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High Resolution Diffraction Imaging for Reliable Interpretation of Fracture Systems

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Summary

Natural fractures in shale formations can provide a pathway for higher permeability; therefore, they need to be characterized. The characterization of small-scale features is a challenge when dealing with conventional seismic methods. Seismic resolution has limitations for understanding sub-seismic scale structural patterns, stratigraphic variations and reservoir heterogeneities.

Minor fault trends, stratigraphic edges and fractures represent scattering sources for seismic wave propagation. The wavefield generated by those source points is identified as diffraction energy. This energy is always registered during seismic acquisition, but suppressed by standard processing sequences and imaging algorithms. The method explained in this paper is based on an imaging algorithm that maps the recorded surface information into the local angle domain (LAD). The differentiator of this method is its ability to preserve the wavefield through decomposition into reflection and diffraction energy. This paper shows the benefits of LAD technology when applied to the Eagle Ford play in South Texas, where seismic data can be of moderate quality, leading to accurate, high-resolution, and high-certainty seismic interpretation for risk management in field development.

Introduction

Natural fractures in shale formations can provide a pathway for higher permeability; therefore, they need to be characterized. The characterization of small-scale features is a challenge when dealing with conventional seismic methods. Seismic resolution has limitations for understanding sub-seismic scale structural patterns, stratigraphic variations and reservoir heterogeneities.

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Eagle Ford Shale – South Texas

Figure 1 illustrates the resolution of diffraction energy, where high-energy reflections from flat events were removed. Energy from reflections is significantly stronger than diffraction energy, so that energy scattered from edge diffractions or corner waves at the fault location is masked by the strong reflection energy. The image below shows a blending between a specular energy stack and a diffraction stack upon removal of the reflection energy. Fault lineaments are clearly highlighted and present better continuity.

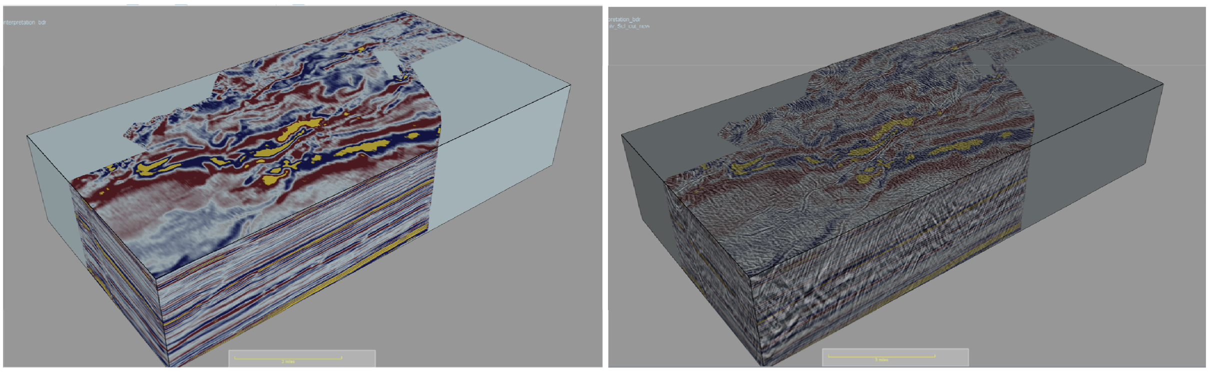

Figure 1 *Specular reflection stack (left) and volume blending between diffraction and specular stack (right) – Data Courtesy of Seitel.*

Geometrical attributes such as coherence and curvature are commonly used for mapping fault/fracture lineaments. The most appropriate process for reviewing diffraction volume results is to compare them with geometrical attributes from conventional poststack attributes. To understand the benefit of interpreting the diffraction volume along with other poststack seismic attributes, a good approach in the case of the Eagle Ford is to extract both attributes onto a depth slice, at the depth of the zone of interest, and merge them into a single view. More continuous lineaments are clearly visible on the diffraction volume (Figure 2, red to blue palette) than on the coherence cube (Figure 2, black and white palette). The position and trend of fault lineaments are consistent between the two attributes. Fault lineaments can be extended from the diffraction volume. New potential fault lineaments are visible on the extracted diffraction attribute depth slice, allowing the interpretation of a high-definition structural pattern at the limits of the seismic vertical resolution.

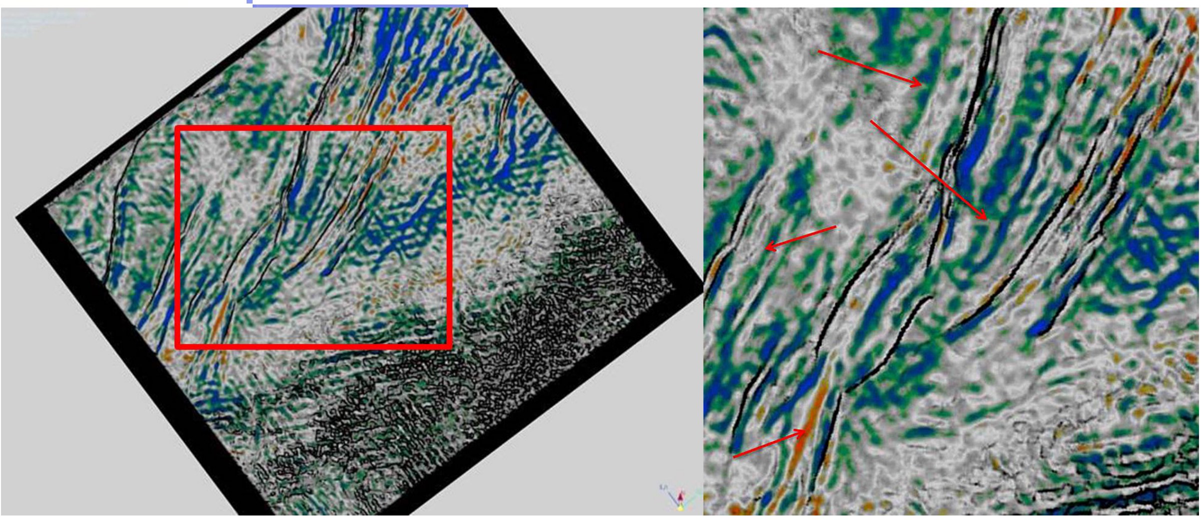

Figure 2 *Depth slice, merge of extracted diffraction and coherence volumes. Enlarged area corresponds to red square. Red arrows indicate improvements in fault definition (continuity, extension and potential) - Data courtesy of Seitel.*

Conclusions

In this paper, we demonstrate the use of diffraction energy to generate a seismic image, for more confident interpretation. When comparing conventional coherence and/or curvature to diffracted images, it is shown that the resolution obtained from depth migrated diffraction stacks is superior to that obtained using a conventional approach. Diffraction stacks provide high-resolution seismic information to supplement conventional interpretation workflows.

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