AOGS 2006

Dependence of Shear Resistance of Rocks on Slip-Rate During Frictional Melting

AKITO TSUTSUMI

Department of Geology and Mineralogy, Graduate School of Science, Kyoto University

A marked negative dependence of shear resistance(a velocity weakening) has been reported for rock samples from frictional melting experiments at fast slip rates(Tsutsumi and Shimamoto, 1997). This velocity weakening was observed for the experiments performed at low normal stress of -1.5 MPa. In this study, we performed frictional melting experiments on gabbro at higher normal stress to 5MPa to investigate the velocity dependence of rock friction within frictional melting regime at higher normal stress conditions. Experiments were conducted on a pair of hollow-cylindrical specimens of gabbro, same in sizes to the previous experiments, with outer and inner diameters of 25 and 16 mm, respectively, initially at room temperature and at a constant normal stress at -5MPa. In the experiments, we slid specimens at a constant slip rate of about 1.2m/s firstly, and the imposed slip rate was changed in a decreasing and increasing step-wise manner after we observe that frictional melting begins and shear resistance becomes almost constant. Normal stress was maintained at a constant value during a run. It is found that(1)velocity weakening phenomena is obvious for the whole period of a run within slow slip rate range $<$0.4 m/s, (2) averaged level of shear resistance at each of the slip rate increases gradually with time if we compare the level for the same slip rate but with a different time-duration of the experiment, (3) shear resistance becomes almost constant for different slip rates at $>$0.4m/s for the later part of a run, and hence the velocity dependence disappears. In the frictional melting regime, host rocks are separated by a continuous molten layer so that the shear resistance is determined by the gross viscosity and shear strain rate of the molten layer(Hirose and Shimamoto, 2005). In our experiment, melt can escape from the sliding surfaces because we do not use jacket around the sample. Because of this situation, melt loss in balance with melt production rate determines a stable thickness of molten layer. If an imposed slip rate(strain rate) increases, shear resistance will increase temporarily and temperature will increase due to increase of the rate of viscous shear heating. With the increase of temperature, viscosity of the frictional melt will decrease and then shear resistance of the molten layer will decrease. However, at the same time, increase of temperature will result in a decrease of the thickness of the molten layer due to melt loss from the sliding surfaces. Decrease of the layer thickness can result in the increase of shear strain rate of the molten layer, which will increase the shear resistance. To understand how slip rate affects viscous shear resistance, we will need a numerical analyses on a physical model of frictional melting. However, our presented results suggest that shear resistance at a steady-state frictional melting will become independent onto the imposed slip rate(strain-rate) at a fast slip rate range($>$0.4m/s) for a long run. Temperature measurement data shows that, although averaged temperature of the sliding surfaces keeps increasing during a run for the whole period of the sliding, it approaches to a constant value gradually for the later period of a run. Frictional melting at the later part of the experiments may be almost in a steady-state.