Scratching the Surface, Limitless Possibilities for Understanding Reservoir Behavior Through the use of Extensive Downhole Seismic Networks

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Abstract

While the current state-of-the-art in microseismic monitoring is continuously developing, it is worthwhile to discuss the future of microseismic data analysis and consider how much analysis can be done with truly extensive downhole monitoring networks. Typically, though, the analysis of microseismicity consists of assessing the arrival times and hodograms of dominant phase groups (compression and shear) and their peak amplitudes to establish event locations and estimates of magnitudes. However, waveforms of individual events contain significant information on source behavior that allow for the dynamics of the fracture/failure process to be identified and the rock conditions/properties through which the waves pass. Assessing first motions of different phases, rise times, coda decay rates, and frequency content and invoking different failure models can achieve this and thereby establish a more complete catalogue of waveform characteristics. Underlying these analysis is the Assumption that data collection utilizes favorable recording geometries incorporating multi-array and multi-well downhole array configurations that remove recording biases typically observed with single array geometries and sensors that faithfully record the relatively 'high' frequencies generated at the source. S pecifically, a more complete waveform catalogue allows for the assessment of source characteristics such as stress release and source dimensions, failure mechanisms and fracture orientations for events (Seismic Moment Tensor Inversion – SMTI analysis), and rock properties such as the velocity and attenuation structure, and rock fabric (anisotropy).

Utilizing SMTI and source dimensions creates opportunities to understand the activation of an interconnected discrete fracture network and its spatial and temporal growth behavior. In conjunction with SMTI derived mechanisms (tensile opening, shear, closure, or mixedmode), the enhancement of fluid flow characteristics from the activation of the interconnected, discrete fracture network can be established to define a realistic estimate of stimulated reservoir volume. With sufficient coverage of crossing raypaths between sensors and events throughout the treatment volume, tomographic inversion of the three-dimensional velocity structure can reveal features in the reservoir and track velocity differences through time. Furthermore, a d etailed analysis of event spectra across the sensor arrays can yield attenuation corrections for each structure and yield the three-dimensional attenuation structure. These velocity and Q structure begin to impose very strong constraints on the rock properties of the reservoir and add greatly to the understanding of reservoir behavior.

Until now, we are just scratching the surface when it comes to these analyses. I nitial investigations are proving to be of value in interpreting reservoir behavior. The integration of above analyses with geology and engineering parameters has validated the approaches and is being used to establish 'go forward' methodologies to better characterize and optimize stimulation programs and provide more definitive reserve estimates. Overall, even the above considerations are limited in scope.