

Naturally Fractured Reservoirs



Natural fractures are important conduits for oil or gas flow to producing wells. Closure of these fractures seriously impairs well productivity. Determination of fracture conductivity and porosity versus closure stress are important for characterizing naturally fractured reservoirs and establishing safe operating conditions.

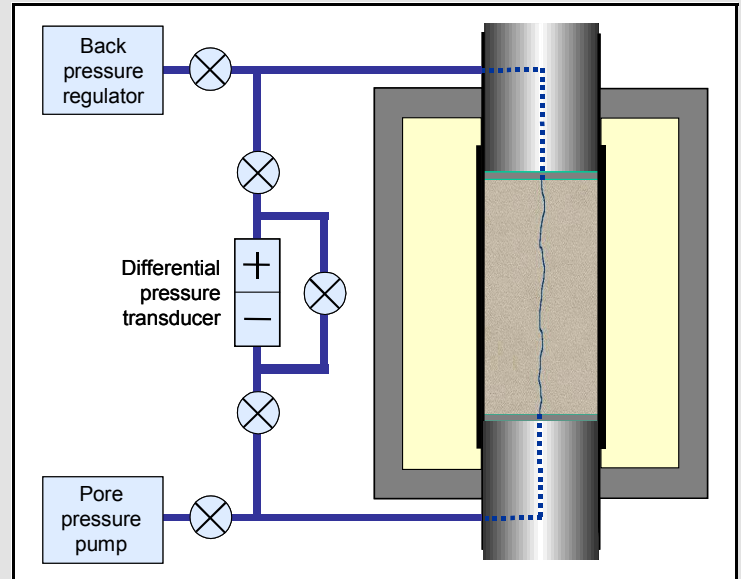
Common problems encountered with naturally fractured reservoirs:

- Extensive formation damage and low recovery.
- Early production decline from stress-sensitive reservoirs.
- Early or frequent stimulation treatments required.
- Uncontrolled reserve migration.

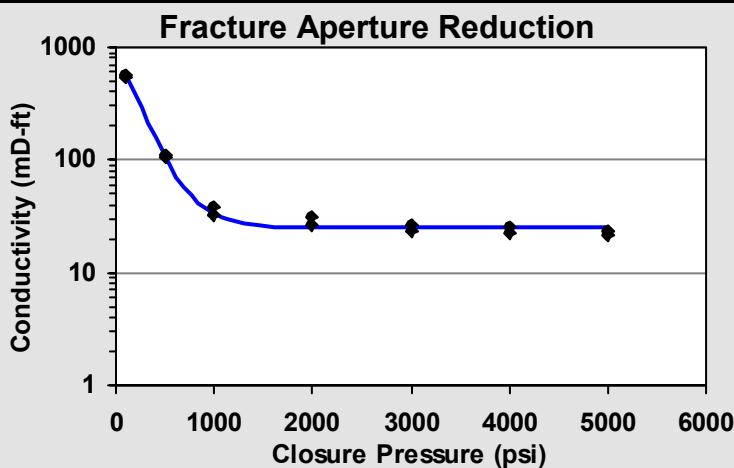
Natural Fracture Analysis Benefits:

- Preserve the natural proppant system and avoid costly stimulation treatments.
- Enhance production drive with detailed knowledge of how stress changes will affect reservoir porosity and permeability.
- Improve how reservoir models predict rock behavior under changing pressures and fluid states with Finite Element Analysis and lab data.
- Secure dependable production for extended periods, dramatically improving percent recovery over the life of a field.

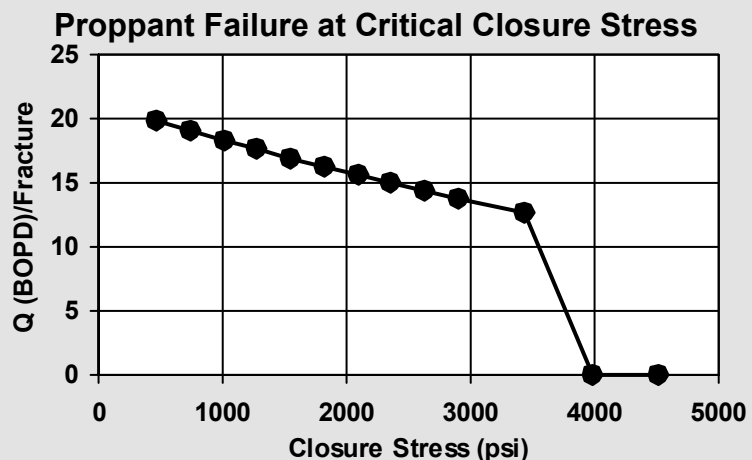
Fracture Conductivity and Fracture Porosity Test Apparatus



Fracture conductivities and porosities are measured on a core plug with a vertical fracture under uniaxial strain (zero radial strain) conditions.



As the reservoir is depleted and the fluid pressure drops, the closure stress acting on the natural fracture increases and productivity declines because of the reduced fracture conductivity.



