Case Study

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Microseismic Monitoring as a Diagnostic Tool for Hydraulic Fracture Operations in Western Canada

Implementation of a downhole microseismic program to monitor a 14-stage horizontal hydraulic fracture provided valuable insight into fracture behaviour in a tight oil formation in Western Canada. In addition to helping optimize future stimulations in the field, diagnostic efforts identified an issue with a sliding sleeve completion that resulted in a bypassed zone during stimulation.

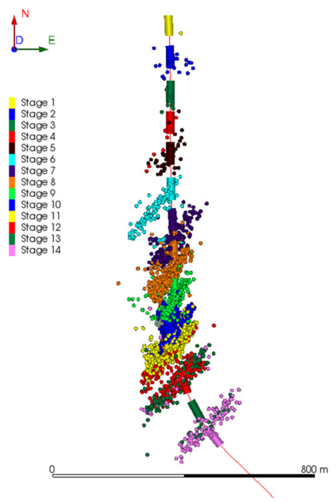

Figure 1: Microseismic events recorded during a 14-stage horizontal fracture stimulation. Events are coloured by stage.

ESG acquired and processed microseismic data from a 14-stage horizontal sliding sleeve hydraulic fracture program near Grande Prairie, Alberta. The operators stimulating the target tight oil formation were interested in observing fracture behaviour in the formation, in order to optimize well position and completion design for subsequent wells in the same field.

Challenge

Tight oil formations in the Western Canadian Sedimentary basin have seen a surge in production in recent years in response to the price of oil compared to natural gas. With this popularity, a number of operators have acquired acreage and are completing wells in fields without prior experience of reservoir behaviour. Microseismic monitoring is a well established tool to visualize fracture behaviour in the sub-surface, and help operators evaluate completions methods to maximize production.

Of additional concern to operators, is the risk of intersecting and/or reactivating geological structures such as faults during hydraulic fracture stimulation. Faults may serve as conduits for large volumes of fluid, acting as a thief zone and re-directing fluid and proppant away from the treatment zone and wasting valuable time and money. In naturally fractured

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formations, an additional risk of diverting frac fluid into faults is the risk of generating induced seismicity of large enough magnitude to be felt on the surface.

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Microseismic data was acquired from a single vertical monitoring well equipped with a 16-level OYO Geospace toolstring of triaxial geophones. Initial observations of fracture dimensions and azimuth suggested that fractures reflected an azimuth of 44° E of N (Figure 1). It is expected that fractures will open perpendicular to $\sigma 1$, and propagate parallel to $\sigma 1$ as shown in Figure 2. Knowledge of local stress conditions near the target formation suggested that $\sigma 1$ typically trends with an azimuth of 50° E of N, therefore drilling future wells perpendicular to $\sigma 1$ will maximize the fracture extent.

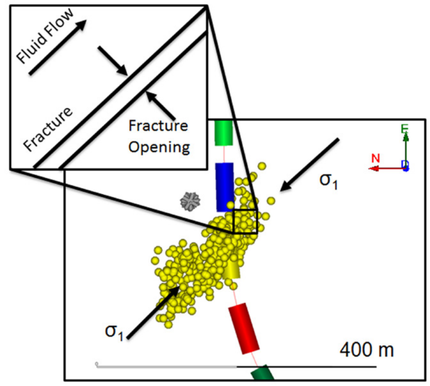

Figure 2: Fractures open perpendicular to and propagate parallel to the direction of principal maximum stress.

Significant overlap of events associated with Stages 12 and 13, along with a conspicuous zone with minimal seismicity noted in the Stage 13 zone (Figure 3A) prompted further investigation into the completion of these stages. Ball seats have distinctive seismic signatures, and ball seat signals for Stages 12 and 13 were both detected and located in the Stage 12 zone (Figure 3B). These microseismic observations would suggest that an error with the sliding sleeve for Stage 13 resulted in inadequate stimulation of the volume surrounding this treatment zone.

A series of unique, larger magnitude events were also observed during Stages 6 and 7 (Figure 4). Further inspection of these events highlighted an east-west trending feature that is notably different from the dominant fracture azimuth observed throughout treatment program. The anomalous events demonstrated moment magnitudes much higher than average values observed during the hydraulic fracture program, and possibly indicate the activation of a pre-existing structure by the fracture treatment.

Using a single monitoring well to capture microseismic activity associated with a 14-stage horizontal hydraulic fracture stimulation revealed information about local stress regimes and potential geological structures that may impact production efficiency in the tight oil field. Further inspection of results during Stages 12-14 were able to diagnose an issue with the sliding sleeve completion that suggests an area of the well was bypassed during stimulation.

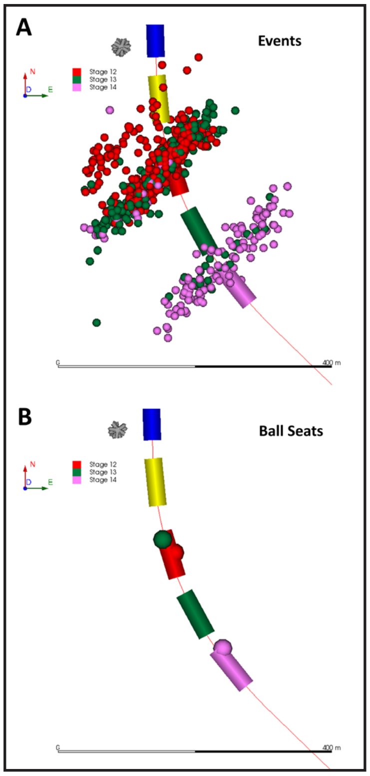

Figure 3: Seismicity observed during Stages 12-14 (A) and the location of ball seats associated with the same stages during the completion (B).

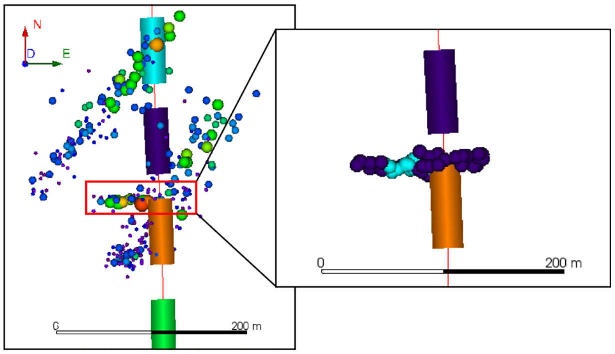

Figure 4: Larger magnitude seismicity may indicate the activation of an east-west trending structure during the stimulation of stages 6 and 7.

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