Zhao, X.P., J.M. Reyes-Montes, and R.P. Young. (2014) Analysis of the stability of source mechanism solutions for microseismic events from different receiver configurations. *The 76th EAGE Annual Meeting*, Amsterdam, Netherlands.

Analysis of the stability of source mechanism solutions for microseismic events from different receiver configurations

Abstract

Microseismic monitoring is a key tool for evaluating the structural and mechanical changes imposed on a reservoir subject to high pressure fluid injection, such as hydraulic fracturing (Maxwell and Urbancic, 2001), enhanced geothermal system (Norio *et al.*, 2008), and carbon sequestration (White, 2009). Locations of microseismic (MS) events enable us to track the fracture network induced through the stimulation in real time and monitor the effectiveness of the hydro-fracturing design and operation.

The MS record has a wealth of information beyond event location that can provide information about the fracturing process. One of the most informative observations from the seismic event record is provided by the interpretation of the event fracturing mechanism. The source mechanism during hydraulic fracturing could provide us the direct information about the in-situ stress and strain, and the relationship between the fracture propagation and the fracturing operation, such as the injections of fluid and proppants (Zhao and Young, 2011). As a result, the focal solution gives us the ability not only to see the location of damage within a rock mass but also the micromechanics that are driving it, and eventually provide guidance towards cost-effective design and operation in order to optimize reservoir production in similar settings. However, the robust inversion of source mechanisms remains a big challenge in the situation of a single linear borehole array deployed in a horizontal or vertical well, a common practice in hydraulic fracturing monitoring. A monitoring array with a limited azimuthal coverage of the source volume restricts the estimation of waveforms P-wave polarities, and hence the inversion of its source mechanism.

In this study, we create a numerical simulation of four typical source modes using a distinct element method, monitor the waveforms using different borehole arrays, and invert the recorded waveforms to validate the modelled source mechanism. The validated events are then investigated to show the effects of varying number of borehole arrays and different geometries on the inverted source solutions in order to study the optimal array orientation and aperture for a consistent solution.

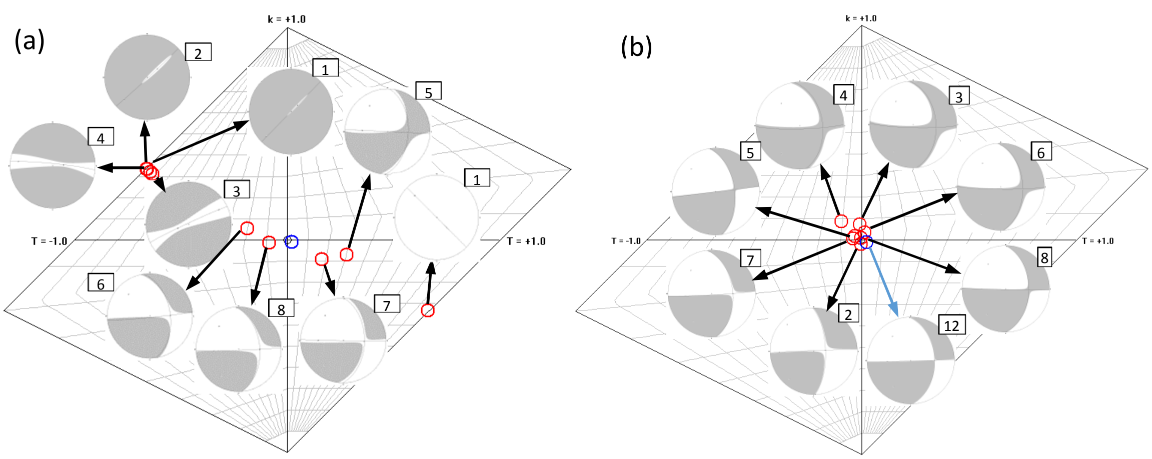

Figure**:** *Hudson T-k plot and focal sphere representation of the mechanism inverted from the modelled strike-slip source. Numbers beside each focal sphere indicate the number of monitoring wells used in the inversion. (a) Examples of inverted solutions using non-optimised array geometries. (b) Inverted source solutions using optimised array geometry.*

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