Geophysical Research Abstracts
Vol. 19, EGU2017-7318, 2017
EGU General Assembly 2017

Are slide-hold-slide tests a good analogue for the seismic cycle?

Martijn van den Ende (1), André Niemeijer (1), George Marketos (1,2), and Christopher Spiers (1)
(1) Department of Earth Sciences, Utrecht University, Utrecht, the Netherlands, (2) Tony Gee and Partners LLP, UK

Earthquakes are among the most disruptive of natural hazards known to man. Owing to their destructive potential and poor predictability, earthquakes and unstable frictional sliding in general receive considerable attention, both in experimental and in modelling studies. For reliable seismic hazard assessments, accurate predictions of the failure strength of seismogenic faults is paramount. To study the time-dependent restrengthening (or “healing”) of faults in a laboratory setting, the slide-hold-slide (SHS) method is commonly employed as an analogue for the seismic cycle. Using this method, it is assumed that the rate of restrengthening as observed in SHS tests is similar to the rate of restrengthening of natural faults during the interseismic phase. However, the dynamic and kinematic boundary conditions of SHS tests are inherently different to those of a fault that is being tectonically loaded. As such, it can be questioned whether SHS tests (in which the interseismic period is characterised by stress relaxation) yield the same rate of restrengthening as would be expected from laboratory stick-slip or natural seismic cycles (characterised by a more complex stress history). This question could in principle be addressed experimentally by comparing the results from SHS tests with the stress drop and recurrence time of regular stick-slips. However, due to technical limitations, direct comparison between SHS and stick-slips is non-trivial, and uncertainties in extrapolating the laboratory results remain.

To assess the validity of SHS tests as an analogue for the seismic cycle, we simulate laboratory SHS tests as well as stick-slips using the Discrete Element Method (DEM). DEM is a particle-based numerical technique that is suitable for modelling granular media, such as fault gouges. Its constitutive relations are linked to grain-scale micro-processes, and, in the work presented here, we incorporate pressure solution creep and frictional sliding. The simultaneous operation of these deformation mechanisms has been proposed as a basis for velocity-weakening behaviour (Niemeijer & Spiers, 2007), and allows for the generation of regular stick-slips in our DEM model. By varying the stiffness of the system, we can control the recurrence interval of slip events, and investigate the relation between stress build-up (or stress drop during the slip event) and recurrence time as a measure for the restrengthening rate. These results are subsequently compared with simulations that mimic the laboratory SHS procedure. We find that, for the assumed micro-mechanisms, there is a good agreement between the restrengthening rate observed in SHS- and in stick-slip simulations, suggesting that the SHS method is a good laboratory analogue for studying the interseismic period of the seismic cycle. Furthermore, we find that the rate of restrengthening observed in the SHS simulations is independent of the stiffness of the system, and therefore the amount of slip during relaxation, implying that the rate-and-state ageing law better describes interseismic restrengthening than does the slip law, as has previously been observed experimentally by Beeler et al. (1994).

References:
Beeler et al. (1994), GRL 21(18), doi:10.1029/94GL01599
Niemeijer & Spiers (2007), JGR 112, doi:10.1029/2007JB005008