Role of Anisotropic Methods in Characterization of Tight Gas Sands

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Fractures $\Rightarrow$ Pathways for Fluid Flow
(fracture azimuths from well logs)
Aligned Fractures Create Anisotropy

Orthorhombic Model

Symmetry plane \([x_1, x_3]\)

Symmetry plane \([x_2, x_3]\)
Multicomponent, Multiazimuth, Walkaway Vertical Seismic Profiling (VSP)
Orthorhombic Model at Vacuum Field
(Dewangan & Grechka, 2003)
Reflection Data Signatures in Fracture Characterization

- splitting of SS- or PS-waves (time delays, amplitudes)
- wide-azimuth, long-offset reflection traveltimes
- azimuthal prestack amplitude (AVO) variation
- azimuthally varying attenuation
Reasons for Azimuthal Variation

- dipping or curved interfaces
- lateral velocity variation
- azimuthal anisotropy due to
  - fractures & stress
  - host rock
Azimuthal AVO Analysis

• high vertical resolution
• sensitive to anisotropy

But

• low signal/noise, especially for S-waves
• gives only jumps in properties
• overburden distortions
Processing/Inversion Methodology for Wide-Azimuth Data

- 3D “global” nonhyperbolic moveout inversion
- estimation of NMO ellipses
- picking of amplitudes
- moveout-based anisotropic spreading correction (MASC)
- azimuthal AVO analysis
Rulison Field, Colorado
(data courtesy of RCP)
Stratigraphic Column

- Bottom of the Reservoir (Cameo Coal, ~7000 ft)
- Top of the Reservoir (UMV Shale, ~5000 ft)
- Mesaverde Top (~4000 ft)
Migrated Section

Top of the reservoir (UMV Shale)

Bottom of the reservoir (Cameo Coal)
Azimuthal AVO for Reservoir Bottom

MASC

Conventional
Comparison with Wrenching Faults
Comparison with FMI Logs

Logs

AVO
Comparison of AVO and NMO Ellipses
Rulison Case Study (P-wave)

- AVO ellipse most sensitive
- Amplitude anomalies correlate with geology

- AVO inversion ambiguous:
  - Poor AVO–NMO correlation
  - Multiple fracture sets?
  - Fractures above and/or below?
  - Fracture infill?
Road to the Future: Multicomponent Seismic Inversion Combined with

- multiazimuth, walkaway VSP
- passive seismics
- well logs (DSI, FMI, saturation)
- core measurements
- geology
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