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Seismic Attribute Assisted Characterization of the Pennsylvanian Unconformity

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Abstract

The Pennsylvanian unconformity, which is a detrital surface, separates the beds of Permian age strata from the Lower Paleozoic in the Central Basin Platform. Seismic data interpretation indicates that the Pennsylvanian unconformity is an angular unconformity, with multiple normal faults beneath it, as well as a thrust fault which adds to the complexity of the region

The Pennsylvanian aged angular unconformity creates pinch-outs between the beds above and below of the unconformity. The spectral decomposition attribute divides the broadband seismic data into different spectral bands to resolve thin beds and show thickness variations. On the other hand, the reflector convergence attribute highlights the location and direction of the pinch-outs as they dip south at angles between 2˚ - 6˚. After reviewing findings from RGB blending the spectrally decomposed frequencies along the Pennsylvanian unconformity, we observed channel-like features and multiple linear bands in addition to the faults and pinch-outs. We suspect that the identified linear bands could be the result of different lithologies associated with the tilting of the beds and, in turn influence hydrocarbon accumulation. Further research is needed to confirm this hypothesis and further characterize the channel-like features.

Research Goal

The aim of the study is to draw attention to these elements which may impact hydrocarbon production and CO_2 sequestration.

Location of Study Area

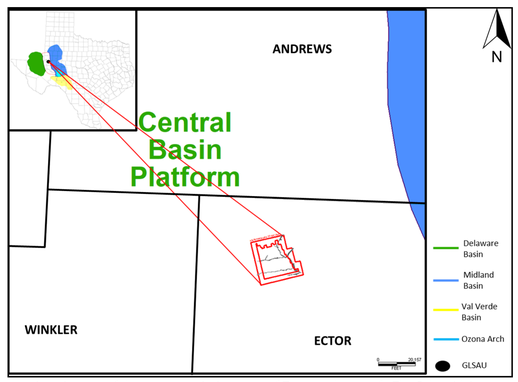

Figure 1. Location map of the study area. An inset map of Texas on the top left. The Goldsmith Landreth San Andres Unit (GLSAU) seismic survey in the red outline. The approximate location of the GLSAU is indicated by the black dot within the map of Texas.

Figures and Results

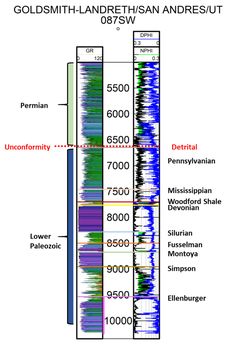

Figure 2a. Digital log showing the gamma ray, density porosity and neutron porosity logs highlighting the various formations and the Pennsylvanian unconformity as seen by the well.

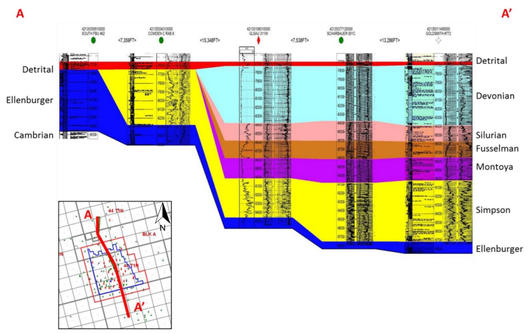

Figure 3. Well Correlation of the various formation tops below the Pennsylvanian Unconformity (Modified from Hodges, 2017).

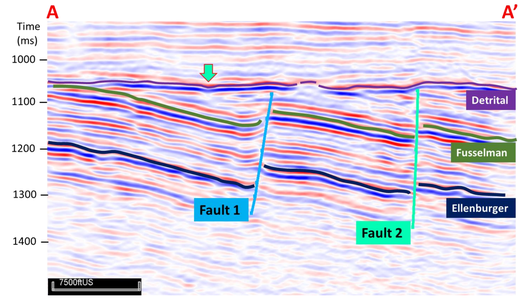

Figure 4. Seismic crossline 5130 showing the two major faults and the Detrital, Fusselman and Ellenburger horizons (Modified from Szypulski, 2021) . The green arrow shows the probable channel.

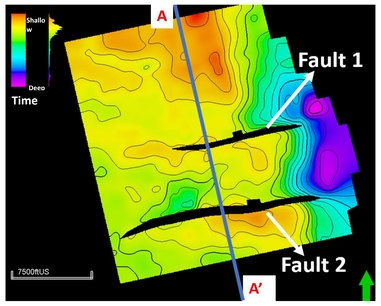

Figure 5. Time structure map of the Detrital Horizon .

