PS Enhancing Spectral Decomposition to Delineates Subtle Channels – A Case Study from Offshore Nile Delta*

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Abstract

Seismic data is a collection of reflection events from the subsurface. There are diffractions, refractions, and noise, but these are minor considerations when used for oil and gas exploration and reservoir characterization. These subsurface reflection events can overlap, partially or completely, depending on frequency and depth, making some geologic features indistinguishable. However, when seismic data is decomposed into individual frequency components, as done in spectral decomposition, some subsurface events can be distinguished from certain frequency components, such as the channels. Sometimes, it is not just one particular frequency component that reveals the geological features, several frequency components can reveal different parts or aspects of the subsurface features. Color blending is often used to put several frequency components together into one map and let us see them simultaneously.

In this case study, we present comparisons between spectral decomposition different volumes over the Sequoia Field, which is one of the Pliocene gas fields offshore Nile Delta. These volumes are representing near-, mid-, far-, and full-angle stacks using different frequency ranges. As predicted, the near-angle stack has higher frequency content than the other angle stacks and even the full-angle stack. Though, the near-angle stack contains a high level of noises compared with the others. We tried to reduce the noises using structural-oriented filters; the difference was minor with few enhancements achieved. The near-angle stack spectral decomposition volume was used to delineate the incised channels and faults inside the main canyon. With the help of the variance volume, the Sequoia's internal architecture becomes very clear. We used the geobody extraction method to export the major and subtle channels to be used in the static model building and the gas initially in place (GIIP) calculation.

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Summary

- In this case study, we present comparisons between spectral decomposition different volumes over Sequoia field (Pliocene gas field) and Messinian field (sands within and below the Messinian evaporites), offshore Nile Delta.
- These volumes represent near-, mid-, far-, and full-angle stacks using different frequency ranges. As predicted, the near-angle stack has higher frequency content than both the other angle stacks and the full-angle stack.
- The near-angle stack spectral decomposition volume was used to delineate the incised channels and faults inside the Sequoia's main canyon and the Messinian thin channels.
- We used the geobody extraction method to export the major and subtle channels for more accurate static model building, gas initially in place (GIIP) calculation, and explore new targets.

Spectral Decomposition

- Spectral decomposition analysis allows the Explorationists to quantify amplitude variation with frequency, and thereby gain insight into the distribution of stratigraphic entities, faults and fractures, and/or hydrocarbons.
- Two methods were tested: Fast Fourier Transform (FFT) and Continuous Wavelet Transform (CWT).
- The frequency analysis over Sequoia field shows that the dominant frequency of the full-stack seismic data is approximately 25 Hz. Consequently, the three frequencies used are: 10, 25, and 55 Hz (Figure 3).
- After the RGB blending of those frequencies, the FFT method was better than the CWT method in delineating the thin channels inside the main canyon as shown in figure 4.
- The same procedure used to produce spectral decomposition volumes for different angle stacks (near, mid, far, and full) over both Sequoia and Messinian fields.

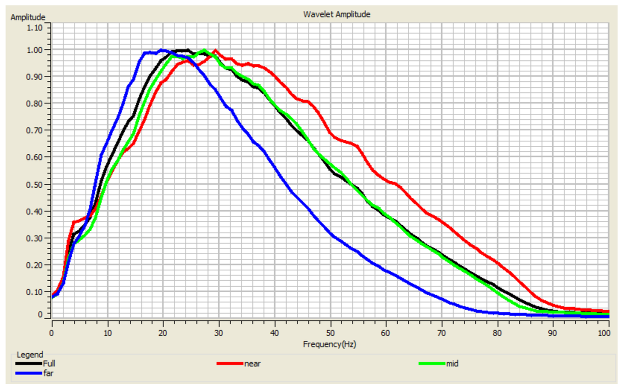

Figure 3: Amplitude spectra of full (black), near (red), mid (green), and Far (blue) angle stacks seismic data over Sequoia field.

