Critically Stressed Fractures

Sets of fractures favorably oriented to fail in shear under the present-day stress field are said to be critically stressed. These fractures exhibit very good fluid flow characteristics. Consequently, their identification is essential for optimal development during all stages of wellbore construction, from trajectory planning and wellbore placement, to stimulation strategy.

Task Fronterra offers a comprehensive multidisciplinary analysis that starts with the identification of geological structures and stress direction, continues with the derivation of the near-borehole geomechanical model, and concludes with the combination of these results to determine the fractures that are critically stressed.

Structural Characterization and Stress Direction

The first stage consists of thorough identification of fractures and faults, as well as determination of stress direction from geomechanical features. The large variety of data sources that our experts may use during this step include: borehole images, core description, caliper logs, cross-dipole sonic logs, etc.

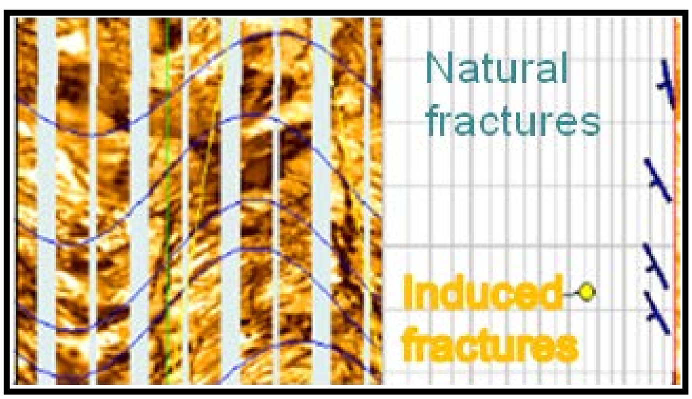
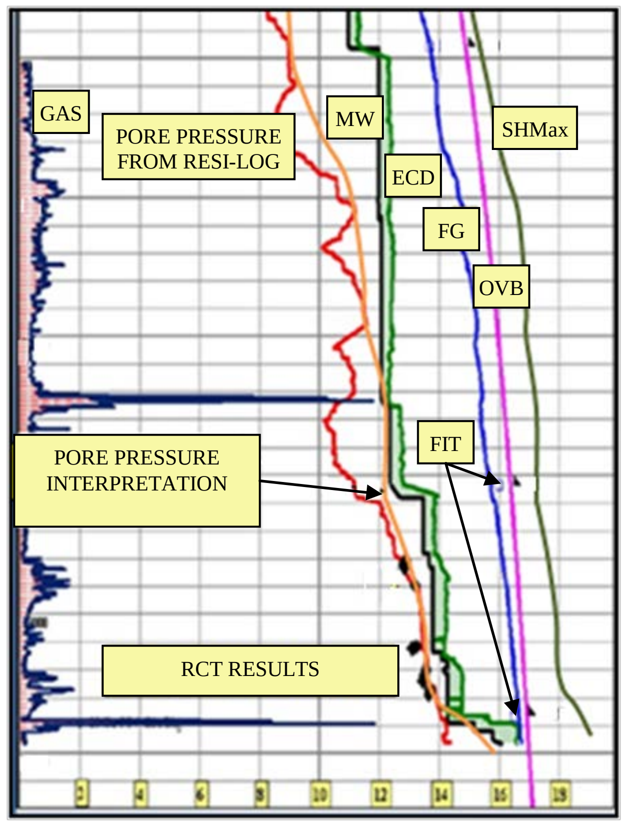


Image logs are one of the sources that can be used for interpretation of structural features. In addition, geomechanical indicators such as drilling induced fractures and breakouts are used to determine the stress field direction.

Near-Borehole Geomechanical Model

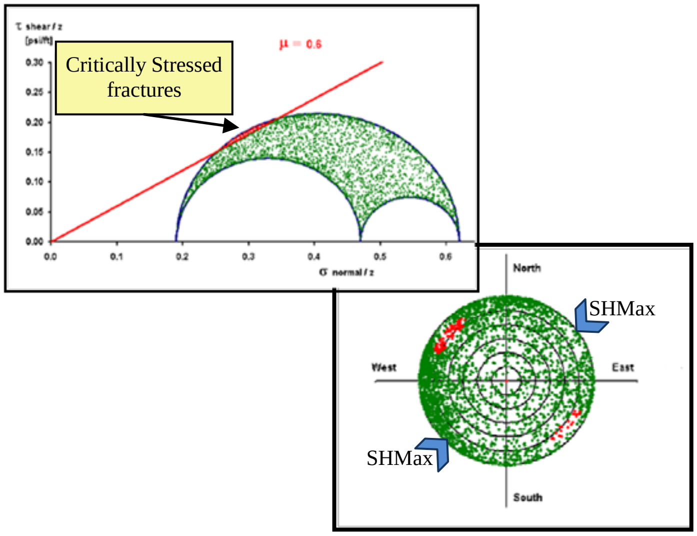
Determination of formation pressure, followed by collection and interpretation of any and all drilling events, measurements, and indicators related to the present-day stress field. The Integration of these data results in a constrained geomechanical model composed of *in situ* stresses and mechanical properties.



Analysis of drilling events and borehole measurements enables the derivation of the constrained stress model, consisting of overburden (OVB), fracture gradient (FG), maximum horizontal stress (SHMax), and pore pressure.

Critically Stressed Fractures Identification

The decomposition of the stress field on the fracture planes allows the identification of fractures that are critically stressed. The Mohr diagram is utilized to identify and visualize both critically and non-critically stressed fractures. Additionally, the categorized fractures may be represented in dip and strike stereonets.



The Mohr diagram (top) is a graphic representation of the effective stress field on the fracture planes. Comparison with a failure criterion (red line) enables identification of critically stressed fractures, which are plotted on a conventional stereographic projection (bottom).

Our critically stressed fracture analysis includes:

- Characterization of the orientation of the natural fractures, faults and geomechanical features from borehole images.
- Derivation of the in-situ stress field acting in the reservoir.
- Evaluation of traction vectors acting on the fracture planes.
- Identification of fractures whose traction components exceed a Mohr-Coulomb criterion; these constitute the critically stressed fractures.
- Representation of the critically stressed fractures poles on a stereographic projection.

The benefits of the critically stressed fracture analysis are:

- The poles depicted on the stereographic projection represent well trajectories that will intersect the largest density of critically stressed fractures.
- Intervals with higher occurrence of critically stressed fractures represent more productive zones. Thus, stimulation stages can be optimized to target these or other reservoir volumes with lesser connectivity to the wellbore.
- Identification of critically stressed fractures in shallow formations is important to prevent gas show events (underbalance drilling) or circulation losses (overbalance drilling).

The data required for critically stressed fracture analysis are:

- Borehole image logs: Identification of breakouts and drilling induced tensile fractures
- Input data to complete the near borehole geomechanical model, except mechanical properties information (see Geomechanical Modeling/Stress Analysis section).
- Logs: Gamma ray, density, resistivity, DTc/DTs, caliper.
- Drilling reports: drilling events, LOT/XLOT/FIT curves, minifrac values, mud program, casing depths.
- Mechanical test results: lab measured dynamic/static deformability and strength parameters, strength envelope.
- Stratigraphic column.
- Structural maps.

Optional data, if available:

- Stratigraphical, structural reports.
- Fracturing, minifracs.
- Neutron porosity log.
- Cross dipole log, stress anisotropy interpretation.
- Oriented (4-6 arm) caliper data.

Task Fronterra Geoscience is a global independent provider of industry leading, integrated geoscience solutions, from single well analysis to complete reservoir studies.