Planning the Perfect Microseismic Acquisition Survey for Hydraulic Fracture Stimulation, Can it be Done?

Ellie P. Ardakani and Adam M. Baig
Meta Innovation Technologies

Microseismic surveys are often planned based on the expected standard of deliverables for hydraulic stimulations, within the constrains of what wells are available for downhole deployments, what land is available for surface-based deployments, and of course what budget is allocated to the monitoring effort. Arrays are designed to be fit for purpose, to detect events within a given volume, to be able to locate these events with a given accuracy, and then to be able to accurately characterize certain source parameters (including potentially the moment tensor).

As an example, discussing what accuracy might be necessary for an array to be effective, we consider the “classical” monitoring problem in the Fort Worth Basin. The need to effectively characterize out-of-zone growth from the targeted Barnett Shale potentially into the water-bearing Ellenburger formation below imposes a strict need for the microseismic system to have the vertical resolution to confidently identify whether a trend of microseismic events represents a connected pathway through the Viola formation. The ability to assess this type of resolution is typically done through workflows involving mapping expected errors in traveltime, hodograms, and velocity models to expected errors in locations.

On assessing how well an array can detect a set of events, the attenuation (both through geometrical spreading and anelastic effects) needs to be modeled for the waveforms to then arrive at the array where a reasonable amount of (potentially highly colored and correlated) noise is added to assess detection above certain thresholds. The accurate characterization problem is more subtle, because the assessment of biases in the characterization of event involves understanding the bandwidth of the instrumentation. For instance, larger magnitude events captured on the 15 Hz geophones typically used for wellbore deployments will have lost the low frequencies necessary for accurate magnitude calculation, and the calculated magnitudes using those instruments will be underestimated (saturated). Furthermore, understanding of which phases are detectable in an unbiased fashion on different arrays deployed at different azimuths admits the possibility to evaluate the resolvability of moment tensors from different geometries.

In order to arrive at a workflow to assess the effectiveness of different microseismic survey designs, we suggest that a combination of synthetic waveform modelling on an interactive platform allows for direct observations on the ability for different configurations to accurately locate events, detect events without significant biases, and resolve their moment tensors. In such a fashion, the ability for a proposed geometry to detect, locate, and characterize events can be modeled.