Predicting Injection Pressure for Natural Fracture Stimulation - A Case Study

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An accurate geomechanical earth model (GEM) including constraints on stress magnitudes and orientations, mechanical rock properties, and the orientations and characteristics of natural fractures, is essential to understanding reservoir response to stimulation and production in low permeability reservoirs such as crystalline basement, tight gas and gas and oil shales. This is because in these reservoirs stimulation response is controlled largely by the properties of natural and induced fracture networks which are in turn controlled by the in situ stresses and by fracture distribution, width, stiffness and strength. These properties are often difficult to quantify, leading to large uncertainties in predictions of the response to stimulation of fractured reservoirs. A well-constrained fracture model makes it possible not only to predict reservoir response to stimulation, including the shape and orientation of the stimulated region but also provides predictions of the required stimulation pressure. And, such a model makes it possible also to predict the change in flow properties during production due to depletion, resulting in better predictions of production rate and ultimate recovery.

As part of the evaluation process of a compartmentalized, fractured basement reservoir in Yemen, wellbore image and other data were used to develop a geomechanical model of stress and natural fractures. Although the results clearly defined the optimal directions in which to drill wells to exploit pre-existing natural fractures, large uncertainties in that model resulted in significant uncertainties in predictions of stimulation response. Analysis of a carefully designed pre-treatment flow test significantly reduced these uncertainties, allowing assessment of the likely effects of stimulation on reservoir flow properties. The results of this test, combined with other information, indicated that while stimulation would result in an improvement in reservoir flow properties, well productivity even after stimulation appeared not to be high enough to justify further field development.