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Smooth stress drop under very heterogeneous background stress

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There is a long lasting discussion why stress drop of an earthquake is uniform independent of its focal depth. This feature affects the friction law of earthquake rupture whether the absolute stress is important for the friction during an earthquake. Here, we propose a model that explains the seismological observation based on our recent experiments.

We conducted a series of large-scale biaxial rock friction experiments using the shaking table at NIED. Slip surface dimension is 1.5m in length and 0.5m in width. During the experiments, many stick slip events were observed by an array of strain gauges glued close to the slip surface at the side of the rock sample. Among them, we could capture many confined stick slip events whose rupture did not reach the edge of the sample. These events could be considered very similar situation as those of natural earthquakes. Mizoguchi et al. (2012) reported that the rupture length of these events seemed proportional to the amount of stress drop, suggesting a scaling relation between size and stress drop in the laboratory.

Here, we found that such confined events occurred under very heterogeneous stress environments. Such stress heterogeneity might come from the complicate geometry of sliding surface. However, during the confined event, the stress drops rather smoothly independent of the absolute stress level (since we know the initial stress state, we can measure the absolute stress). This feature suggests that the rupture propagation (or constitutive relation) is rather independent on the fluctuation of total stress field. In contrast, the amount of slip is considered rather continuous due to smooth stress drop distribution in space, which is quite reasonable in the theory of continuum medium. We think that this slip controlled feature could be a main reason for the constant stress drop observation in seismology.