Geophysical Research Abstracts
Vol. 18, EGU2016-7952, 2016
EGU General Assembly 2016

Frictional behavior of experimental faults during a simulated seismic cycle

Elena Spagnuolo (1), Stefan Nielsen (2), Marie Violay (3), Fabio Di Felice (1), Giulio Di Toro (4,5)

(1) Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy (elena.spagnuolo@ingv.it), (2) Durham University, Durham, UK (stefan.nielsen@durham.ac.uk), (3) ENAC, LEMR, Lausanne, Switzerland (marie.violay@epfl.ch), (4) University of Manchester, Manchester, UK (giulio.ditoro@manchester.ac.uk), (5) Università degli Studi di Padova, Padua, Italy

Laboratory friction studies of earthquake mechanics aim at understanding complex phenomena either driving or characterizing the seismic cycle. Previous experiments were mainly conducted on bi-axial machines imposing velocity steps conditions, where slip and slip-rate are usually less than 10 mm and 1 mm/s, respectively. However, earthquake nucleation on natural faults results from the combination of the frictional response of fault materials and wall rock stiffness with complex loading conditions. We propose an alternative experimental approach which consists in imposing a step-wise increase in the shear stress on an experimental fault under constant normal stress. This experimental configuration allows us to investigate the relevance of spontaneous fault surface reworking in (1) driving frictional instabilities, (2) promoting the diversity of slip events including the eventual runaway, and (3) ruling weakening and re-strengthening processes during the seismic cycle.
Using a rotary shear apparatus (SHIVA, INGV, Rome) with an on-purpose designed control system, the shear stress acting on a simulated fault can be increased step-wise while both slip and slip-rate are allowed to evolve spontaneously (the slip is namely infinite) to accommodate the new state of stress. This unconventional procedure, which we term “shear stress-step loading”, simulates how faults react to either a remote tectonic loading or a sudden seismic or strain event taking place in the vicinity of a fault patch. Our experiments show that the spontaneous slip evolution results in velocity pulses whose shape and occurrence rate are controlled by the lithology and the state of stress. With increasing shear stress and cumulative slip, the experimental fault exhibits three frictional behaviors:
(1) stable behavior or individual slip pulses up to few cm/s for few mm of slip in concomitance to the step-wise increase in shear stress;
(2) unstable oscillatory slip or continuous slip but with abrupt changes in slip rate (lower than 10 cm/s) under about constant imposed shear stress;
(3) fault dramatic weakening or continuous slip with gradually increasingly slip rates up to 6.5 m/s (an imposed upper bound limitation).
The shear stress-step loading experimental technique proposed here provides new hints on the behavior of pre-existing faults during the seismic cycle and, for instance, reproduces precursory slip events observed in some large in magnitude earthquakes (e.g., Izmit, Mw 7.6, 1999).