AAPG Datapages/Search and Discovery Article #90227 © 2015 AAPG Education Directorate Geoscience Technology Workshop, Fourth Annual Eagle Ford Shale, March 9-11, 2015, San Antonio, Texas

Geomechanical Modeling of Hydraulic Fracturing: Why Mechanical Stratigraphy, Stress State, and Pre-existing Structure Matter

Kevin J. Smart[1], Goodluck Ofoegbu[1], Alan P. Morris[1], Ronald McGinnis[1] and David Ferrill[1]

[1]Southwest Research Institute

Abstract

The increasing exploration and production in unconventional resource plays in the past decade has been accompanied by a greater need for understanding the effectiveness of multistage hydraulic fracturing programs, particularly in long (>1500 m or 5000 ft) subhorizontal boreholes (laterals). Traditional (analytical) analysis techniques for estimating the size and orientation of fractures induced by fluid injection typically result in predictions of relatively long and planar extension (mode I) bi-wing fractures, which may not be representative of natural systems. Although these traditional approaches offer the advantage of rapid analysis, neglect of key features of the natural system (e.g., realistic mechanical stratigraphy, pre-existing natural faults and fractures, and heterogeneity of in situ stresses) may render results unrealistic for planning, executing, and interpreting multimillion-dollar hydraulic stimulation programs. Numerical geomechanical modeling provides a means of including key aspects of natural complexity in simulations of hydraulic fracturing.

In this study, we present the results of two-dimensional finite element modeling of fluid-injection-induced rock deformation that combines a coupled stress–pore pressure analysis with a continuum damage-mechanics-based constitutive relationship. The models include both the natural mechanical stratigraphic variability as well as the in situ stress-state anisotropy, and permit tracking of the temporal and spatial development of shear and tensile permanent strains that develop in response to fluid injection. Our results show that simple, long planar fractures are unlikely to be induced in most mechanically layered natural systems under typical in situ stress conditions. Analyses that assume this type of fracture geometry may significantly overestimate the reach of hydraulically induced fractures and/or effectively stimulated rock volume.