

March 16, At the Borehole Scale Discussion Sessions

Fractures and Fault Identification using BH Acoustics and Other Technologies

Discussion Leader: Bill Borland, Schlumberger Geophysics Domain Champion

Stoneley

- High Permeability Contrast – Vertical or Horizontal
- Travel time, attenuation affected by permeability
- Reflections from fractures
- Open productive fractures detected
- Permeable faults detected
- Should not show induced fractures from drilling process
- Limits
 - Fault / fracture must intersect the borehole
 - Cannot detect fractures parallel to the axis of the borehole
 - Must be permeable
 - Borehole must contain fluid
 - Measurement / Interpretation affected by:
 - Fracture geometry / angle
 - Borehole rugosity
 - Caliper
 - Modeling to see impact of rugosity and bedding
 - Can use both high and low frequency to interpret quality
 - Processing parameters
 - Tool effects
 - LWD can provide but poorer
 - Vertical Resolution (Length of array receivers)
 - Pore Plugging by drilling fluid
 - Vugs and Dissolution Zones may appear as fractures
- Calibrate to BHI log

Shear Waves

- Dipole Measurements – designed for 8" B.H, can be used to 18"
 - Sees fractures sub-parallel to axis of the B.H.
 - Dispersion analysis (intrinsic versus stress induced)
 - Potentially can detect fractures through casing.
 - Need well direction survey (gyro)
 - Active fault changes (change in Azimuth of Anisotropy)
 - BHI image log shows conductive fractures but not necessarily productive.
 - Limits
 - Bedding anisotropy (image log useful)

- Cannot detect fracture perpendicular to the borehole

Compressive (P) DT

- KT (Kuster-Toksoz) to evaluate fractures

Sonic Imaging

- Monopole / Dipole P/S waves
 - Depth of investigation up to 20 to 30 meters
 - P wave frequency 4 – 12 KHz
 - S + P (dipole) frequency 1 – 4 KHz
 - Good for sub-seismic faults plus large fractures
 - Does not need to intersect the borehole
 - Do not know where fracture fault is relative to the BH (mirror imaging)
 - Sh imaging as opposed to Sv
 - Processing is not real time, after the fact. Can take a while.
 - Mirror imaging problems with dipole
 - Residual mirror imaging seen on monopole
 - No LWD solution

Ultrasonic Imaging

- Conductive / open versus closed fractures
- Travel time and amplitude images
- 360 deg image
- Provides a BH caliper
- Open hole only
- Image negatively affected by:
 - Elliptical shaped B.H.
 - Borehole rugosity
 - Centralization (not centralized well enough)
 - High Mud weight

Spectral Noise Log

- Distinguishes between fracture and matrix flow
- DOI ~ 3 meters
- Works CH or OH
- Station measurement

Microseismic

- Passive or active measurement
- Detects noise events (stress release) in rock caused by changes in reservoir pressure and or temperature.

- Events can be reactivated faults, fractures.
- Also used to detect hydraulic fracs
- Measurement takes place over a long time period (Months to years) for passive or a few hours to days for active hydraulic fracture monitoring
- Run Cased Hole
 - Dedicated observation well best
 - Producer injector wells can be used but issue with background noise
- Interpretation problems due to changes in velocity due to changes in type and position of fluids