High Resolution Seismic Characterization of Carbonate Reservoirs

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Abstract

Seismic interpretation of thin layers, and their correlation to well data, is limited by the natural filtering characteristics of the subsurface, reducing the imaging capability of the seismic data to properly resolve individual layers of interest. This resolution limitation is maximized in carbonate layers due to their natural high velocities. The vertical resolution limitation of the seismic data not only affects the thickness estimations of the layers in the interpretation process, but also limits the accuracy of the estimation of elastic properties from conventional inversion workflows, further limiting the understanding of the reservoir characteristics and extension.

Sparse Layer Inversion is applied on a PreSTM seismic volume covering a carbonate sequence of Lower Permian to Mississippian age to enhance the vertical resolution of the seismic data, revealing geologically meaningful higher resolution events, improving the stratigraphic imaging of the seismic in the carbonate sequence, and reducing the risk of interpretation and detection of thin layers of interest, giving a better understanding of the porosity distribution in the carbonate reservoirs. Sparse Layer Inversion uses a wavelet dictionary to solve for the optimum number of layers to represent the seismic trace, additionally, the thickness of the individual layers and the magnitude of the spikes, representing the top and base of the individual layers, is further constrained by the natural spectral response of the seismic data. The inversion process is trace by trace and amplitude-preserving and it does not require the use of a priori models.

Well-to-seismic correlation analysis on the resulting high resolution seismic data shows the geologically meaningfulness of the high-resolution events estimated by the inversion process. Vertical resolution analysis shows that it is increased from ~120ft (~36m) in the conventional seismic to ~70ft (~21m) in the high resolution seismic. This increment in the resolution allows the interpretation and identification of thinner events, giving a better understanding of the reservoir architecture.

The high resolution seismic is also used in conventional inversion to produce elastic properties, then in machine learning to predict porosity in the carbonate sequence. The results show increased stratigraphic detail and detection of thin layers that is not achievable in the conventional resolution seismic.