir zones. In the area between 2–4 s at the anticline area there is a low-frequency anomaly. It can be seen that the area that has been penetrated by the production well has a smaller sweet zone, it can be seen from the less low amplitude at low frequencies while in the unpenetrated zone by the well, high amplitude at low frequencies is highly possible undrained gas reservoirs (figure 3).
Different results are shown by the CWT process (figure 4). The frequency anomalies are more clearly seen at 10 Hz in the area before the fault between 2–4 s. This case can be a good scenario for hydrocarbon traps. There is an anomaly which is quite clear in the layers below the fault plane. If the fault is sealing, the location can be the next production target.

GSD process results show that there is a sweet spot low-frequency anomaly in the inner zone (figure 5). High low-frequency amplitude is also seen in the sub-thrust fault zone. GSD results strengthen the results of two previous processes. That is, the reservoir that has not been penetrated has high amplitude on the low frequency while in the zone that has been penetrated by the production well; it remains less even though it is closer to the anticline axis.

Figure 3. The STFT results from frequency (a) 40 Hz and (b) 10 Hz.

Figure 4. The CWT results from frequency (a) 40 Hz and (b) 10 Hz.

Figure 5. The GSD results from frequency (a) 30 Hz and (b) 10 Hz.
4. Conclusion

This research shows that the spectral decomposition method can predict a new reservoir and at the same time from it, we can see reservoir zone that has not been drained. But each spectral decomposition method is complementary. The STFT method is better in mapping layers on rocks and increasing the level of confidence in mapping facies while the CWT method can detect the gas-bearing zone located below the fault plane. Although the GSD method is not as strong as the previous two methods, it can moderate the two weaknesses in the other two methods. This research also assumes the reservoir gas zones in this area are correlated with a frequency of 10–15 Hz.

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