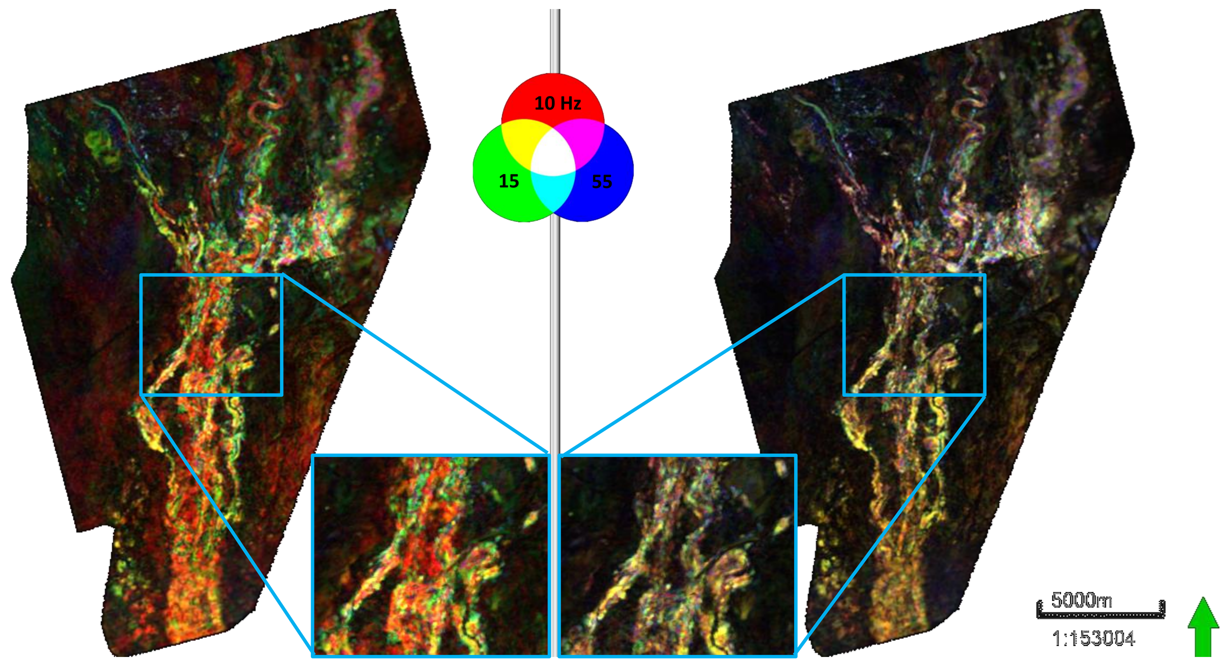

Figure 4: A comparison between two spectral decomposition methods; CWT (left) and FFT (right).

Introduction

Location

The area of interest includes both Sequoia and Messinian fields, lies in the West Delta Deep Marine (WDDM) concession, 50–100 km offshore in the deep water of the present-day Nile Delta (Mohamed et al., 2017)(Figure 1).

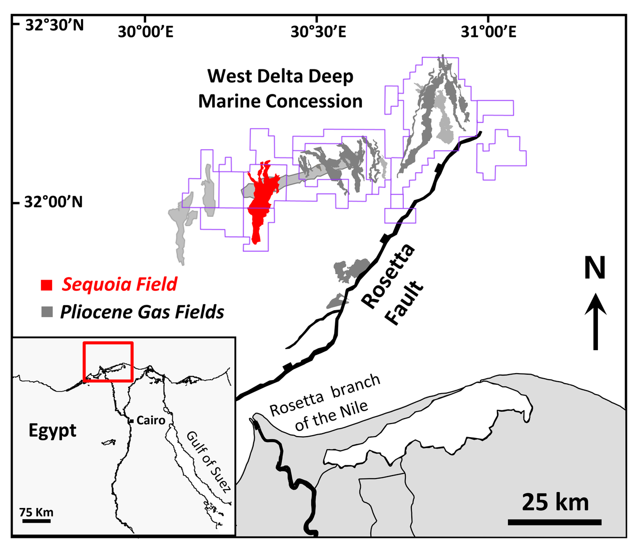

Figure 1: Location map of the offshore Nile Delta and study area (red box). Upper Pliocene gas fields are in grey, and Sequoia Field is in red. Modified from Samuel et al. (2003).

Reservoir Geology

Sequoia Field

Sequoia field is a Pliocene submarine delta slope canyon system with complex turbiditic channel-levee reservoirs (Cross et al., 2009). Seismic mapping indicates that the structure is fairly simple (Figure 2).

The reservoir consists of a succession of sandstones and mudstones organized into a composite upward-fining profile. Sand bodies include laterally amalgamated channels, sinuous channels, channels with frontal splays, and leveed channels and are interpreted to be the products of deep water gravity-flow processes (Cross et al., 2009).

Messinian Field

During the Messinian, canyons cut down to a lowered sea level. The subsequent late Messinian transgression filled the canyons with clastic sediments which is the reservoir for Messinian fields (Figure 2).

