Seismic polarity-based sequences for imaging of carbonate depositional environments via the application of seismic attributes

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Summary
This study was carried out to illustrate the advantage of seismic attribute analysis on the high-resolution seismic sequences in imaging carbonate depositional environments. The workflow of imaging carbonate using attributes has been applied on carbonate platform in Central Luconia, offshore Sarawak. Amplitude-based seismic attributes and spectral decomposition (CWT and matching pursuit) were used to inferred the depositional environments. However, spectral decomposition produced better image compared to amplitude-based seismic attribute.

Introduction

The study area is located in the northern part of the Central Luconia Province on the Jintan High. Central Luconia geological province is part of Sarawak Basin which is flanked by Baram Delta at the east side with major transform fault (Madon, 1999). The province is proven to be prolific sub-basin with numerous discoveries have been reported. Several former isolated carbonate buildups at the base of the Jintan High amalgamated and formed a Mega Platform. The Mega Platform is a 1200 m thick carbonate buildup and extends 30 km x 50 km in a roughly SWNE orientation.

This study was carried out to demonstrates the workflow for improve imaging carbonate depositional environments by using high resolution of seismic sequences with the application of seismic attributes. The results of this study shows that attributes extraction and mapping onto horizons generated based on seismic polarity has improve the delineation of carbonate depositional environments.

Methodology

The workflow of this study comprises of 3 phases. The first phase was core description of A-1 well. The objectives are to identify the carbonate facies and the facies association.

Next phase of the study is 3D seismic interpretation. Volume based seismic interpretation is conducted using a semi-automated interpretation technology. This advance technology is applying the depended-seismic similarity algorithms to connect the horizons patches. The horizons patches are generated for each seismic polarity; peak, trough and zero crossing. Thus, allowing the volume-based interpretation from top to base of carbonate. The horizon patches then are connected to produce a Relative Geo-time Model (RGT). The RGT was then used to generate a horizon stack. A horizon stack is basically a book of horizons that extracted based on sequence which correspond to the RGT.

The workflow then followed by the cross-correlation of core facies with the interpreted horizons. The final phase if the workflow was mapping the seismic attributes onto the generated horizons stack. The attribute applied such RMS amplitude and spectral decomposition were generated to enhance the sedimentary and structural features with an unprecedented level of accuracy.

Results

Lithology of core of A-1 well is identified as mainly limestone with occasionally argillaceous limestone. The presence of argillaceous limestone indicates the rising of the sea level which marked as the flooding surfaces. The facies associations described is low to moderate shallow lagoon for the lower part of the core. While, for the upper part, the evidence from core shows the FA changed to moderate energy back reef.

Fifteen (15) horizons were extracted out based on the seismic polarity and were cross calibrated with the facies as shown in Figure 1.

