Microseismic focal mechanism inversion based on the general dislocation source model

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The study of seismic source focal mechanisms is very important for both natural earthquakes and human-induced seismic events. During unconventional resources exploration, fluid injection activities may generate fracturing within the reservoir and cause microearthquakes. Through microseismic focal mechanism study, we can obtain the fracture directionality, scale and stress state of hydraulic fracturing areas, which are extremely important for the unconventional exploration. For microseismic events, the double-couple (DC) or moment tensor (MT) models are usually adopted to describe the source. However, whether the microseismic sources can be fully represented by DC model is still controversial. Many recent studies have shown that both natural earthquakes (Miller et al., 1998; Ross et al., 2015) and induced seismic sources (Vavryčuk, 2002; Vavryčuk et al., 2008; Julia et al., 2009; Boettcher et al., 2015) may contain certain non-DC components. For MT model, it can describe all kinds of seismic mechanisms, but when applying it to the microearthquakes, information of the fracturing scales can't be fully obtained.

In this study, we use the "Shear & Tensile" general dislocation source model to describe the mechanisms of microearthquakes. This model takes account of tensile movement as well as shear slip and can directly reflect the fracturing scale along each direction. Based on this model, we develop a microseismic focal mechanism inversion method using amplitude spectra fitting and simulated annealing techniques in the frequency domain. The new method uses full waveform information including phase and polarities of first P wave arrivals to perform the inversion, and can provide dislocation length along each direction as well as common source parameters (strike, dip and rake angles) in the study area. We tested the proposed method on surface and borehole microseismic monitoring systems using synthetic waveforms, and evaluated the sensitivity and dependence of microseismic source inversion on data and model. This method was then applied to several real microseismic datasets. Results of numerical tests and real data processing both proved that the proposed method is robust and efficient.

Keywords: Microseismic, Focal mechanism inversion , General dislocation source model

