Syn-Rift sequence and depositional environment analysis using spectral decomposition in field “G” North West Java Basin

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Abstract. Study about depositional environments is one of the purposes of many researches which is done for academic and economic purposes in oil and gas exploration. This study needs enough comprehensive analysis to generate more detail interpretation. In this case we analyze syn-rift sequence framework, syn-rift depositional architecture, and its depositional system in Field “G” Talang Akar Formation (TAF), Ciputat, North West Java Basin. The ability to analyze seismic data in the frequency domain through spectral decomposition allows the user to extract additional geological information that may be missed by using more traditional methods, for instance amplitude extraction and attribute analysis. By using spectral decomposition as an enhanced seismic attribute, in correlation with more conventional interpretation methods through log data and seismic sections, it is possible to identify distributary channels that have previously been inferred from seismic reflection data. It is found that the best frequencies which can help well in interpreting the seismic is 25 Hz, 35 Hz and 45 Hz.

Keywords: Syn-rift, depositional environments, spectral decomposition, frequency

1. Introduction

Seismic data have various frequencies content in time. Time-frequency decomposition (spectral decomposition) of a seismic signal aims to characterize the time-dependent frequency response of subsurface rocks and reservoirs. Spectral decomposition unravels the seismic signal into its constituent frequencies. This allows the interpreter to see amplitude and phase tuned to specific wavelengths, just as radio can pick out a single station or a prism a single color. Since the stratigraphy resonates at wavelength depends on the bedding thickness, the interpreter can image not only subtle thickness variations and discontinuities but also accurately predict bedding thickness quantitatively [1]. Through the spectral decomposition with some frequencies taken, it can produce the model which pictures the geologic condition on the target zone layer.

North West Java Basin is in the west part of Java Island on Java Sea. Based on the area, this basin is divided into onshore and offshore area [2]. The offshore area has an approximately wide of
15,000 km² while the onshore area has an area of 25,000 km². The location of North West Java Basin can be seen in figure 1 [3].

The whole region of North West Java Basin consists of extensional faults. Only few faults are compressional ones. Basin is dominated by rift related to extensional faults which form half graben. Half graben structure which is formed for instance can be identified on Arjuna Sub-Basin, Jatibarang Sub-Basin, Ciputat Sub-Basin, and Pasir Putih Sub-Basin. Important structures on North West Java Basin are the forming of any kind of anticlines and horst structure that comes from horst-graben system. A compressional structure like fault can happen at the beginning of rift establishment which direction was northwest–southeast on Paleogene period. This fault then reactivated on Oligocene.

Based on tectonostratigraphic, sediment deposited on North West Java Basin can be differentiated into three phases, those are syn-rift, post-rift, and back arc. On this case we only focus on syn-rift phase. On this phase, the developing structure is extensional fault. The fault structure resulted half depression surface (half graben). At the end of Eocene until the beginning of Pliocene, Jatibarang formation (equivalent to Pre-Talang Akar formation) was deposited while at the end of Oligocene Lower Talang Akar started to be deposited. Jatibarang formation was deposited on two kinds of source rocks, first one was volcanic, which was related to volcano and the second one was sedimentary deposit consists of volcanic materials and epiclastic deposits. It was not only volcanic materials, but it was also shale, limestone insertion, and conglomerate. It indicated the relation of the rocks with depositional environment which was associated to volcanic body as well as river flow. It can happen to the fluvio-deltaic as well as shallow marine depositional environments.

Peyton [4] used spectral decomposition and coherency to interpret incised valleys. Hardy [5] showed that an average frequency attribute produced from sine curve-fitting strongly correlates with shale volume in an area. Spectral decomposition transforms the seismic data into the frequency domain via mathematic methods such as Discrete Fourier Transform (DFT), Continuous Wavelet Transform (CWT), and other methods. The transformed results include tuning cubes and a variety of discrete common frequency cubes.

Figure 1. Research area (red circle), located in Java Island, West Java, Indonesia.
Spectral decomposition has proved to be a robust approach for seismic interpretation. It is used for mapping temporal bed thickness [2], indicating stratigraphy traps [6], and delineating hydrocarbon distribution [7].

2. Methodology
The seismic data used in this research is 3D Seismic Data. First step is loading the 3D seismic Data and then the next step is doing the well seismic tie step. After that, before applying the spectral decomposition attribute using RGB (Red, Green, and Blue) blend, we need to choose the possible frequencies that can give the clearest model to show the seismic features through the attribute. In this case, we use the frequencies of 25 Hz, 35 Hz, and 45 Hz. By using spectral decomposition method, discrete frequencies showing detail of stratigraphic and structural edges could efficiently help the seismic interpreter [8].

Steps showed on figure 2 below is the step to do tuning cube process [9]. The step that must be done is choosing the window analysis on the seismic cube which will be the area of interest, after that the seismic data in the time domain is being transformed through DFT to frequency domain.

3. Results and discussion
From the 3D seismic dataset, we know that there are two channels found. It is the channel that appears clearly on the seismic and it can be interpreted. On the figure 3 and figure 4, we can also find the meander lobe which shows a strong green color and a very sharp turn.

The spectral decomposition workflow focuses on processing Discrete Fourier Transform (DFT) around a very smooth seismic horizon interpretation, transforming the amplitude or phase data into the frequency domain. Data were visualized, colored and conventionally interpreted using Petrel software (Schlumberger Limited, USA). We used the Red-Green-Blue (RGB) color blended maps;

![Figure 2. Working flowchart used in this study, modified from Verzi et al.](image-url)
where each color corresponds to a specified frequency range. The three frequency ranges are: 25 Hz in Red color, 35 Hz in Green color, and 45 Hz in Blue Color. These three frequencies help in picturing clearly the fault, channel, and meander lobe. It is found that these three frequencies are best to picture this result as previously other frequencies were tried but it did not give clearer result. By finding the presence of fault-controlled channel, channel discontinuity, and meander lobe, we can picture the depositional environments in the zone-of-interest area.

![Figure 3. Spectral decomposition model at time 2000 ms.](image1)

![Figure 4. Spectral decomposition model at time 1934 ms.](image2)
4. Conclusion
Spectral decomposition helps to identify the fault-controlled channel, channel discontinuity and meander lobe. By using the color blending maps, the thickest and highest quality of paleochannel could be shown to assist next well drilling location. The color blending display helps to optimize the well location in terms of targeting the thickest and high quality part of the channel which appears (a mix of the three RGB frequencies) on the display. The frequencies used with RGB blend are 25 Hz, 35 Hz and 45 Hz for each color. The spectral decomposition provides substantially more detail and fidelity than full bandwidth conventional attributes. It reveals stratigraphic and structural edges as well as relative thickening and thinning. It allows viewing subsurface seismic interference at discrete frequencies.

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