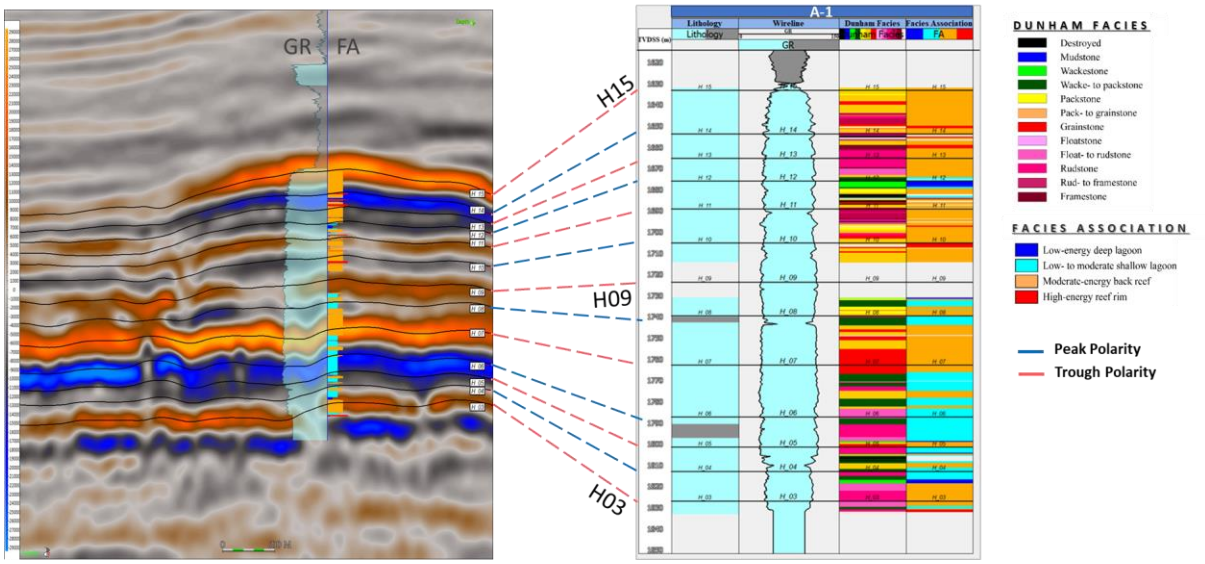

Figure 1: Extracted stratal slicing based on seismic polarity and cross-calibrated with interpreted facies.

Relative acoustic impendence, RMS amplitude and co-blending of frequencies map as shown in Figure 2 highlight associated FA on H14. The interpreted FA as penetrated by A-1 well is moderate energy back reef. Based on the seismic response and attribute value, area which not penetrated by well can be predicted to be deposited in the same environment setting. However, amplitude-based attribute sometime give same attribute response at the non-reservoir area, as can see in the Figure 2. Thus, spectral decomposition technique is applied to better delineate geological features in carbonate platform. The spectral decomposition tuned to the frequency that associated with lithologies. Hence, improve the carbonate imaging.

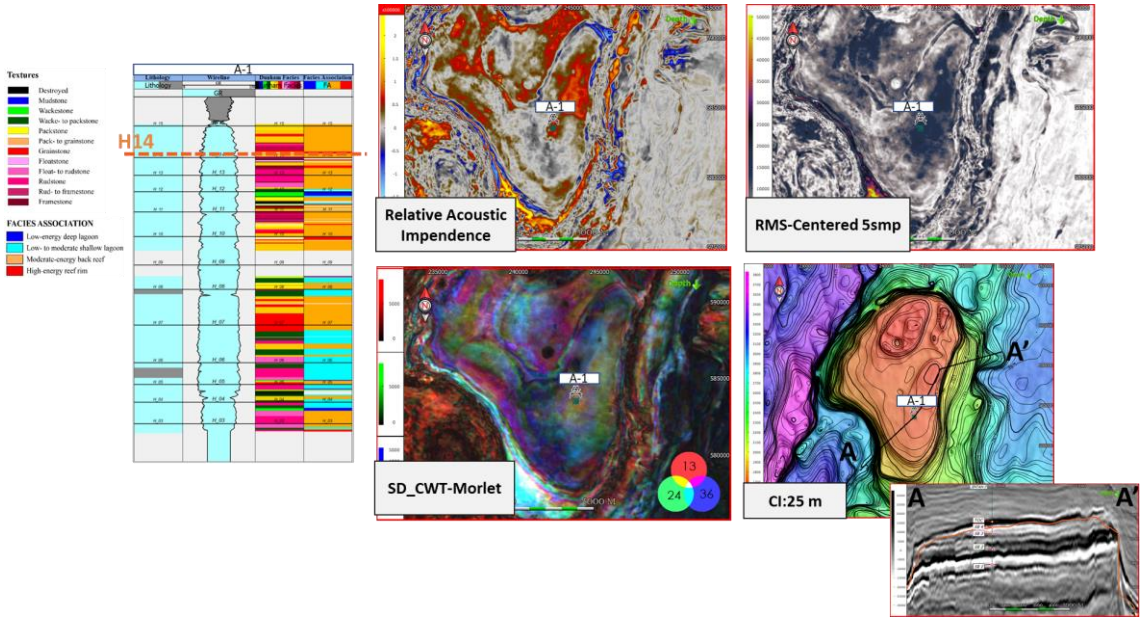

Figure 2: Amplitude-based seismic attributes mapped and spectral decomposition using continuous wavelet transform of H14.

