Geophysical Research Abstracts
Vol. 19, EGU2017-10897, 2017
EGU General Assembly 2017


# Local thermal pressurization triggered by flash heating causes dramatic weakening in water-saturated gouges at subseismic slip rates

Lu Yao (1), Shengli Ma (1), Toshihiko Shimamoto (1), Tetsuhiro Togo (2), Jianye Chen (3), Hiroko Kitajima (4), Yu Wang (5), and Honglin He (6)

(1) State Key Laboratory of Earthquake Dynamics, Institute of Geology, China Earthquake Administration, Beijing, China (yaolu_cug@163.com), (2) Research Institute of Earthquake and Volcano Geology, National Institute of Advanced Industrial Science and Technology (AIST), Tsukuba, Japan, (3) HPT Laboratory, Department of Earth Sciences, Utrecht University, The Netherlands, (4) Department of Geology and Geophysics, Texas A&M University, College Station, Texas, USA, (5) Shanghai Synchrotron Radiation Facility, Shanghai Institute of Applied Physics, Chinese Academy of Sciences, Shanghai, China, (6) Key Laboratory of Active Tectonics and Volcano, Institute of Geology, China Earthquake Administration, Beijing, China

High-velocity friction studies on water-saturated gouges in recent years have demonstrated that the wet gouges subjected to high-velocity shear tend to have smaller peak and steady-state friction, much shorter slip-weakening distance and lower fracture energy, as compared to the air-dry gouges. Thermal pressurization, compaction-induced pressurization, and flash heating were previously recognized to be the important weakening mechanisms in causing these behaviors. However, in spite of theoretical expectation, there is few evidence to support the occurrence of flash heating in wet gouges, mainly due to the superimposition of multiple weakening mechanisms especially for thermal pressurization.

We devised friction experiments to study the role of flash heating in dynamic weakening of water-saturated gouges. In each experiment, we used a pressure vessel to impose a pore pressure of 2.0 MPa on the gouge layer sandwiched between porous ceramics blocks, and applied a long preslide of 1.0 m in displacement before starting the experiment at the target slip rate. By doing so we could (1) suppress rapid thermal pressurization in the bulk gouge layer by means of the designed drained condition and elevated temperature of phase transition of pore water; (2) suppress or even eliminate the pressurization effects due to compaction especially at the very beginning of the experiment.

The experiments were performed on a granular gouge (mainly quartz, plagioclase, calcite and illite) and a clay-rich gouge (illite and chlorite $\sim$58 wt%), which were both collected from the Qingchuan fault of the Longmenshan fault system. For the granular gouge, the steady-state friction coefficients ($\mu_{ss}$) are 0.39–0.42 at slip rates ($V$) of 100 $\mu$m/s–10 mm/s; however, at $V$ $\geq$40 mm/s, the friction coefficients ($\mu$) decrease suddenly at the onset of the slip. For instance, $\mu$ reduces by 0.29 within displacement of 0.05–0.08m at $V$=100 mm/s. For the clay-rich gouge, $\mu_{ss}$ increases from 0.24 to 0.34 as $V$ increasing from 10 $\mu$m/s to 100 mm/s. At $V$=0.4 and 1.0 m/s, the evolutions of friction are characterized by sharp weakening, quick strengthening and slight weakening as slip proceeds. It is noteworthy that the sharp initial weakening is always accompanied by a contemporaneous axial dilatancy of 10–20 $\mu$m for both gouges, and the latter friction evolutions are accompanied by axial shortening for the granular gouge and by further dilatancy for the clay-rich gouge. Moreover, microstructure observations reveal that only 40% of the gouge layer was involved in shear deformation for the granular gouge at $V$=10–100 mm/s, as compared to distributed shear over the entire clay-rich gouge layer at all the tested velocities. The observed data, microstructures and modeling results suggest that flash heating probably triggers thermal pressurization at asperity-contacts or within extremely localized slip zones, causing the sudden initial weakening and contemporaneous dilatancy. The difference in the efficiency of flash heating could explain the different frictional behaviors of the two gouges. Given the extremely fast weakening caused by flash heating and the resulting local thermal pressurization, seismic faults could be weakened more rapidly at much lower slip rates below characteristic weakening velocities previously recognized.