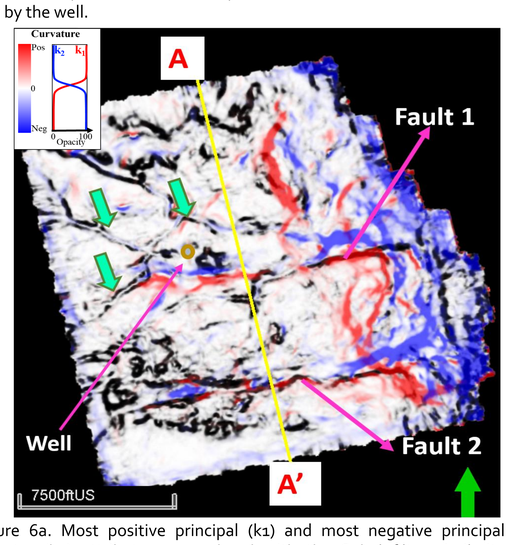

Figure 6a. Most positive principal (k1) and most negative principal curvature(k2) attributes co-rendered with the Sobel filter similarity along the Detrital surface. This figure allows visibility of the fault throws (blue– downthrown, red– upthrown) and edges of features (black). The green arrows show the possible channels.

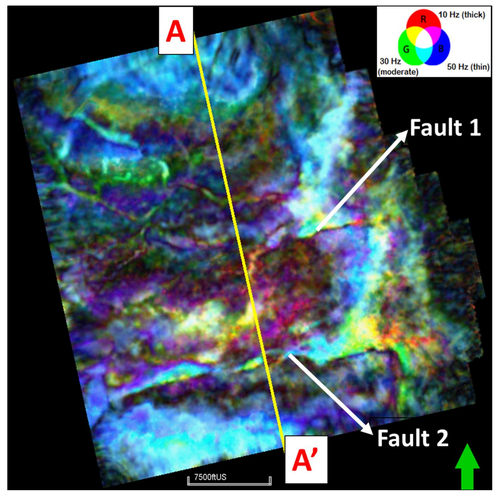

Figure 6b. RGB blending of the spectrally decomposed volumes at 10Hz, 30Hz and 50Hz frequencies along time slice at 1090ms (very close to the detrital surface) highlighting the faults, thickness of beds and variation in lithology. Note the NW-SE oriented channels in the north central part.

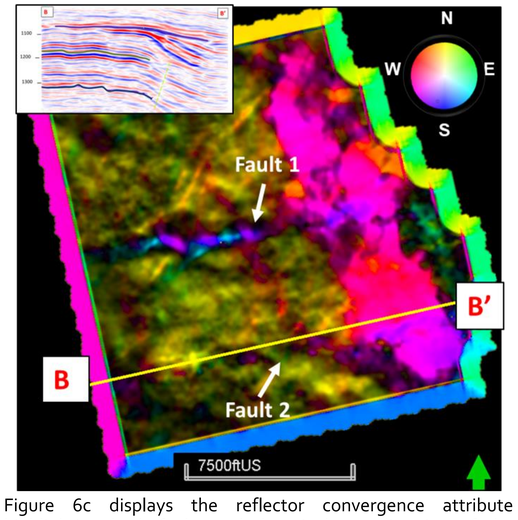

Figure 6c displays the reflector convergence attribute highlighting both faults and the pinch-out direction of the angular unconformity.

Conclusion & Further Studies

Flattening the seismic data and modifying the color scales enabled an accurate representation of small faults, probable channels, bed pinch-out directions, and other subtle features. In the future, a well-to-seismic tie could be used to determine which formation sits directly beneath the unconformity at various points due to bed tilting. This can assist in comprehending some of the subtle features highlighted by the seismic attributes.

Acknowledgments

We acknowledge Kinder Morgan for providing the 3D seismic survey data. The Attribute Assisted Seismic Processing & Interpretation (AASPI) software was used to compute the seismic attributes. We are also grateful to Schlumberger for providing the Petrel software that was used for seismic interpretation.

References

Hodges, R. A., 2017, Late Paleozoic Faulting and Its Effects on the Deposition of the Permian San Andres Within the Goldsmith Landreth San Andres Unit in Ector County, Texas: M.S. thesis, UTPB.

Szypulski J.E., 2021, The Influence of early Paleozoic Tectonics on Permian Aged Strata using Seismic Attribute Analysis in the Goldsmith Landreth San Andres Unit in Ector County, Texas: M.S. thesis, UTPB.

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