One Method for Evaluating the Effects of Confining Stresses and Rock Strength on Fluid Flow Along the Surfaces of Mechanical Discontinuities in Low Permeability Rocks

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Changing the confining stress can modify rock properties such as porosity and permeability but also affect the ability of fluid to flow along planar mechanical discontinuities such as faults, shear fractures, tensile cracks, or bedding planes. The degree to which the flow of fluids will be altered with variation of confining stress depends on the spatial orientation of the mechanical discontinuity and the strength of the rock. Similarly, if hydraulic fracture stimulation is conducted in the vicinity of a mechanical discontinuity and the pressurized fracture fluids establish hydraulic continuity with the discontinuity, then the pressurizing fluids can alter the stresses at the mechanical discontinuity. These changes can cause the mechanical discontinuity to reactivate in shear resulting in an increase in the ability of the mechanical discontinuity surface to allow fluid flow, thus potently diverting the stimulation fluids off in a direction other than anticipated.

A key component in the characterization of fluid flow along mechanical discontinuities is an understanding of the surrounding subsurface stress field. To constrain the present-day horizontal stress magnitude, a stress-strength equilibrium approach is employed using overburden rock density estimation and insights as to present-day tectonic setting. Stress orientation can also be inferred from structural geology principles via interpretation of mapped active features and wellbore information such as drilling history and image logs. Once information about stress magnitudes and orientation is available, one can calculate the shear and normal stress magnitudes acting on planar mechanical discontinuities of all possible strikes and dips. Furthermore, one can evaluate what magnitude of fluid pressure within each mechanical discontinuity would be required to encourage shear failure reactivation. An example from the Barnett shale play is presented as an application of the method, offering various solutions to the likely orientations of fractures that could interact with hydraulic fracture treatment.