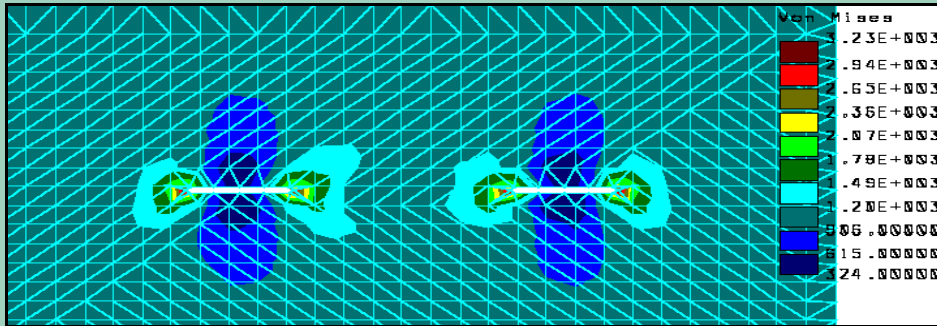
Natural fractures are naturally propped open by formation materials in the form of sand grains. When drawdown pressure reaches a critical value, closure stress is strong enough to crush the proppant and close off the fracture.

Realize the full potential of a reservoir with indispensable knowledge of basic fracture properties. Core Laboratories offers quality geomechanics data and expert analyses to maximize recovery.

Typical Tests for Natural Fracture Characterization:

- Fracture conductivity test for closure stress.
- Fracture porosity reduction with production.
- Brinell hardness test for fracture wall hardness.
- Embedment test for embedment of naturally propped fracture.
- Triaxial compressive test for static elastic constants.
- Sonic velocity test for calibration and prediction of closure stress.
- Sonic anisotropy for determination of fracture azimuth.

Finite Element Analysis of Multiple Fractures

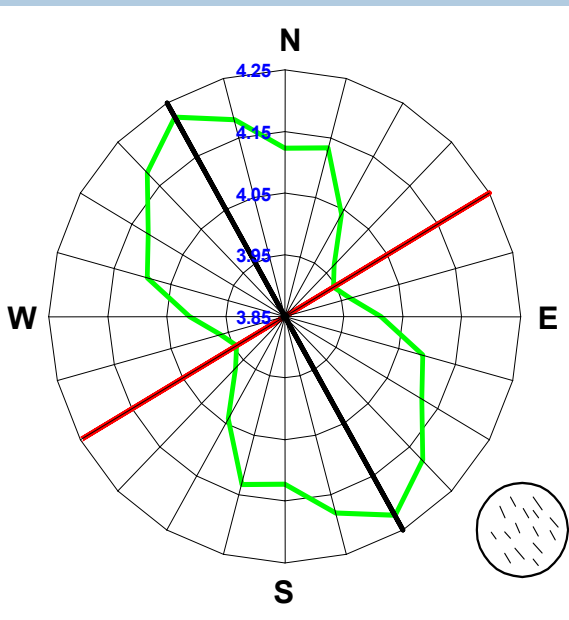
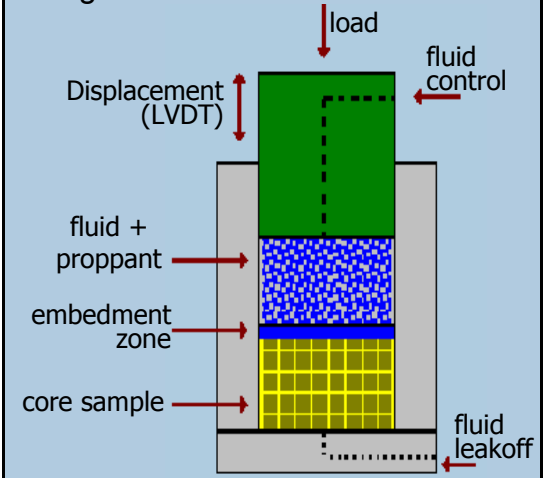


Stress profile for two parallel fractures at 1150 psi closure pressure.

Reservoir modeling techniques such as the Finite Element Analysis employed by Core Lab's Protechnics division use hard data from real-world rock mechanics testing to evaluate fracture conductivity and find the closure pressure for a system of multiple fractures.

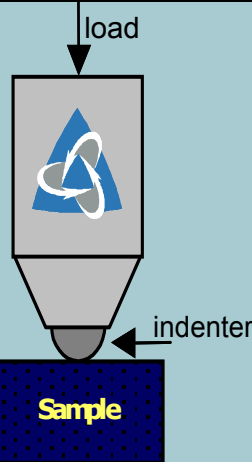
Proppant Embedment Test

When naturally occurring proppant particles penetrate the walls of the fracture, the effective width of the fracture and thereby the fracture conductivity is decreased. Proppant embedment can reduce fracture width up to 60% with subsequent reduction of productivity from oil and gas wells.



Fracture Azimuth

Knowledge of fracture azimuth is important for the placement of horizontal wells and for determining the optimum well locations in tight formations for drainage optimization and drive/sweep efficiency of water flooding or EOR. Sonic velocity anisotropy determines the direction of optimum fracture azimuth with a field proven method (over 100 wells) that is inexpensive and reliable.



Brinell hardness is a measure of the resistance of the rock to indentation and has a direct implication for proppant embedment problems.



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