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Coda-Based Estimation of Source Parameters of Laboratory Acoustic-Emission Events

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We propose an approach that is aimed to enrich the catalogs of acoustic emission events recorded in laboratory experiments with such parameters as seismic moment and corner frequency. Because of the difficulty of separation of direct waves in experiments performed on small samples, we use the coda waves that are composed of the reverberation of the acoustic field in the tested sample. After multiple reverberations, the resulting wavefield can be approximated as nearly homogeneously distributed over the sample and with signal amplitudes decaying exponentially in time (linearly in a logarithmic scale).

Within the framework of this model, the frequency-dependent coda amplitude at any moment of time is described as combination of a source spectra, of a decay rate combining internal attenuation with reverberation losses, and of a sensor response. One of the main difficulties with the laboratory experiments is that acoustic sensors are very difficult to calibrate and their absolute response function in most of cases remains unknown. With the simple reverberation model, the logarithms of coda amplitudes at different times and sensors and for multiple events are described by a system of linear equations that we solve in a least-square sense to find frequency-dependent coda-decay rates, relative signal spectra and sensor responses. In a next step, we compute spectral ratios between spectra of different events to eliminate the sensor responses and to estimate main source parameters such as corner frequencies and relative seismic moments.

We provide details of our data analyses technique and present time-dependent corner frequency vs relative moment diagrams for two experiments on granite of the Voronezh massif and Berea sandstone under pseudo-triaxial loading. The dependence close to the cubic that is frequently estimated for tectonic earthquakes observed on the first stages of both experiments when confining pressure steps applied to the intact rock and therefore to the pre-existing inhomogeneties. After applying axial load changes in stress-drop is being observed: with higher stress-drops prevailing in granite and lower stress-drops in sandstone. Also there is a significant difference in Gutenberg-Richter relation in these two experimental conditions observed.

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