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The Effects of Faults and Fractures on Microseismic in Horn River Basin Shales

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Introduction

Hydraulic fracturing of wells in unconventional shale reservoirs creates fractures but also has the potential to reactivate pre-existing faults. When this occurs, microseismic events in fault zones take on unique characteristics. Parameters that are explored include magnitude, *b*-value, location and focal mechanism.

Theory and/or Method

Microseismic events were recorded on a shallow buried array. The array was designed to have a large aperture and capture high fold and wide-azimuth information. Stations are buried at 30 m depth and cover 40 km^2. Data captured with the array are processed using an imaging approach. The resulting points are used to describe faults using event position, attributes and source parameters.

Examples

Often magnitudes associated with fault reactivation are elevated as compared to those associated with induced failures from hydraulic fracturing. Magnitudes produced from fault reactivation are often not sufficiently high to be felt at surface, but fall in a distinctly different range, allowing these two types of events to be easily separated, as demonstrated in Figure 1.

One measure of this magnitude range is the *b*-value. This value reflects the slope of the relationship between magnitude and the number of events that occur at this magnitude or above. *b*-values associated with hydraulic fracturing tend to be approximately 2.0, reflecting the high number of low magnitude events as compared to higher magnitude events. Event populations produced from fault reactivation tend to have more events in the higher magnitude range and tend to have *b*-values near 1.0 (Maxwell et al., 2009, Kratz et al., 2012). Using magnitude alone, this property easily identifies wells, stages or areas of successful hydraulic stimulation versus areas affected by fault reactivation within the Horn River Formation.

The locations of events, or hypocentres, can be used to quantify growth out of zone. In the Horn River Basin, reactivated faults tend to locate within the Evie completion zone. Events emanating from fault reactivation tend to grow downward into the Keg River carbonates, whereas hydraulic fracture-induced events tend to localize within the completion zone. Events rarely grow above the Muskwa completion zone and are often bounded by the more ductile Fort Simpson shale.

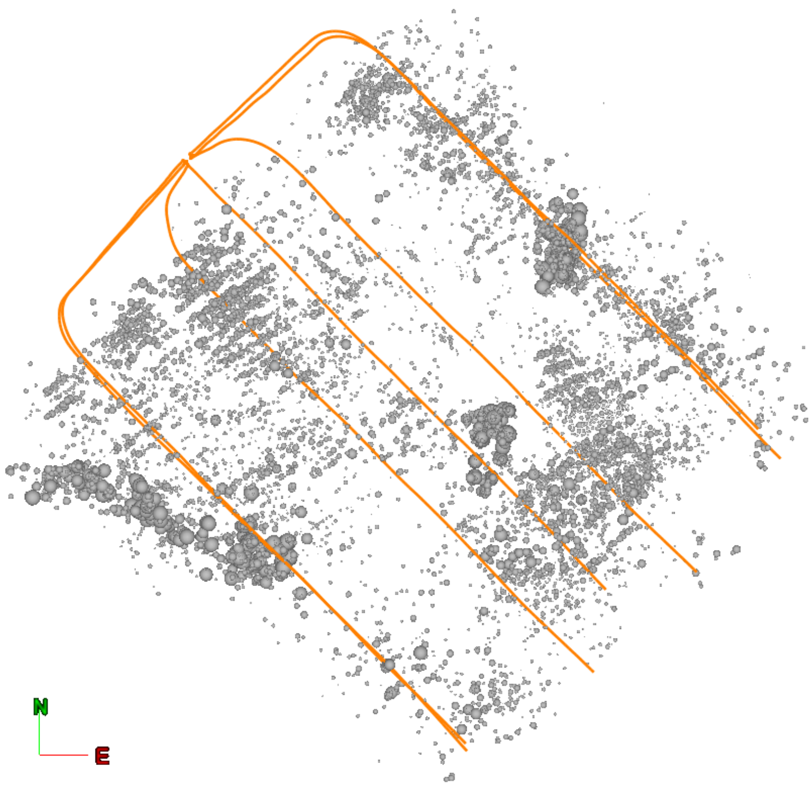

Figure 1: Microseismic events sized by magnitude

Focal mechanisms, which can be determined using a single surface or near-surface array or with multiple downhole monitoring arrays, also tend to uniquely characterize faults and fractures. Hydraulic fractures within the Horn River Basin gas shales tend to have a dip-slip focal mechanism, with a vertical plane oriented in the direction of S_{Hmax}. Faults that experience reactivation are usually oriented at an angle to S_{Hmax}, allowing for shear stress to exceed shear strength. When this occurs, recorded fault reactivation events tend to have strike-slip focal mechanisms with a failure plane that aligns with the trend of the reactivated fault. A change in the orientation of a fault plane also produces a change in the orientation of the focal mechanism solution plane.

Conclusions

Understanding the characteristics of faults and fractures can help avoid fault reactivation in real-time or during lengthy completions by recognizing changes in magnitude, *b*-value, event location or focal mechanism. Distinguishing differences in these event properties can aid operators to better understand how target formations will respond to hydraulic fracturing and to evaluate the effectiveness of their completions program based on the microseismic response.

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