Establishing confidence in fracture orientations from microseismicity

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Summary

Recent work on the interpretation of microseismicity has suggested that bedding plane slip may play a very definitive role in the propagation and dynamics of hydraulic fractures in unconventional resource plays. These interpretation are based on looking at a series of moment tensors obtained through microseismic monitoring, observing that one of the nodal planes aligns well with a horizontal rupture surface, and suggesting that this plane is the one that slips. However, because these microseismic ruptures are occurring under (generally) dynamic stress conditions, there rupture of one fracture over another is subject to this stress state and one of the possible fracture planes may actually be under a high degree of clamping stress. However, a set of mechanisms themselves can be used, under the assumption the they are occurring under a relatively uniform stress state, then the orientations of the principal stress vectors as well as the stress ratio may be constrained. Therefore, critical to establishing the orientation of fracture plane or another needs to be an evaluation of the relative values of shear and normal stress on the fracture. In this abstract, we will illustrate how geomechanical constraints from the microseismicity themselves are to establish the likelihood of one rupture over another. The results of this exercise are not only the disambiguated fracture plane from the moment tensor, but an understanding on how stress may be varying during the stimulation, and how far the fractures are from being critically stressed.

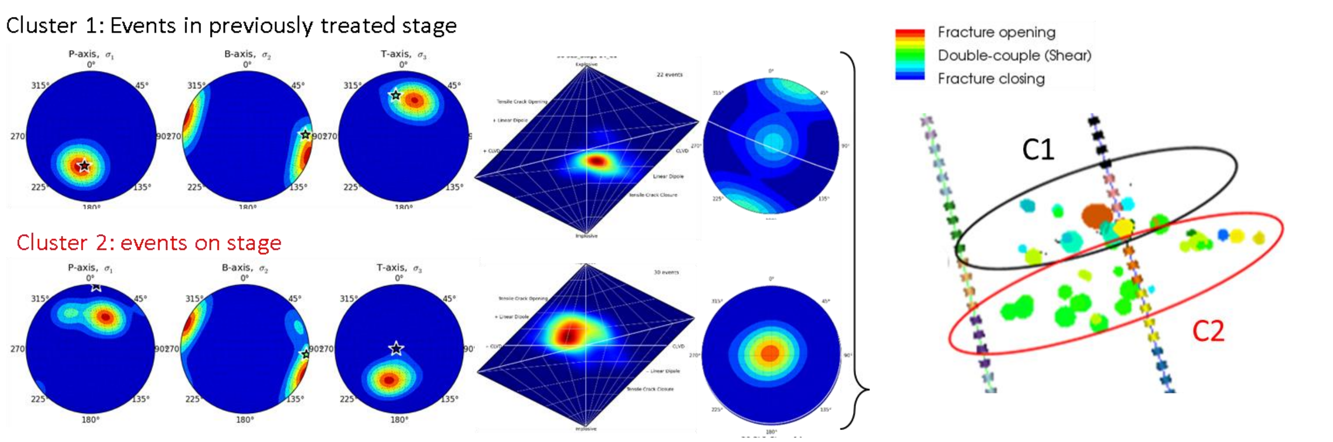

Figure 1. Contour plots on lower hemisphere stereographic projections of compressional, intermediate, and tensional strain axes with associated stress axes plotted as stars (leftmost three plots); source type plots (fourth from left); poles to the fracture plates (fifth from the left); for the clusters outlined in the rightmost plan view image of the microseismic derived DFN (events are displayed as penny-shaped cracks coloured by mechanism). Cluster 1, comprising events occurring in the previous stage , is plotted on top and cluster 2, events occurring on zone, is plotted below.

We illustrate this methodology with respect to a stage of data associated with the completion of a horizontal well in a North American unconventional play (figure 1). The stage in question features two dominant behaviours, as can be observed from the spatial distribution of the fractures as well as from the strain axes of the moment tensors. There is one cluster, located in the previously treated stage towards the toe of the well, where the P axes plunge moderately to the SSW and the T axes plunge to the NNE and a second cluster representing on-stage seismicity where the P and T strain axes are reversed relative to the first cluster. This flip flop in P and T axes indicates that there is a strong spatial heterogeneity in the perturbed stress field. The mechanisms for these events show for cluster 1, in the previous stage, there is a slight closure component to the shear-dominant mechanisms while for cluster 2, there is an equally slight opening component. Inverting for the stress on these two clusters shows that there is a large rotation spatially between these two clusters that accounts for a differences in the chosen fracture planes. In cluster 1, both subhorizontal and subvertical fractures are stimulated whereas in cluster 2, the dominant fracture orientation is subhorizontal consistent with a bedding-plane slip mechanism. Overall, the interpretation of bedding plane slip in this case is supported by the inversion of the stress field that favours slip for features with this orientation.