In this study, the spectral decomposition analysis is conducted using continuous wavelet transform (CWT) with Morlet type wavelet. However, the CWT has a limitation. Due to its restricted frequency parameter, it is unable to generate accurate estimation of the frequency content of waveform (Wang, 2007). Spectral decomposition using matching pursuit is applied to improve the imaging. Figure 3 shows the result of matching pursuit clearly improved the imaging of carbonate environment.

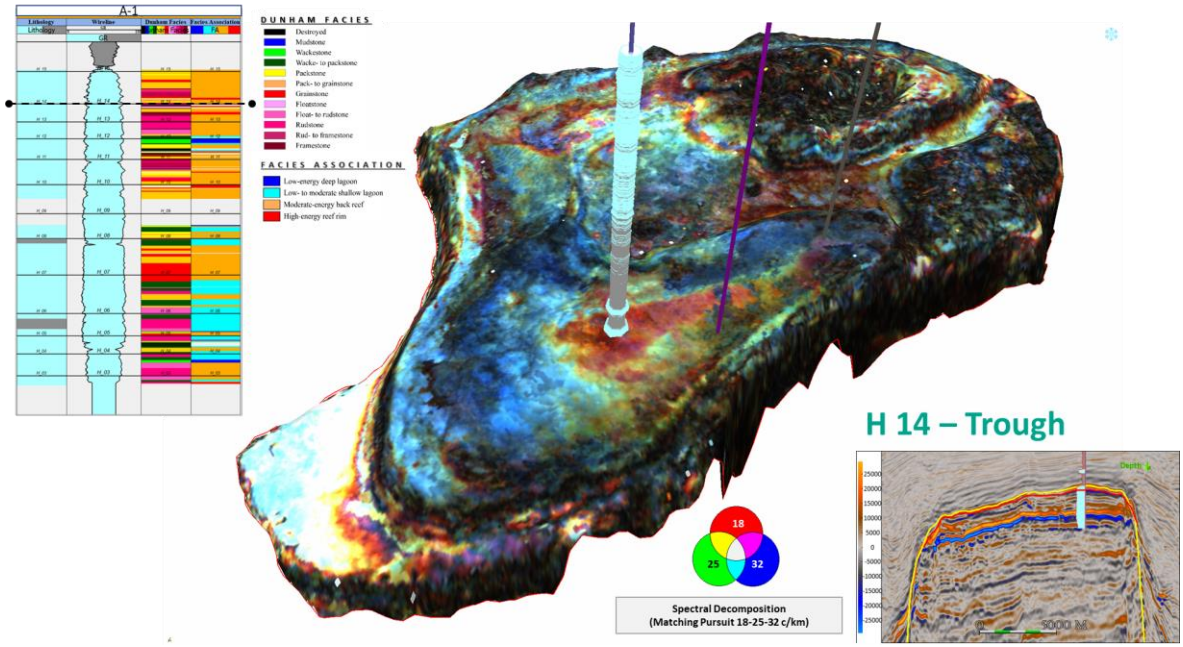

Figure 3: Spectral decomposition using matching pursuit of horizon H14.

Conclusions

Application of attributes on seismic polarity-based sequences has improve the imaging of carbonate depositional environments. The study shows the spectral decomposition application either using CWT or matching pursuit illuminate features better compared to amplitude-based attributes.

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References

Madon, M. B. H. (1999). Geological setting of Sarawak. In *The Petroleum Geology and Resources of Malaysia* (pp. 275–290). Petroliam Nasional Berhad (PETRONAS).

Wang, Y. (2007). Seismic time-frequency spectral decomposition by matching pursuit Seismic time-frequency spectral decomposition by matching pursuit. *GEOPHYSICS*, *72*(January 2007), 13–19. https://doi.org/10.1190/1.2387109