URTeC: 2902077

Revealing Geologic Features in the Midland Basin Through Frequency Decomposition

Rachael Moore*[1]; 1. GeoTeric

This paper was prepared for presentation at the Unconventional Resources Technology Conference held in Houston, Texas, USA, 23-25 July 2018.

Introduction

Using conventional reflectivity data alone to determine geologic features from seismic is a long drawn out process which requires careful interpretation of several surfaces. In order to help make the process more efficient, attribute volumes and RGB (Red, Green, Blue) blends of frequency bandpass volumes can be used to reveal the geology before interpretation begins. Understanding the geology before beginning the interpretation process allows the interpreter to make more informed decisions.

The data in this study is multi-client data presented with permission from Geophysical Pursuit, Inc. The 3D seismic was shot in Dawson County, Texas; in the Midland Basin. The stratigraphy of interest will be the San Andres formation down to the Ellenburger (Wright, 2008).

Method

Frequency data reveals another dimension of information within seismic data. Besides geologic features, frequency data can also tell us about the thickness of events (Paton and McArdle, 2014). Thicker homogeneous events tend to be lower frequency than thinner events, this is easily highlighted on the RGB color blends by reds (lower frequency) and blues (higher frequencies). Within a volume variation in lithology also affects frequency, as harder more compacted units are usually higher frequency than unconsolidated units.

Theory

Frequency decomposition is a method of filtering the seismic into the frequency bandpass volumes and recombining 3 select volumes into red, green and blue channels for the low, mid and high frequencies respectively. This interplay of colors allows for more geologic detail to been seen than when using amplitude alone. There are several types of frequency decomposition available; this study will focus on continuous wavelet transform (CWT) and matching pursuit algorithms (Lowell et al, 2014) to achieve the desired outputs.

In a CWT frequency decomposition there is a constant relationship between the bandwidth and frequency of the bandpass volumes. A low frequency bandpass volume will have a narrow bandwidth, where as a high frequency volume will have wide bandwidth. The wide bandwidth of the higher frequency volumes means that more of the frequency spectrum is contributing to the result.

A matching pursuit algorithm uses a library of Gabor wavelets to match each point along the trace. This is a trace by trace method which results in almost the same resolution as the input seismic data.

Results

Through the generation of CWT RBG blends, several key geological features can be identified. A few are highlighted in the following images. Figures 1 is a time slice through the San Andres formation. A channel system can much more easily be identified on the RGB color blend than the reflectivity data alone. Information, such as the direction of flow can be gained from the RGB blend. In this instance the direction of flow from the north to the southeast. The core of the channel system can be seen as blue and the channel edges are highlighted in black.