Gas sand was proved but never followed up by new methodologies as the carbonates/evaporates hinder their discrimination using most of the used seismic attributes.

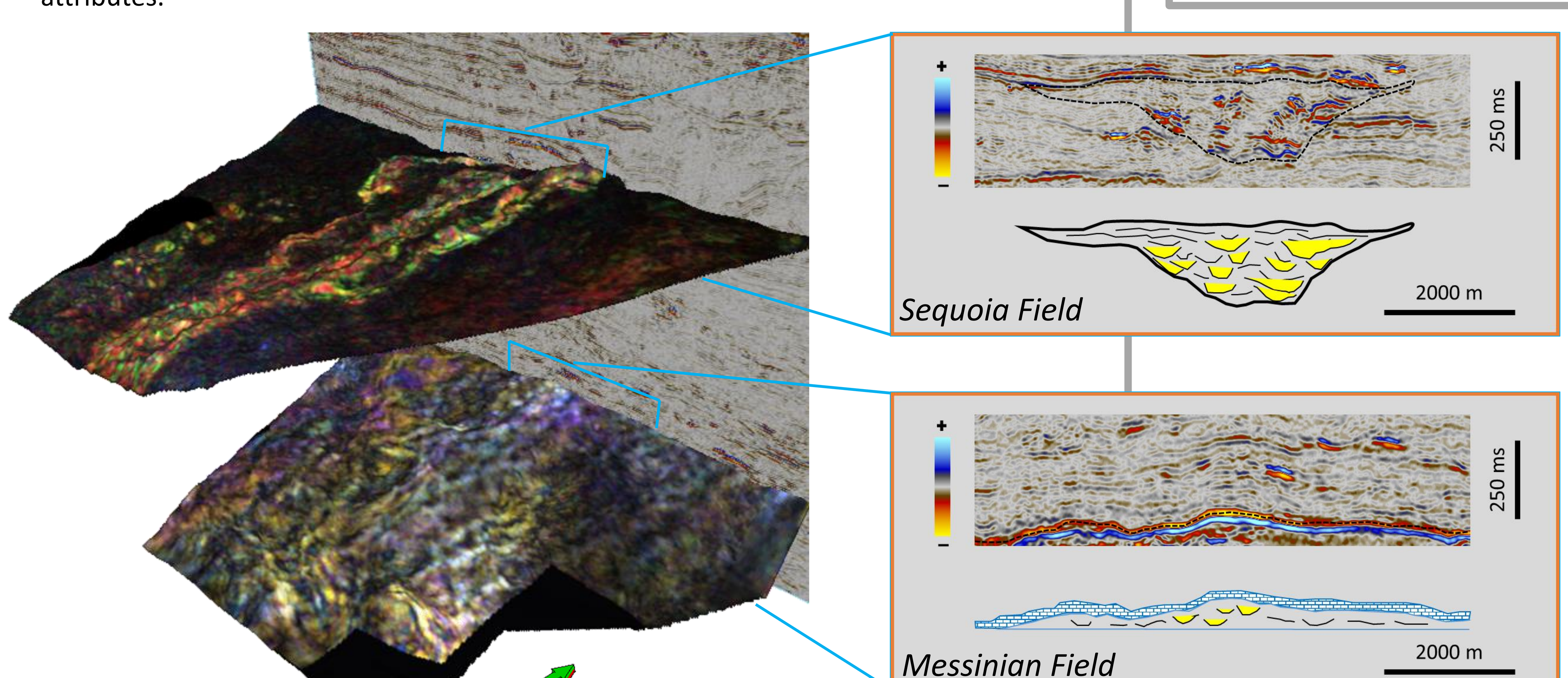

Figure 2: An East–west seismic cross section with Spectral Decomposition slices and line interpretations of both Sequoia channel system and Messinian system, showing the reservoir facies.

