Increased Completions Efficiency using Advanced Microseismic Interpretation

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Introduction

Microseismic monitoring is a vital tool in the evaluation of a completions program in today's shale plays. In an environment where companies need to extract more while spending less, microseismic data, when combined with engineering data, can offer insights into the effectiveness of a treatment, which can lead to cost savings and increased completions efficiency. This process is demonstrated on four wells from a multilateral pad in a shale play in British Columbia, Canada (Figure 1). These multi-stage laterals targeted a single formation and were completed by means of a plug and perf method in a zipper-frac sequence using slickwater and proppant. Completions were monitored with a near-surface array of single-level geophones buried at a depth of 30 metres.

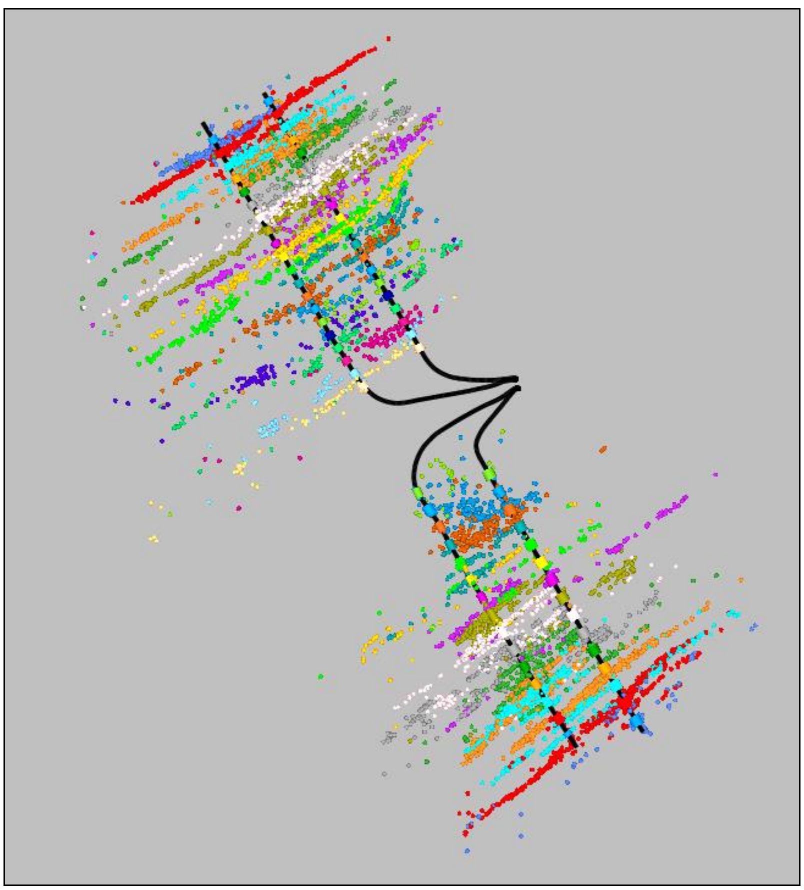

Figure 1: Microseismic results from 4 horizontal wells completed in a Canadian shale play

Method

Located microseismic events are used to assess the overall success of the completions program. The efficiency of fracture generation, stimulated reservoir volume, and propped reservoir volume are assessed in order to evaluate stage spacing, well spacing, and well placement. This is accomplished using advanced interpretation methods that include discrete fracture network modeling and fracture density maps.

Results

As is expected for completions in this area, fractures extend in the direction of the maximum horizontal stress. Growth in this direction is enhanced by a regional fracture network that is also parallel to the maximum horizontal stress. The result of these compounding factors is that fractures on many stages have a length that exceeds the wellbore spacing. Local geological structure, however, tends to prevent outward growth and results in more complex stage geometry.

On three of the four wellbores, a unique stage geometry is observed: Two event trends form for a single stage. Often, the toe-ward event trend overlaps with the heel-ward event trend of the previous stage, creating significant overlap between stages. This may be an effect of the pre-existing fracture system, influence from adjacent wells in the zipper frac sequence or an effect of stress at the packer location.

