Prestack Seismic Data Inversion for Shale Gas Reservoir Characterization in China

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Abstract

An integrated study of the well Zhao-104 and surrounding wide-azimuth 3D seismic data volume within the shale gas reservoir in South China has been conducted with the objective of generating shale formation properties related to fracture orientation and intensity in the area and deriving such reservoir rock properties as data quality allows. Well data, structural seismic information, and prestack inversion products were combined in an integrated interpretation.

Seismic gather conditioning improved seismic data quality prior to prestack inversion by improving signal/noise ratio, removing NMO stretch, and aligning reflection events. Velocities from residual moveout (RMO) analysis on individual sectors were used as input to detection of fracture orientation and anisotropy.

Fracture strike and P wave anisotropy were calculated using the RMO updated sector velocity fields in elliptical velocity inversion, while inversion for P and S impedance and derivative attributes produced volumes that relate to rock properties such as brittleness and rigidity that are likely to impact fracturing.

Seismic attribute analysis of anisotropy from elliptical velocity inversion indicates that anisotropy varies horizontally and vertically, and that it is dominantly controlled by stress azimuth, which conforms to the current day stress field as independently determined from borehole break-outs.

Elliptical velocity inversion results are compatible with fault and fracture description from other methods and data sets. The inversion for P and S impedance and derivative attributes produced volumes that relate to rock properties such as brittleness and rigidity that are likely to impact fracturing.

Given the noise level in the data and the concern with regard to variability of near and far amplitudes, the prestack simultaneous inversion residual amplitudes are acceptably low. Extracted seismic P impedance traces are a good match to the upscaled log data. Seismic S impedance less so as might be expected given the data quality concerns and the resulting Poisson's ratio, while moving in the correct sense, is lower than that of the well log. Nevertheless, geologically sensible integrated interpretation results show that this data set may be usefully used to infer information on fracture orientation and brittle/ductile layers that are important indicators of TOC and for horizontal well placement.