Geophysical Research Abstracts
Vol. 17, EGU2015-1589, 2015
EGU General Assembly 2015

Experimental evidence of thermo-mechanical pressurization of faults during earthquakes

Marie Violay (1), Giulio Di Toro (2), Stefan Nielsen (3), Elena Spagnuolo (4), and Jean-Pierre Burg (1)

(1) ETH D-ERDW, Sonnegstrasse, 5 CH-8092, Zürich, CH, (2) Dipartimento di Geoscienze, Università degli Studi di Padova, Via G. Gradenigo 6, 35131, Padua, IT, (3) Earth Sciences Department, University of Durham, South Road, Durham DH13LE, UK, (4) INGV, Via di Vigna Murata 605, 00143, Rome, IT

Earthquakes occur while fault strength decreases with increasing slip and slip rate. Thermo-mechanical pressurization of pore fluids induced by frictional heating during seismic slip is one of the possible mechanisms responsible for fault dynamic weakening. However, has not yet been observed in the laboratory.
To investigate seismic slip in the presence of pore fluids, 26 friction experiments were conducted at room temperature on hollow cylinders (50/30 mm external/internal diameter) of Etna basalt (1) under room-dry conditions or immersed in water under either (2) drained conditions (constant pore pressure, preventing fluid pressurization), and (3) undrained conditions (constant pore volume). Experiments were performed by spinning two basalt cylinders with the rotary shear machine (SHIVA, INGV Rome) at target slip rates (V) of 3 m/s, displacements (δ) from 4 m to 6 m, normal stress (σn) ranging from 15 to 35 MPa and initial pore fluid pressure (Pf) of 5 MPa.The experimental data are compared with those obtained from carbonate-bearing rocks (Carrara marble).

In all the experiments, the coefficient of friction μ decayed exponentially from a peak value (μp = 0.55 $\mp$ 0.07) at about the initiation of slip towards a steady-state value μss of 0.1 under room-dry conditions, 0.1 under drained conditions and 0.08 under undrained conditions. The shear stress decay was about 75 percent over the first 5 cm of slip, independently of the ambient conditions. However, at a given σneff, δ and V, steady state shear stress was 20 percent lower under undrained than under drained and room dry conditions. Moreover, Pf under undrained conditions increased with displacement following a power law. Conversely, Pf and σn did not vary under drained conditions. After all experiments, a continuous, 100-200 μm thick, layer of glass (Scanning Electron Microscope investigation) separated the rock cylinders, irrespective of the ambient and hydraulic conditions.
In summary, the mechanical data and the microstructural observations suggest that:
1) the 20 percent reduction of steady state shear stress under undrained conditions is due to thermal pressurization of pore water;
2) frictional melting of basalt is almost coeval with thermal pressurization of pore water;
3) the contribution of thermal pressurization to bulk dynamic weakening is negligible.