

Case Study: Application and Integration of Emerging Technologies in Microseismic Monitoring of a Shale Gas Reservoir

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Summary

The development of gas bearing shales is optimized with the use of microseismic tools. The integration of borehole and near surface microseismic with engineering data can be used to characterize the reservoir, test wellpad designs, test completions techniques, optimize frac techniques, and ultimately enhance gas recovery. Recent developments in microseismic processing provide new insight into frac mechanics, rock physics, and the effectiveness of hydraulic stimulation. Results from advanced microseismic analysis provide insightful recommendations for frac order, well spacing, stage spacing, proppant volumes and timing, stimulated reservoir volumes, and reservoir characterization. As these results are correlated with production information, specific inputs can be determined for reservoir modeling, reservoir characterization, and frac characterization.

Introduction

Microseismic monitoring of a hydraulic fracture stimulation program plays an important role of reservoir characterization. It is used for detection and placement of microseismic emissions induced in gas bearing shales. In turn, specific characteristics of the reservoir and stimulation operations can be observed. Recent advances in monitoring and processing have provided tools for advanced analysis using the moment tensor inversion.

Methodology

Nexen completed a multiwell hydraulic frac program in the Horn River Basin in the summer of 2010. This program was monitored from multiple monitoring locations as close as 400m from the fracport and up to 3500m away. Multiple borehole arrays made up of multiple geophones were used to monitor over 140 frac stages. Multiple near surface 3 component geophones were also installed for microseismic monitoring during hydraulic fracturing and during initial production of these gas wells. The data collected was field processed to return preliminary frac stage reports within 24 hours. The standard deliverables were event location and error, moment magnitude, corner frequency, seismic energy, distance to each array, distance to frac port, and the source radius of the event. In addition, Seismic Moment Tensor Inversion was performed on a specific set of high quality events, and these deliverables include Moment Tensor (focal mechanism) plots, Source Type plots (Hudson Plot), deformation analysis, fault plane analysis, fracture sets, volumetric strain, and Stimulated Reservoir Volume estimation. These results were presented to the well program design team, and the drilling and completions engineering group for data integration. Integrated data

includes chemical and radioactive sand tracers, pressure monitoring, pumping rates, slurry rates, and sand types and concentrations.

Data

The collected raw data was harvested and examined for location and source parameters. Over 300,000 microseismic triggers were identified, and over 40,000 events were located. A high quality subset of 12,000 events was chosen and analyzed. Moment Tensor analysis was performed on 2100 events from 7 frac stages.

Results

The moment tensor information provided insight to sample points of the reservoir as it is stimulated by the hydraulic frac. The results are correlated with the frac operations and reveal details of the rock response far beyond “dots in the box”. A complex display of cracks opening and closing can be followed, requiring the interpreter to integrate completions engineering data to understand specific mechanisms. In addition, we assess fracture planes and orientations, volumetric strain, crack opening and closing locations and timing, and specific relationships with pumping operations. Further analysis indicate re-activations of stimulated areas, shadow zones, overlapping frac stages, azimuthal variations and bedding planes influences in geology, which affect the effectiveness of the treatment, and ultimately gas production (Baig and Urbancic, 2010).

Next Steps

Significant progress has been made in understanding the effects of frac techniques and parameters. To conclusively demonstrate our results, correlations to the Production Logging (PLT) is recommended and presently scheduled. These correlations will help future wellpad design, reservoir modeling and ultimately develop the best strategy for commercial development of the shale gas resource. Additional processing of the microseismic data recorded during monitoring of the initial production phase may reveal drainage information based on the deformation determined by the moment tensor analysis (Baig and Urbancic, 2010).

Acknowledgements

Thanks to ESG for their technical work and contribution to our project.

References

Baig, A. M. and Urbancic, T. I., 2010. Microseismic moment tensors: A path to understanding frac growth. *The Leading Edge*, **29**, 320-324