Geophysical Research Abstracts
Vol. 17, EGU2015-4803, 2015
EGU General Assembly 2015

Dynamic weakening of fault gouge affected by thermal conductivity of host specimen: implications for the high-velocity weakening mechanisms

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Since many high-velocity weakening mechanisms are thermal in origin, we study the effects of thermal conductivity of host specimen on fault gouge friction behavior at seismic slip rates. By using host specimens made of brass, stainless steel, Ti-Al-V alloy and gabbro with thermal conductivities of 123, 15, 5.8 and 3.25 W/m/K, respectively, the experiments in this study produce completely different temperature conditions within the same gouge under the same slip rates and normal stresses. Fault gouges used in the experiments are a natural illite- and quartz-rich gouge from Longmenshan fault zone and pure periclase (MgO) nanopowder. High-velocity weakening of gouges were more pronounced with decreasing thermal conductivity of the specimens. Particularly, almost no dynamic weakening was observed in the tests performed with brass host specimens, while tests with specimens of gabbro and Ti-Al-V alloy exhibits quite similar dramatic weakening behaviors. Such differences in gouge frictional behavior cannot be explained by original flash heating model, since asperity contacts within the slip zone and experimental conditions are still same, even though host specimens are different. Microstructure observations under scanning and transmission electron microscopes reveal that slip zone materials tend to change from individual ultrafine nanograins to larger sintered grains or aggregates, with decreasing thermal conductivities of host specimens. Calculated temperature together with observed microstructure indicate that bulk temperature rise may be also play an important role in fault weakening, as predicted by a recent theoretical analysis of the role of flash heating within the gouge zone [Proctor et al., 2014]. Current results demonstrate the importance of frictional heating in causing the dynamic weakening of gouge, and the powder lubrication hypothesis is not consistent with our experimental data.