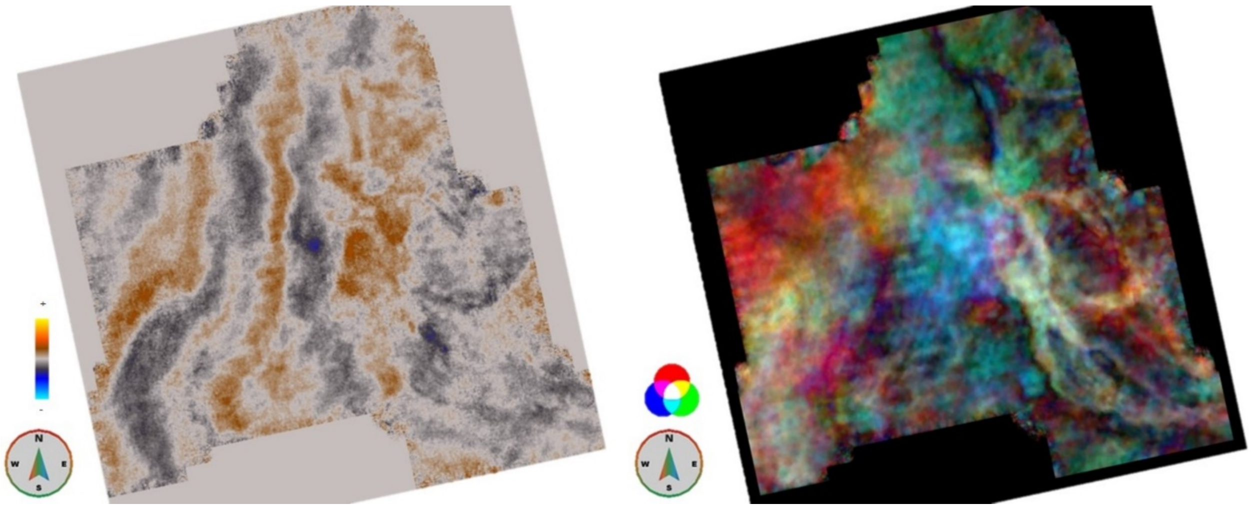

Figure 1: Reflectivity data on left and CWT RGB of the same slice on the right.

Southward prograding clinoforms are more apparent on the CWT RGB color blend than on the reflectivity data. On the left side of figure 2, is a time slice through the Sprayberry. On the left side of the figure 2 is the reflectivity data and on the right the CWT RGB blend. There is some hint of a striation in the reflectivity data, but where the data is low frequency, more information is apparent in the RGB blend. The clinoforms can be seen as almost blue lines, moving through the slice, showing the direction of progradation.

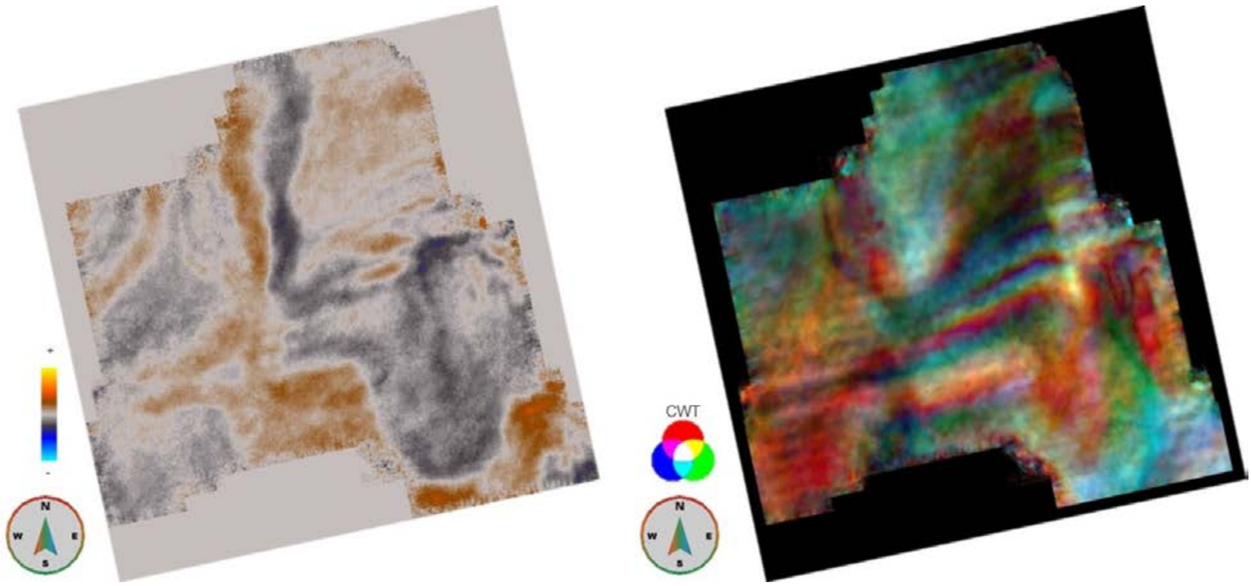

Figure 2: Time slice through the Spraberry, reflectivity data on the left and CWT RGB on the right.

Significance

Understanding the geologic features within the seismic data before beginning the interpretation will garner more precise interpretations. Frequency decomposition RGB blends allow for a quick visual understanding of the geologic features contained within seismic data – knowing the geology before interpreting enables faster, more efficient horizons and faults to be generated.

The CWT frequency decomposition is a quick method that allows for rapid screening of the data. With the wider bandwidths, longer wavelets are needed to match the data, which results in smearing of events. Depositional features displayed on time slices, may not necessarily be localized at that exact time.

