Moment tensor analysis of acoustic emissions induced by hydraulic fracturing in laboratory experiments

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Hydraulic fracturing has been used for the development of Enhanced Geothermal reservoirs and Shale Gas/Oil reservoirs in order to stimulate reservoirs by producing artificial fractures. Microseismic observation is often employed to monitor the hydraulic fracturing. Some field observations suggested that shear events were dominated (e.g., Maxwell, 2013), although an open crack along the maximum compression axis is predicted by stress concentration around a circular hole in elastic medium. Focal mechanisms of earthquakes induced by hydraulic fracturing is important because, for example, proppants are injected so as to prevent closing cracks in Shale Gas/Oil Reservoirs and they should enter open cracks more easily. It is however difficult to constrain focal mechanisms of induced earthquakes in such fields due to insufficient network coverage.
In the present study, we conducted hydraulic fracturing laboratory experiments under uniaxial loading by using 7 granite samples, and monitored acoustic emissions (AE) by a 16-channel AE monitoring system, estimating their seismic moment tensors. Generally, moment tensor analysis, in which accurate measurements of waveform amplitudes are necessary, is difficult for AE data owing to unknown and complex sensor characteristics such as sensor sensitivity depending on sensor coupling. In this study, we estimated the influence of coupling of individual AE sensors in each experiment by using an approach similar to Kwiatek et al. (2013), and estimated moment tensors by using calibrated AE amplitudes. We classified the obtained moment tensor solutions into isotropic, double couple and CLVD dominant solutions on the basis of the decomposition method of Knopoff and Randall (1970). The shear-dominated events occupied 20%-55% whereas CLVD dominated events indicating open-mode cracks occupied 10–20%. In addition, T-axes of the CLVD dominated events (corresponds to open axis of the corresponding open cracks) were consistent with that of the open cracks predicted by stress concentration nearby a circular hole.

Keywords: Acoustic Emission, Hydraulic fracturing, Moment tensor

