Constraint of focal mechanisms of induced seismicity by using misfit angles based on known *in-situ* stress

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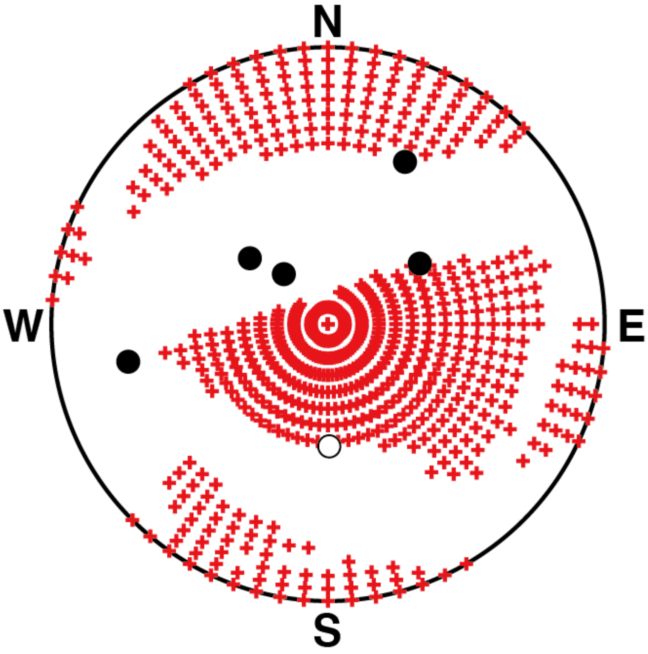
Microseismic monitoring is essential for successful hydraulic stimulation/fracking in unconventional oil/gas development, engineered geothermal system development and carbon capture and sequestration. In addition to the hypocenter location of the microseismicity, knowledge of the geometry of the fracture is also crucial for better understanding of fractured reservoir, fluid flow, and design of the energy extraction. Geofluid flows in the fracture and its permeability are correlated with the relation of the geometry of the fracture and in-situ stress. Fracture orientation can be estimated by the seismological method such as moment tensor inversion or focal mechanism analysis, only when the waveforms of the events are well recorded by a number of well-distributed stations. However, in realistic microseismic monitoring situations, it is often difficult to constrain the focal mechanism of microseismicity from first motion information due to the small number of stations.

We proposed a method to improve the estimates of focal mechanisms by introducing in-situ stress information from borehole logging information. We eliminate candidate focal mechanisms that are consistent with first motion data but cannot have shear slip under a given stress state and pore pressure increase. In this study, we also check the consistency between the shear slip vector estimated from the stress state and the rakes. We compare the shear slip vector and the slip vector from the rake. Then we reject the fault if the difference in the two vectors is significantly large. With this process, we reject the fault planes and auxiliary planes which are not consistent with stress state. We apply this method to induced seismicity dataset from Basel, Switzerland, where we already have well-constrained focal mechanisms estimated by many surface stations over a large region. We use these focal mechanisms as references to check whether our method can constrain the range of focal mechanisms using a small number of nearby stations. We find that the consistency check between two vectors significantly and reliably limits the range of focal mechanisms. Furthermore, we combine the constrained range of focal mechanism by this method and that by stability analysis to have more constraint of focal mechanisms satisfying the conditions of the geomechanical problem.

Keywords: Induced seismicity, Focal mechanism, In-situ stress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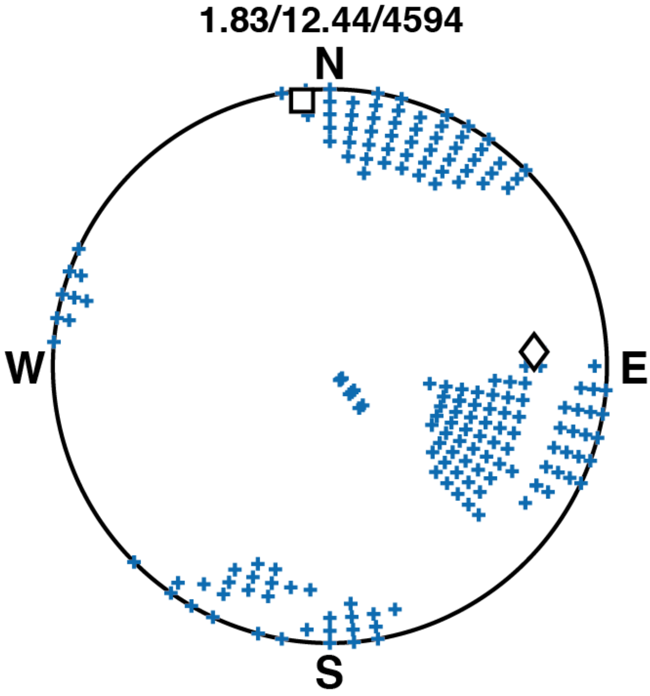
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