In Figure 1, the CWT frequency decomposition time slice of 836ms gives hints of another channel system, joining the one in the image. If we examine the same time slice through the matching pursuit frequency decomposition, the full extent of the channel system is not exposed (figure 3, left image). It is not until we move down 20ms, right image in figure 3, that we see the channel system on the matching pursuit. Since the matching pursuit method is traced base, the events seen on a time slice have exact localization.

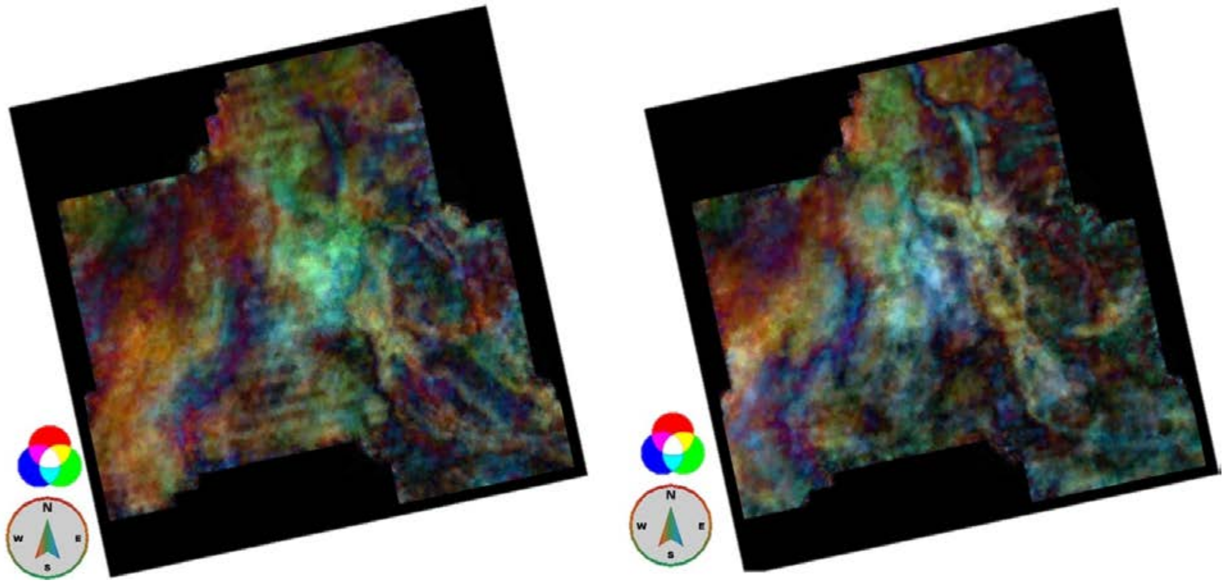

Figure 3: Matching pursuit RGB blend. Left side is 836ms, right side is 856ms. More the channel is revealed at the deeper interval.

From the matching pursuit RGB blend, it can be seen that the channel system is two channels draining from the north and northwest to the southeast and converging in the middle of the data set. It can also be estimated that the feeder channels are thinner, higher frequency, than the combined channel system.

Using the frequency decomposition blends to understand the geology before beginning the interpretation process will produce more precise interpretations. There are several types of frequency decomposition algorithms, the CWT is a fast method to gain a quick understanding of the subsurface. To localize depositional features, using a method with high vertical frequency resolution, for example a matching pursuit, can be used in reservoir scale interpretation.

Acknowledgements

This project would not be possible without Geophysical Pursuit Inc and their contribution of the multi-client data that was used in this study.

References

Lowell, J et al. 2014, ‘Improvements to Frequency Decomposition Methologies for Use with Broad Bandwidth Seismic Datasets’, 76th EAGE Conference & Exhibition 2014.

Paton & McArdle, 2014 ‘Improved Geological Inference from Seismic Data Using Composite, Colour blended Seismic Attributes’ PESGB Evening Lecture, Dublin, 11-February 2014.

Wright, Wayne, 2008, ‘Depositional History of the Desmoinesian Succession (Middle Pennsylvanian) in the Permian Basin. Bureau of Economic Geology, the University of Texas at Austin.