Rock Mechanics and Geomechanics Capabilities

Customer Need

Unconventional Rock Mechanics Test (RMT) measurements differ from conventional rock testing when laminations and fractures (natural vs induced – drilled vs. core handling) are considered. Heterogeneity and anisotropy within core plug scale is important to capture thin beds, ash beds which are typically missed within the well log tool resolution to build more robust rock physics models with less uncertainty.

Core handling processes are a key starting point in rock mechanics testing to measure various mechanical attributes to better represent the reservoir. Core drilling-induced fractures can potentially create pseudo-anisotropy that might overestimate well log properties for Completion fracture modeling workflow. POL technicians and Engineers are trained and skilled when it comes to core preservation, core handling and preparation which are the heart of workflow for better quality measurements.

Methods and Materials

Figure 1: Triaxial pressure vessel for rock mechanics testing

All six POL pressure vessels have wide range of rock mechanics testing capabilities as follows:

- Axial stress up to 200,000 psi
- Confining and pore pressure of 20,000 psi
- Static and dynamic closed-loop servo control
- High temperature mechanical testing up to 200 °C (350 °F)
- Acoustics for compressional and orthogonal shear velocities
- Independent Poisson's ratio for parallel and perpendicular anisotropy
- Testing can be performed at strain rate or stress rate controlled
- Post failure analysis for residual strength organics
- K_0 test for pore volume compressibility with acoustics
- Single stage and multi stage triaxial testing ($S1 \neq S2 = S3$) for Mohr-Coulomb analysis based on yield vs peak failure strengths

Prior to destructive compression testing, it is recommended practice to perform pre-testing CT scans to aid in the selection of competent sample intervals for successful core plug drilling following ASTM (American Standard Testing Methods) standards. Followed by CT scans, high resolution XRF –non-destructive, high resolution measurements for sample interval selection will be performed to capture mechanical properties in the highly-layered zone that are normally missed within sonic tool resolution. Selected plugs will be air/oil/water drilled (Length : Diameter – 2:1 or 3:1.5) and sleeved immediately to maintain competent sample quality to hold any natural fractures or high laminations.

Drilled plugs will be carried to core prep zone to ensure parallel surface in both the plug ends for proper stress loading and strain measurements. Poor core prep can lead to highly incorrect axial strain measurements and eventually result in a poor Young's modulus. Axial strain gauges 1 and 2 on both sides within the pressure vessel as a function of applied stress should show minimal variability ensuring proper core preparation. Loaded core samples are fully controlled by our high end automated software to measure both static (stress-strain) and dynamic (acoustics) properties. Various test types can be executed by understanding application objectives.

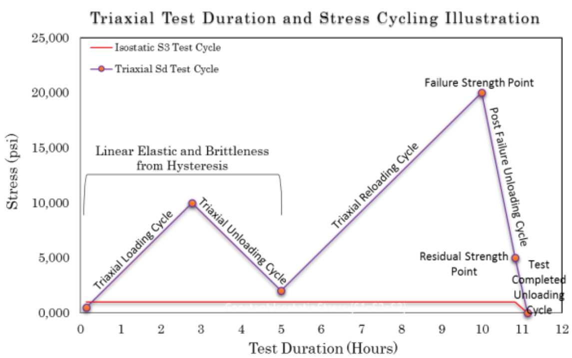

Figure 2: Typical Single Stage Triaxial (SST) test procedure

Results of the Analysis

Carefully handled vertical and horizontal oriented core samples are subjected to in-situ isostatic stress path followed by triaxial stress to measure key mechanical attributes such as Young's modulus, Poisson's ratio, anisotropy magnitude, rock strength (UCS, yield, peak and residual), and unique internal pore pressure prediction models to build various Geomechanical models to feed as an input for drilling and hydraulic fracturing objectives. Core-based experimental studies are further utilized to capture thin beds/ash beds and for log calibration purposes to capture and reduce Geomechanical uncertainties.

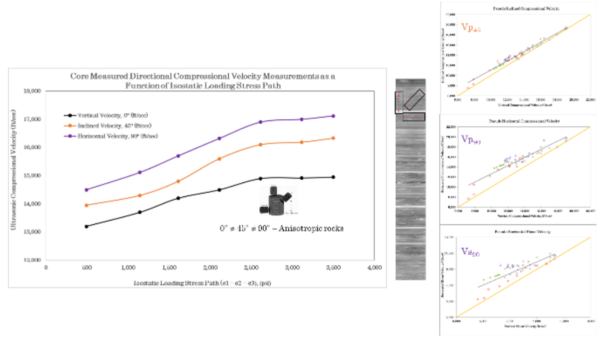

Figure 3: Azimuthal velocity measurements for anisotropy

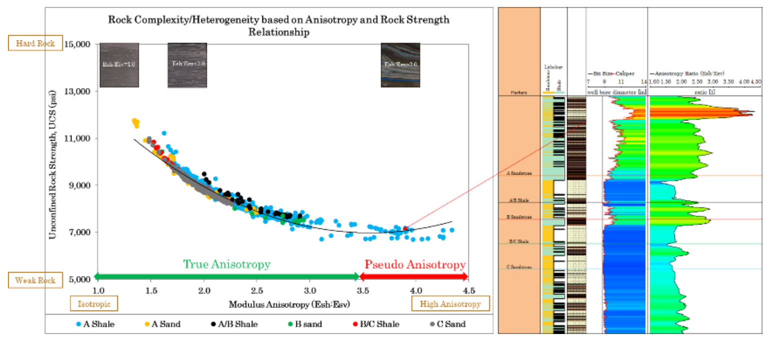

Figure 4: Validating fully developed anisotropy with UCS

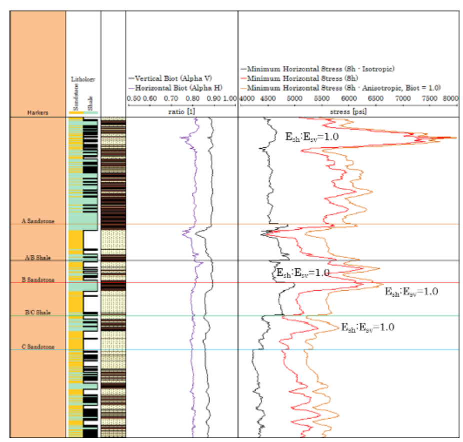

Figure 5: Calibrated stress profile for drilling and completion

Numerous iterations within the developed core model to capture uncertainties in the zero-lateral stain based variable Biot stress model is performed via three steps calibration process - developed stress profile calibrated to mini-frac closure stress, Pressure History Matching (PHM) and with micro seismic data. Moving away from over simplistic isotropic models to anisotropic models aid better optimum hydraulic fracturing.