Development – Sequoia Field

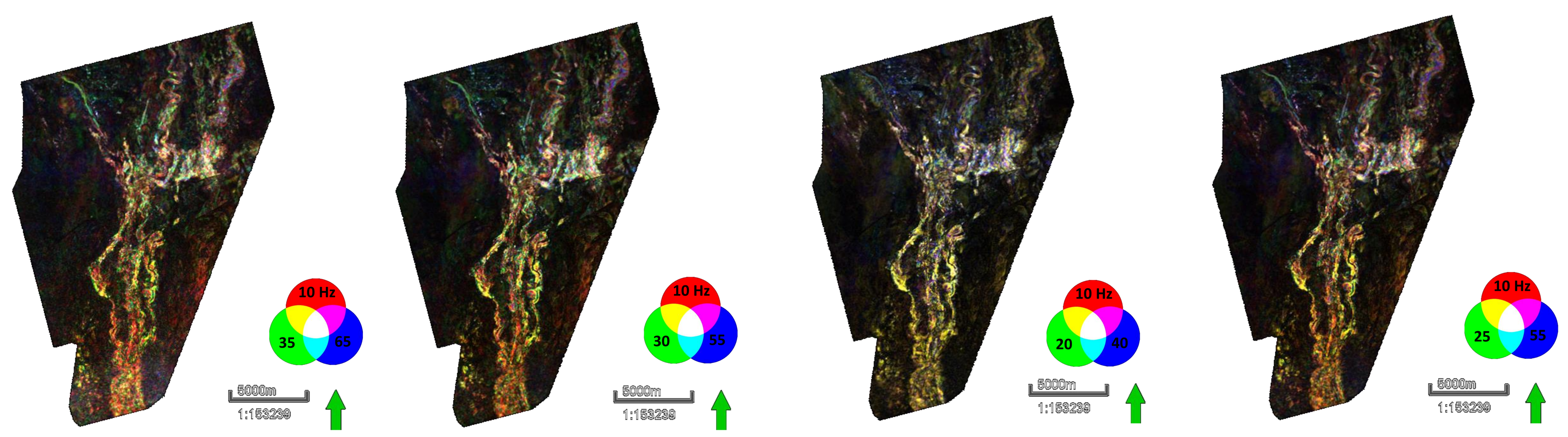

Figure 5: A comparison between spectral decomposition slices (70 ms below the top of Sequoia channel) representing from left to right; near-, mid-, far-, and full-angle stacks.

- A comparison was made between the spectral decomposition volumes from the partial angle stacks (near, mid, and far) in addition to the full angle stack (Figure 5).
- The near angle stack gave the optimum resolution and showed the fine details of the channels' internal architecture.
- The filtered (background removed) spectral decomposition volume (Figure 6) was then used to extract channel geobodies (Figure 7).
- The extracted geobodies were very helpful for both static model building and the GIIP calculation.

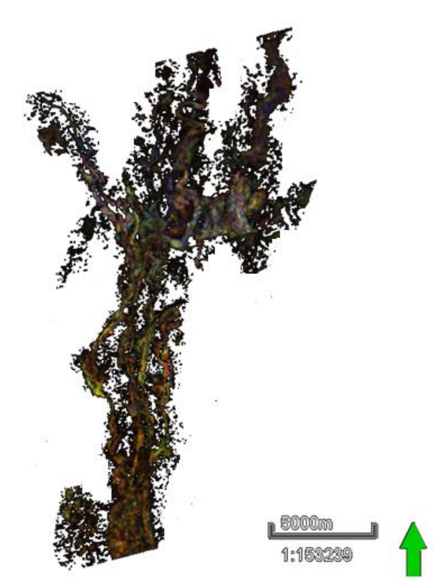

Figure 6: Filtered spectral decomposition volume over Sequoia field.

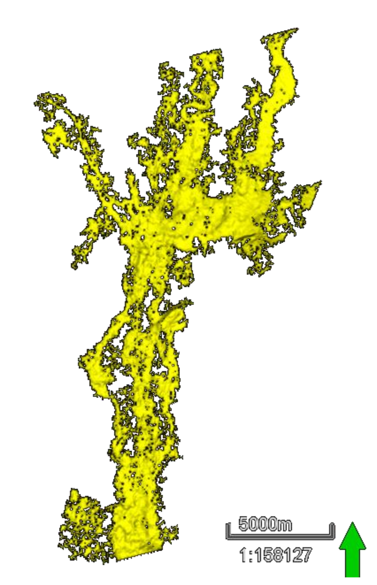

Figure 7: Geobody extraction over Sequoia field.

