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Using the Evolving Stress Changes Around Hydraulic Fracture Stimulations as a Tool for Improving Reservoir Access

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Summary

Understanding realistic hydraulic fracture geometry is of interest to organizations exploiting unconventional reservoirs. Industry has long understood that contacting more low permeability reservoir with propped and unpropped fractures will enhance well productivity. Microseismic mapping technology has been used to show that zipper fracturing, simultaneous fracturing, and areas of reservoir depletion can re-orient fractures in some basins and formations, or to cause these induced fractures to have strongly assymetric or non-ideal geometries. The introduction of a new fracture creates a local stress change, or a stress shadow, and might cause a subsequent fracture in an adjacent fracture stage or adjacent well to re-orient under the right conditions. This paper explores the conditions that are required for fractures to re-orient in various completion and production scenarios.

Introduction

We have analysed the inter-related issues of reservoir stress changes and hydraulic fracture re-orientation using a combination of analytical and numerical models applied to real-world case study data. The objective was to establish some rules of thumb to guide further investigation.

Theory and/or Method

Calibrated reservoir geomechanical models were constructed with laboratory and wireline measured rock mechanical properties and an assessment of in situ stresses. A hydraulic fracture simulator was used to generate planar fractures. These fractures were mapped into the calibrated geomechanical model. Finite element analysis was used to study stress changes induced by fracturing with variable fracture geometry, spacing, wellbore spacing, and in situ stress conditions. This sensitivity analysis shows the alteration in stress magnitudes and orientations as a result of hydraulic fracturing and thus provides a fundamental understanding of the conditions required for fracture re-orientations. Next, a discrete element complex fracture simulator was used to generate complex fracture geometries driven by the reservoir's natural fracture system interacting with a hydraulic fracture. The resulting stimulated discrete fracture network (DFN) was simulated using different pumping conditions. Different scenarios were run to determine if complexity of fracturing could influence fracture re-orientation between adjacent fracture stages and in adjacent wells. The application to refracturing scenarios was considered.

Examples

If stimulated fracture complexity is the goal, it can be shown that there is often an optimal range of operating conditions that will be most likely to enhance fracture complexity and ultimately productivity for a given reservoir and natural fracture network condition. However, in some cases, enhanced complexity is not predicted to be significant. In theory, complex fracturing involves shearing of some kind. It can be shown that shearing of rock, without natural fractures, can be preferred over planar tensile fracturing under certain stress conditions.

Conclusions

The controlling effects of in situ stress magnitudes, reservoir mechanical anisotropy and the natural fracture network on optimal fracture geometry, fracture spacing, wellbore spacing, and refracturing strategies are investigated and discussed. The findings from this study provide general guidelines for managing and enhancing the complexity of hydraulic fractures in a formation.