**Prestack Data Conditioning and Analysis for Resource Plays**

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**ABSTRACT**

Modern resource plays such as gas and oil shales, tight sands, and tight carbonates have been enabled by three key technologies – horizontal drilling, hydraulic fracturing, and 3D seismic data. The most common use of 3D seismic data is to delineate geohazards such as faults, joints, and karst that may result in a well going out of the zone of interest, in fluid and proppant loss, or in significant water production. Such analysis is made from the poststack seismic data volume. Somewhat less common is the use of 3D seismic data to estimate brittleness from prestack inversion and the direction of maximum horizontal stress and the presence and orientation of open fractures from amplitude vs. azimuth (AVAz) analysis. Both of these products are derived from the prestack seismic data. An additional prestack data analysis innovation is 5D interpolation to better balance the subsurface illumination and minimize acquisition footprint.

Stacking of high fold data is a powerful filter, particularly when the fold approaches 400 traces per CDP. While a given stacked seismic data volume may be of high quality, the input migrated gathers may be contaminated by noise that corrupts prestack inversion and AVAz analysis. Unfortunately, the “kaizen” or gradual, orderly, continuous improvement of prestack seismic data is a tedious, multistep process, beginning with careful survey design and several passes of velocity analysis and surface-consistent statics.

Migrated data suffer from the equivalent of NMO stretch. Long offsets suffer from non-hyperbolic moveout. Subtle lateral variations in velocity result in data misalignment and destructive interference of the higher frequencies upon stack. 5D interpolation accurately interpolates specular reflections ameliorating acquisition footprint but inaccurately interpolates diffractions needed to map faults, joints, and karst.

We review several recent innovations that address these data quality issues. First, we extend the well-established concept of structure-oriented filtering to attenuate crosscutting noise to not only individual common-offset and common-azimuth volumes, but also across the offset and azimuth directions. Second, we use gather by gather semi-automated velocity analysis for anisotropy to retain longer offset information and more accurately invert for S-impedance and density. Third, we correct for long-offset migration stretch to improve the vertical resolution of S-impedance and density volumes. Fourth, we use least-squares Kirchhoff migration preconditioned by prestack structure-oriented filtering to suppress data and operator aliasing and better balance the migrated amplitudes for irregular surface acquisition. Finally, we use 5D interpolation via demigration within a least-squares migration framework to accurately interpolate both specular reflectors and diffractions.

We demonstrate the value of these incremental improvements on data acquired over the Barnett Shale of Texas and the Mississippi Lime of Oklahoma and Kansas. We conclude with unresolved questions on how to analyze the shift in spectral response after hydraulic fracturing.