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Determining Fracture Orientation from Pre-Stack 3C3D Seismic Data

We acquired, processed, and analyzed 3-component 3-D (3C3D) seismic data over a fractured carbonate reservoir to determine fracture orientation. Seismic data were acquired by Grant Geophysical, data processing was done by Fairfield Industries, and data analysis was a joint effort by Global Energy Development PLC, and the Bureau of Economic Geology. Our objective was to build a seismic-based map of fracture azimuths across a prospect so a horizontal wellbore could be optimally positioned to produce hydrocarbons from a targeted fracture system. Drilling results confirmed that fracture azimuths were reliably determined from the seismic data.

We did all of our seismic data analysis and interpretation in the pre-stack domain. Our philosophy was to create common-azimuth trace gathers of radial geophone data at closely spaced stacking-bin coordinates so converted-SV reflections from the targeted reservoir could be studied for azimuth-dependent arrival times to identify fast-S and slow-S polarization directions. This objective required that we implement a 3C3D acquisition geometry that provided a full range of offsets in all azimuth directions. The converted-SV reflections from the fractured reservoir were robust events, which caused our analysis technique to be effective in this instance.

Although our data acquisition, processing, and interpretation procedures led to accurate predictions of fracture azimuths, we have not yet been able to decide which combinations of seismic attributes are optimal for predicting fracture openness, which is a second critical fracture property needed for siting wells. Our fracture-openness research is ongoing, and research findings will be reported at a later date. We will describe here our methodology for determining fracture orientation from 3C3D seismic data so the technology can be used by others in appropriate situations.