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Irregular stick-slip and the role of cohesion in an ice friction experiment

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Understanding the evolution of fault strength over multiple interseismic periods is crucial to quantifying seismic hazard. According to Coulomb's failure criterion, restrengthening, or healing, may result from an increase in friction and/or in cohesion. Classic sliding experiments on rocks and fault gouges are not able to resolve the contribution of cohesion to the healing of frictional interfaces. Here, we present a zero nominal normal stress friction experiment capable of large displacements that exhibits similar complexity as the deforming lithosphere (intermittent, aperiodic deformation; Gutenberg-Richter-type scaling of event sizes). This Couette-type apparatus is designed to shear millimeter-thick layers of columnar ice, grown in-situ in a meter scale circular water tank. When the system is driven at low sliding velocities, the ice plate fractures and sliding occurs along a complex, non-prescribed frictional interface. Water beneath the ice can percolate through the sliding interface and freeze, increasing its strength. A torque gauge and an array of acoustic emission transducers are used to measure the shear strength of the frictional interface and to monitor acoustic activity. Previous work, using constant values of sliding velocity, showed that deformation occurs via a combination of slow and fast slip events, and that the "seismic" part consists of two populations of acoustic emission (AE) events: standalone and correlated, with different Gutenberg-Richter b-values. The asymmetric shape of the shear stress (torque) fluctuations was attributed to cohesion-dominated strength recovery. We are currently using a new, high speed sampling system to investigate the relationship between the stress fluctuations and the concurrent AE activity in constant as well as variable sliding velocity experiments. This work aims to evaluate the effect of time-dependent processes on systems that deform intermittently.