Fracture mapping and feasibility of monitoring CO₂ in situ from seismic data at the Mississippian Carbonate Reservoir, Wellington oil field, south-central Kansas

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Significance

Analyze the effects of azimuthal anisotropy on 3D P-P wave seismic data to provide insight in the in situ stress and relative fracture characteristics of the Mississippian and Arbuckle reservoirs.

Amplitude variations are analyzed with the azimuth about a common midpoint or common image point in order to quantify reservoir anisotropic properties in the azimuthal domain.

Seismic Anisotropy

- Variations in elastic properties with orientation of wave propagation observed as variation in seismic velocity and amplitude.
- Radial Anisotropy, or Vertically Transverse Isotropy (VTI), is observed in shales and thin layers, and interpreted as Amplitude Variation with Offset (AVO).
- Azimuthal Anisotropy, Horizontal Transverse Isotropy (HTI), is due to in situ horizontal stress and vertical fractures.

Background

A CO₂ injection pilot study was conducted by the Kansas Geological Survey in spring of 2016 to determine the feasibility of CO₂ for EOR. A 3D seismic survey and two 2D seismic lines were acquired pre-injection, with a final 2D seismic line acquired post-injection. The Mississippian is a heterogeneous low resistivity-high porosity reservoir, which primarily consists of cherty dolomite. The Arbuckle is comprised of stacked aquifers and aquitards, and is non-producing of oil or gas in the Wellington field (Watney et al., 2001). These carbonates exhibit anisotropy due to varied crystalline structure, porosity geometry, and micro-fracture. The heterogeneity of the reservoirs makes the seismic analysis challenging; however, additional well control and seismic data supplement the modeling effort.

Conclusions

- Analysis of azimuthal anisotropy of the Mississippian and Arbuckle exhibits results consistent with fracture and maximum horizontal stress direction.
- Large scale features such as faults are indirectly observed through AAVz.

References


Conclusions

- Post-stack seismic amplitude analysis for CO₂ detection is inconclusive, however this is not unexpected given the relatively small amount of CO₂ injected and high matrix incompressibility.
- Gassmann and Patchy fluid substitution models for the Mississippian reservoir display a decrease in amplitude with an increasing angle of incidence and CO₂ saturation.
- Use of AVO and impedance inversion in the pre-stack domain will be employed to test the utility of surface seismic for detecting the CO₂ plume and to verify fluid substitution modeling results.

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