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Acoustic monitoring of laboratory faults: locating the origin of unstable slip events

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Over the past several decades, much work has been done on studying the frictional properties of fault gouges at earthquake nucleation velocities. In addition, post-experiment microstructural analyses have been performed in an attempt to link microphysical mechanisms to the observed mechanical data. However, all observations are necessarily post-mortem and it is thus difficult to directly link transients to microstructural characteristics. We are developing an acoustic monitoring system to be used in sliding experiments using a ring shear apparatus. The goal is to locate acoustic emission sources in sheared granular assemblages and link them to processes that act on microstructures responsible for the frictional stability of the simulated fault gouge. The results will be used to develop and constrain microphysical models that explain the relation of these processes to empirical friction laws, such as rate- and state-dependent friction. The acoustic monitoring setup is comprised of an array of 16 piezo-electric sensors installed on the top and bottom sides of an annular sample, at 45 degree intervals. Acoustic emissions associated with slip events can be recorded at sampling rates of up to 50 MHz, in triggered mode. Initial experiments on 0.1 to 0.2 mm and 0.4 to 0.5 mm diameter glass beads, at 1 to 5 MPa normal stress and 1 to 30 um/s load point velocity, have been conducted to estimate the sensitivity of the sensor array. Preliminary results reveal that the intensity of the audible signal is not necessarily proportional to the magnitude of the associated stress drop for constant loading conditions, and that acoustic emissions precede slip events by a small amount of time, in the order of a few milliseconds. Currently, our efforts are focused on developing a suitable source location algorithm with the aim to identify differences in the mode of (unstable) sliding for different types of materials. This will help to identify the micromechanical mechanisms operating during the nucleation of (unstable) slip events.