Azimuthal Anisotropy as a Potential Fracture Diagnostic from 3D Surface Seismic Data: Example from Wildcat Hills, Alberta

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Abstract

In azimuthally anisotropic media, normal-moveout velocity is represented as an ellipse in the horizontal plane, with the orientation of the axes determined by both the symmetry of the medium and the interface geometry. All inversions of multi-azimuth traveltimes for the properties of fractured media are derived from this analytic representation. Consequently, all of the recent work has generally assumed a dominant fracture direction and vertical fracture planes, and no lateral variation in reflector structure. However, Foothills geology is structurally complex and therefore these are simplistic approaches. Quantification of fracture-related effects on the seismic response is a difficult attempt since even a small deviation of fracture planes from the vertical can change the orientation of fractures predicted under these assumptions. There are also theoretical expectations from the equivalent medium theories that the resulting anisotropy is dependent on the crack and pore shape, fluid physical properties, and saturation ratio.

The Wildcat Hills project focused on identifying azimuthal anisotropy based on velocity variations with azimuth in a small 3D survey. The azimuthal analysis consisted of three phases: full data processing, 3D structural interpretation to delineate the structure, and azimuthal processing and analysis on 30o sectors. There are clear traveltimes differences among the azimuthal sectors, with the pair of orthogonal azimuths differing most significantly oriented at 60o and 150o. If the azimuthal traveltime variation indicates fracturing, differences in traveltimes can be further used to quantify the fracture properties. We are currently applying and expanding this method to another seismic dataset in Foothills.