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Using Microseismicity to Identify and Verify Increased Fracture Complexity During Hydraulic Fracture Stimulations

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Abstract

We examine microseismicity associated with hydraulic fracture stimulation in a naturally fractured shale formation. The stimulation program was designed to assess the potential for increasing fracture complexity by considering the number of perforations, injection pressure rate changes, and different fracture hesitation approaches. In addition to event locations, multi-array and multi-well configurations allowed for the assessment of general moment tensor solutions for the observed events. This approach provided an opportunity to examine the relative spatial and temporal behaviour of fracture orientations (azimuths and dips) as a function of the stimulation program. In general, derived fractures typically grouped into two orientations (sets), similar to mapped natural fractures or secondary (induced) fractures. Reducing the number of perforations resulted in increased fracture variability and complexity whereas sequential failure of different mapped fracture sets occurred as a result of pressure rate changes. Our results also suggest that the hesitation approaches achieved their objective, with the dominance of natural fracturing early in the sequence as compared to induced fracturing upon re-injection, a direct result of localized stress re-orientation during the stimulation. Our observations suggest that varying the stimulation program can potentially be used to control fracture complexity and potentially result in a direct impact on stimulation effectiveness.