Geomechanical Analysis of Diagnostic Fracture Injection Test to Characterize Natural Fractures

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Summary

Unconventional hydrocarbon production has rapidly increased in recent years. Oil and gas from unconventional reservoirs is typically extracted using hydraulic fracturing, which has become a standard completions technique. A diagnostic fracture injection test (DFIT) provides important geomechanical information, such as breakdown, fracture reopening, and in-situ pore pressures, and minimum principal stress. Determination of these geomechanical parameters is important during designing, modeling, and evaluating a hydraulic fracturing program.

Introduction

This study presents a field example to determine minimum principal stress and characterize natural fractures in terms of permeability. The operation was conducted using a wireline conveyed formation tester by injecting a small volume of fluid into an isolated zone at low rates to create a hydraulic fracture. The cycle of fluid injection and pressure falloff was repeated four times. In each cycle following the first, the fracture pressure was reduced by approximately 20 psi. The pressure history provided the breakdown pressure and fracture reopening pressures. Preclosure data was analyzed using standard G-function and square-root-time techniques. This involved analysis of early pressure falloff data to determine the fracture closure stress of a particular formation at a specific depth. A customized model was developed, and poromechanical simulations were performed to characterize natural fractures in the formation by conducting a sensitivity study based on the initial natural fracture aperture. For relatively impermeable natural fractures (low initial aperture), net pressure increased during injection; however, for permeable natural fractures (large initial aperture), net pressure decreased during hydraulic fracture injection operations. In formations where natural fractures are present, this result can enable hydraulic fracturing analysts to infer the qualitative permeability of the natural fracture system.

Performance of multiple pressure injection and falloff cycles provides a consistent minimum in-situ stress. The characterization of natural fractures during microfracturing provides additional information not captured by a traditional G-function or square-root-time analysis. Understanding the fracture pressure and natural fractures in the formation is a key component of successful reservoir completion and development.