Strength and Stability of Frictional Sliding of Gabbro Gouge under Hydrothermal Conditions

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The mechanical behavior of mafic lower crust is important in analyzing the possibility of earthquake nucleation or triggered shocks in the lower crust under wet or dry conditions. In this context, data for both plastic flow and frictional sliding are necessary to determine the predominant deformation mechanisms under certain tectonic conditions. As a parallel study to a previous work under nominally dry condition, in this work we have performed experiments of frictional sliding on gabbro gouge under hydrothermal conditions.

Experiments were performed with temperature up to 616 degrees centigrade and under constant effective normal stress conditions. Two series of experiments were carried out with effective normal stresses of 200MPa and 300MPa respectively. Pore pressure of 10 MPa was applied for most of the experiments.

The result shows that (1) coefficient of friction picked at 1.5mm sliding distance resolved to axial direction increases with temperature and comes to a cut-off at -500 degrees centigrade. Compared to the dry case, the frictional strength shows no significant weakening due to the presence of water in the high temperature range. (2) Steady state rate dependence shows different behaviors under the two different effective normal stresses. While the high effective normal stress case shows only positive values of a-b, the lower effective normal stress case shows negative values in a narrow temperature range from -210 to -315 degrees centigrade, and periodical stick-slips occurred in the 252 degrees centigrade run. For temperature greater than 315 degrees centigrade, the rate dependence becomes positive again, which implies the transition from negative rate dependence to positive one due to increasing temperature. A complementary test with pore pressure of 100MPa shows that the negative rate dependence at around 250 degrees centigrade does depend on effective normal stress rather than other single parameters.

Though the mechanism that controls rate dependence is not clear, it is evident that the hydrothermal condition makes the situation quite different.