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Relationship between fc and Mo for AE from continuous and broadband records under a triaxial compressive condition

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Micro fractures observed in laboratory experiments (acoustic emission; AE) have been studied to investigate a detailed faulting process [e.g., Yanagidani et al., 1985; Lockner et al., 1991]. To apply findings obtained in laboratory to field scales, it should be revealed that whether source characteristics of micro fracture is common with natural earthquakes or not due to large differences in scale. Seismic moment and corner frequency are fundamental parameters that characterize the source properties of the earthquake rupture. Down to events having a moment magnitude about -4, seismic moment thought to be proportional to cube of corner frequency [e.g., Abercrombie, 1995; Kwiatek et al., 2011]. However, it is still unclear whether AE size events also satisfies this relationship.

Previously, PZT elements which have narrow frequency ranges were often used as AE sensors, but their record were unsuitable for source parameter estimation. To overcame this problem, Sellers et al. [2003] tried to record AE with broadband transducers under a uniaxial rock fracture experiment. Though they indicated that the source parameters of AE events satisfied the same scaling relationship as that of natural earthquakes, the scaling relationship of AE themselves was still unconfirmed. In this study, we achieved multi-channel, broadband and continuous recording of AE and estimated source parameters of them in a higher accuracy.

We mounted nine broadband transducers (sensitive range: 100 kHz - 2000 kHz) that were hermetically sealed with metallic cases around a cylindrical Westerly granite sample (100 mm in height and 50 mm in diameter). Sampling rate was 20 MS/s per channel. Loading was continued until differential stress decreased (46 MPa) after the peak strength (296 MPa), under a confining pressure of 10 MPa.

We focused on two clusters of events (around 1000 events) which occurred after the peak strength was reached. The hypocenters of each event in a cluster located less than 2 mm apart, and correlation coefficients exceeded 0.80 for four or more channels in the cluster. After the spectral correction, we obtained displacement spectra for S waves. We estimated corner frequency and seismic moment for events with sufficiently high signal-to-noise ratios.

Corner frequencies and seismic moments obtained from AE events in each cluster (moment magnitude of events are around -8 to -7) satisfied the scaling relationship that applies to natural earthquakes. In addition, they were found to satisfy the same scaling relationship for AE events alone. Stress drops of events were distributed from 0.4 MPa to 12 MPa.

This result indicates self-similar relationship between micro fractures in laboratory and natural earthquakes.

Keywords: corner frequency, seismic moment, scaling, AE, rock fracture experiment