Geomechanical Prediction of Hydraulic Fracture Geometry from Reservoir Characterization

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Unconventional reservoir development typically utilizes multiple, evenly spaced, parallel wells with identical engineering plans of uniformly spaced hydraulic fracture stages. However, 3D seismic often shows significant reservoir heterogeneity, including geohazards and variations in rock properties and stratigraphy. Microseismic data during hydraulic fracturing also often shows significant variation in the hydraulic fracture geometry. Ultimate production and recovery rates from apparently similarly engineered wells can also be dramatically different, suggesting that the common engineering practice of standardized design is poorly suited to the geological heterogeneity of unconventional reservoirs.

Gray et al., 2012, analyze 3D seismic data to estimate geomechanical and stress parameters within a reservoir, and describe the application of reservoir characterization for improvement in decisions of drilling wells and hydraulic fracture stimulation. The pioneering work transforms 3D seismic into engineering parameters such as fracture breakdown pressures and to define brittleness parameters to qualitatively interpret the expected hydraulic fracture variability. In order to transform such reservoir characterization information into a complete engineering tool, a method is required to quantitatively predict the hydraulic fracture variation within this reservoir heterogeneity framework. A geomechanical simulation of hydraulic fracture networks is a way of integrating discrete fracture networks, reservoir elastic and stress properties from 3D seismic to model expected hydraulic fracture characteristics and ultimately predict the expected microseismic response (Figure 1). In other words the geomechanical model can reconcile the geological model with engineering injection data and microseismicity for a unified interpretation of the hydraulic fracture. The predictive geomechanical model is relevant to engineers for scenario testing to tailor the injection to local geological conditions and ultimately optimize hydraulic fracture effectiveness. A calibrated geomechanical fracture network model is able to optimize various well, completion and stimulation scenarios. An assessment of the value of the information can then be made by the estimated production enhancement relative to the more common method of repeating the same well and completion design regardless of the variability of the geomechanical conditions.

Here we utilize published reservoir characterization case studies as input to a geomechanical model to compare the effective fracture-reservoir contact from scenarios of uniformly designed wells versus tailored to the local conditions. This quantification of the fracture effectiveness enables an estimation of the relative production expected from different well designs and hence a relative value assessment can be made of the engineering design improvements. The objective of the study is to demonstrate the impact of a geomechanical model for a predictive engineering tool leveraging reservoir characterization data for improved hydraulic fracture effectiveness.
Figure 1 Geomechanical simulation of hydraulic fracture network. Upper left shows the simulated pore pressure diffusion within a DFN (blue). Upper right shows the fracture dilation or opening of the primary hydraulic fractures (red segments). Lower left shows the calculated shear displacements, indicating the induced slip within the DFN. Lower right shows the estimated microseismicity.