Using Machine Learning Approaches to Characterize Stress Flow Based on Seismicity

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Microseismic data is becoming a commonly used tool to evaluating the effectiveness of horizontal well completions through hydraulic fracturing. Sophisticated analysis techniques, such as cluster-based descriptions of deformation based on source parameters or moment tensor analysis have been successfully employed to elucidate different processes in the reservoir. The recognition of the moment tensor as a waypoint connecting a microseismic event with a model of a discrete fracture in the reservoir provides a tangible asset alone in terms of describing the value of microseismic data to geomechanical modelling of the discrete fracture network.

As powerful as being able to connect microseismic data to a DFN may be, what may perhaps go unrecognized is that the moment tensor itself, being proportional to the strain rate tensor, gives a first approximation to imaging the stress conditions in the reservoir. Moment tensors datasets, with significant event counts to provide for a necessary level of resolution, often show a level of consistency with space and time in terms of the orientations of their strain axes, and as such this consistency can be understood in terms of relatively stable stress conditions. Not infrequently, though, large shifts in the strains may be observed directly, indicating stress has rotated to a new regime. Finally, stress can sometimes behave with sufficient instability to result in no apparent stability. Connecting these deflections with geological features or changes in the stimulation can offer operator actionable conclusions in terms of how to progress or adapt well completions to develop the field.

In order to image the flow of stress in the reservoir, during a completion program, we can use the moment tensor strain axes as input into a machine learning approach that describes the directions of stress and their deflections with space and time throughout the course of the completion.