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Integrating Microseismic with Geomechanics to Improve Reservoir Characterization

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Abstract

Stimulating natural fractures and associated networks/corridors through hydraulic fracturing often creates a wide zone of microseismicity. The distributed microseismic events clearly indicate the formations are inflating along both the primary hydraulic fracture, but also along natural fractures far away from the primary fracture plane. In other words, the effect of stimulation reduces the effective normal stresses that are closing natural fractures. This process is often accompanied by mechanically activating natural fractures causing them to slip (since the associated shear stress reaches levels that overcome the frictional resistance of these fractures to slide) and trigger a microseismic event.

Detailed analysis of these stimulated fractures can be utilized to further understand the architecture of the reservoir. This is done through comprehensive quality-control and analyses of the microseismic data to maximize locations accuracy and to determine event magnitudes and (to the ex-tent possible) the focal mechanisms. The relative magnitudes of the horizontal and vertical stresses required to explain the focal mechanisms are then evaluated as a means to extrapolate well-centric geomechanical models outwards into the reservoir.

Similarly, the existence of an accurate geomechanical model can help to identify where and when natural fractures are stimulated in the current stress field as well as helping to determine the pressures necessary to reactivate and make them permeable. The same model can be used to determine optimal drilling directions for either intersecting existing permeable natural fractures, or for stimulating the fractures through hydraulic fracturing. In other words, with the help of a geomechanical model, stimulation of sets of natural fractures can be predicted and then compared against microseismic observations.

The characteristics of the microseismic data can also be used to constrain a tensor hysteretic fracture permeability model calibrated using pressure and injection rate data collected during stimulation. This information may then be added to a commercial reservoir flow simulator, and utilized to model the shape and permeability of the stimulated rock volume for selected frac stages. The results can be compared to the measured contribution of each stage from a production log run in the same well (after being brought on line) and the resulting full well model is used to match and predict the well's short and long term performance.