Modeling Propagation of Hydraulic Fractures in Mechanically Layered and Naturally Fractured Rocks

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Abstract

Sedimentary basins where unconventional reservoirs (e.g., shale gas/oil) are currently being exploited around the world show a degree of complexity that is rarely captured by conventional hydraulic fracture (hydrofrac) design soft ware. These geologic complexities include: sedimentary heterogeneities both vertical and lateral (e.g., layering, laminations, bedding, lateral facies changes, sedimentary structures, etc.), and structural heterogeneities (e.g., joints, natural fractures, faults, folds, etc.), both of which control rock properties and in situ stresses.

In outcrops where mechanically layered rocks exist, natural hydraulic fractures (e.g., dikes and sills) and joints often show complex interaction behaviors close to geologic interfaces. Well documented field examples exist of T-shaped hydrofracs in volcanic regions, where the fluid has accumulated parallel and adjacent to an interface; field evidences also show slip along bedding planes and natural fractures where dikes and sills are offset. The interaction between a hydrofrac and a geologic interface can lead to propagation crossing the interface, arresting by the interface, or offsetting the fracture path. Several mechanisms exist that would cause a hydrofrac to arrest or offset, including stress variations, discontinuities, and changes in elastic properties (e.g., stiffness). Understanding the conditions by which a hydrofrac will either arrest at an interface or grow to create communication pathways and enhance permeability to increase hydrocarbon production is very relevant for unconventional exploitation. In fact, one of the main issues of hydraulic fracture design is predicting fracture height, containment, and aperture.

In this contribution we will focus on ongoing modeling work in which we are investigating systematically, using a fully coupled three-dimensional simulator, different realistic conditions by which a hydrofrac will propagate through a geological interface in geologically complex zones. An initial aspect of this work also includes benchmarking the 3D code against lab experiments, other codes, and analytical solutions.

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