Exploration – Messinian Field

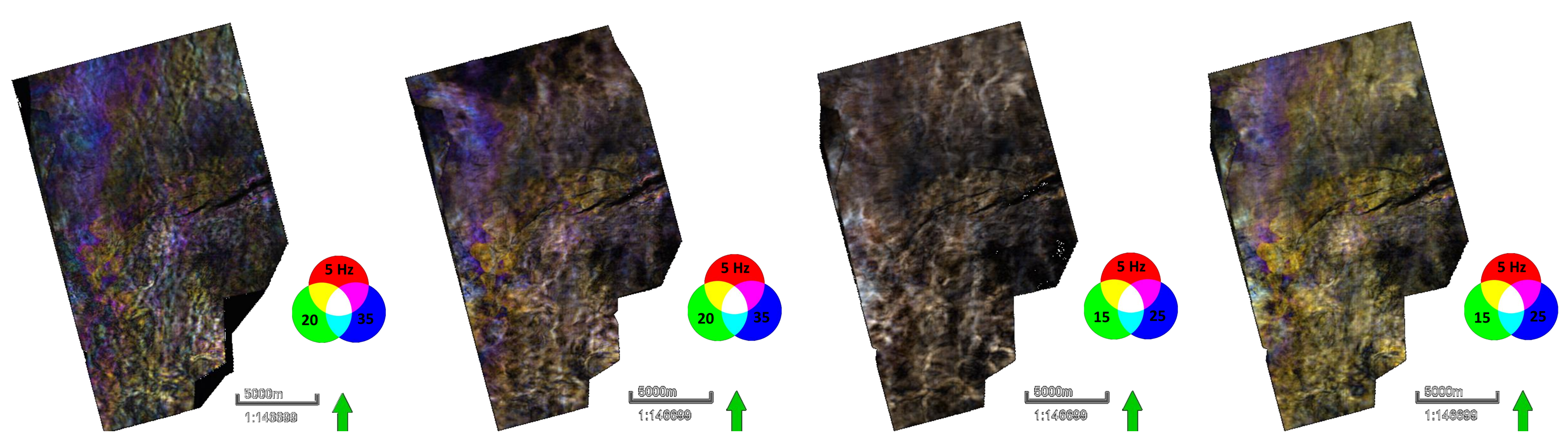

Figure 8: A comparison between spectral decomposition slices (20 ms below the base of Messinian carbonates/evaporites) representing from left to right; near-, mid-, far-, and full-angle stacks.

- A comparison was made between the spectral decomposition volumes of the partial angle stacks (near, mid, and far) and the full angle stack (Figure 8).
- The near angle stack showed clearly the subtle channels below the Messinian carbonates/evaporites (Figure 9).
- Now we have the chance to delineate and target the Messinian thin channels that have been hidden for along time (Figure 10).

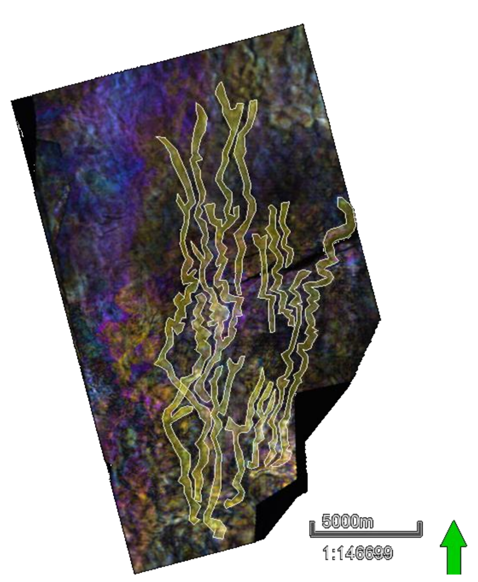

Figure 9: Messinian subtle channels' polygons lay over the Messinian near angle stack spectral decomposition volume.

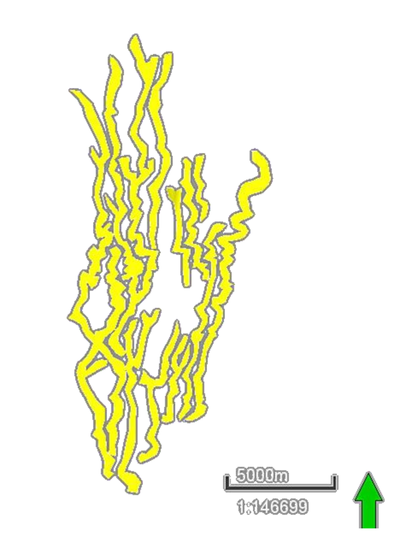

Figure 10: Messinian channelized system.

Conclusion

- A case study is presented, where spectral decomposition is being used successfully to image and delineate the subtle channels. Understand the subtle details of complex channels at different levels inside the canyon.
- Although the near-angle stack has the highest frequency content. The full-angle stack still produce good image at the shallow (Pliocene) depths.
- By using the near-angle stack spectral decomposition volume we have the chance to discover the Messinian hidden channels.

Acknowledgments

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