Microseismic Evidence of Fault Activation During Hydraulic Fracturing

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Microseismicity was used to image a hydraulic fracture stimulation of a gas well in Western Canada. The well intersected a reverse fault system with low angle thrust faults ranging in dip from 20-30°. Throw along the faults averages 30m. The reservoir is a thin sandstone, bounded above and below by mudstones. The fault overthrusted the sandstone, so that this particular well intersected the sandstone twice: both above and below the intersection of the fault. The microseismic events recorded during the simultaneous hydraulic fracture stimulation of both the upper and lower sandstones, define a fairly simple fracture oriented approximately N45E. Two discrete clusters of events are observed, one extending about 100 m around the perforations, and a second cluster about 150 m to the NE. In depth, the event locations cluster close to the depth interval of the open perforations.

Typically, microseismicity recorded during a hydraulic fracture stops when injection ends, characterized by an exponential decrease in the activity rate. In this particular example, the microseismicity rate initially decreases and then after several minutes the rate significantly increases. Furthermore, the increased activity rate is associated with the occurrence of larger magnitude microseisms. This observed increase in seismic deformation after the end of suggests a unique mechanism. These microseisms recorded after the end of pumping also had a relatively low slope for the corresponding frequency-magnitude relation more consistent with natural earthquakes along a fault then typical hydraulic fracture values observed during the pumping. Spatially, the events are clustered to the NE of the treatment well in an area where few microseisms occurred during the frac. Finally, the P/S amplitude ratio of these post pumping events are relatively high compared to the events recorded during the pumping, suggesting deformation occurring in a different orientation. Geomechanical assessment of the stress state on the intersecting thrust fault, support the conclusion that the hydraulic fracture stimulation induced deformation on the nearby fault.