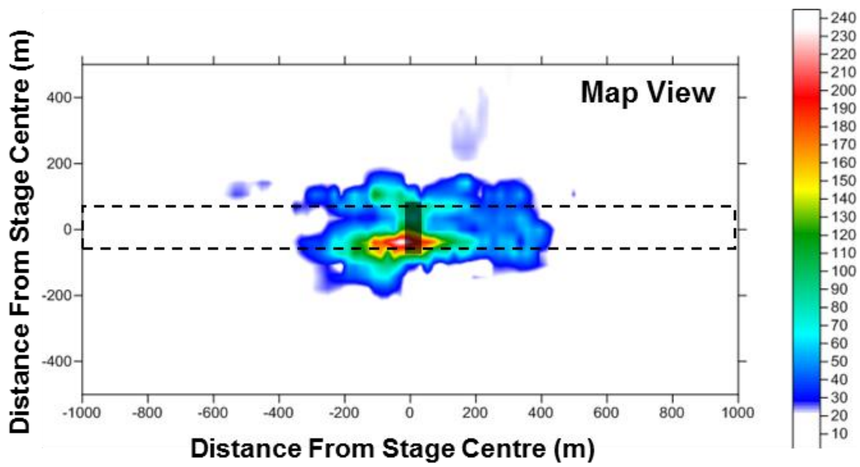

Figure 2: Cumulative stage map of fracture volume density shows two event trends for a single stage. The black bar shows the interval. This interval is projected away from the wellbore by dashed lines.

The total stimulated reservoir volume (SRV) is estimated by replacing each event with a scaled fracture and placing the discrete fracture network (DFN) into a geocellular volume, as described by McKenna and Toohey (2013). The fracture network can then be filled with proppant. Propped fractures can be used, following the same methodology, to estimate the propped SRV to estimate the long-term productive reservoir volume (Figure 3). Models for wells with two fractures per stage show a denser propped fracture distribution along the wellbore, whereas the well with one fracture per stage shows that proppant can be transported further into the formation.

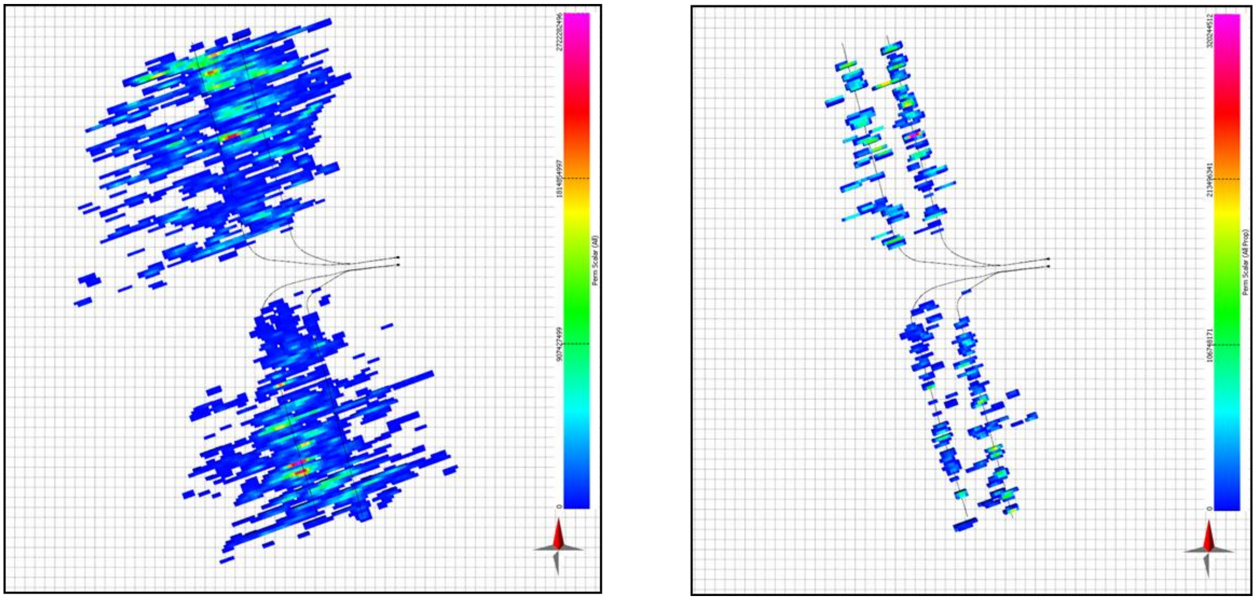

Figure 3: Total stimulated reservoir volume (left) and productive reservoir volume (right) are shown. Warmer colours represent areas of relative increased fracture permeability.

Conclusions

In this study, completions design and efficiency are evaluated using near-surface microseismic data. Several key observations are made that impact future pad development.

It is found that total fracture lengths exceed wellbore spacing, creating overlap between wells. It is possible that modifying fluid volumes in unstructured areas may allow the operator to take advantage of the preexisting fracture network, while introducing cost savings.

Overlap between stages is observed when two fractures develop per stage. This fracture distribution results in propped fractures being modeled close to the wellbore. Adjusting stage spacing may reduce overlap in future completions, although the reason for the observed overlap is unclear.

Lastly, optimizing future pad placement relative to structural features may improve fracture development and maximize SRV.

References

McKenna, J.P., Toohey, N., 2013. A magnitude-based calibrated discrete fracture network methodology. First Break (31), p. 95-97.