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Slide-Hold-Slide tests on gabbro under dry and room-humidity conditions: Effect of moisture on frictional strength of faults

Kazuo Mizoguchi[1]; Takehiro Hirose[2]; Toshihiko Shimamoto[3]

[1] NIED; [2] Dept. Geol. & Mineral., Kyoto Univ.; [3] Dept. of Geol. & Mineral., Graduate School of Science, Kyoto Univ.

Friction experiments on initially bare solid-cylindrical rock specimens using the high-speed rotary-shear testing apparatus have investigated a relationship between friction and moisture. The rock specimens used in the experiments are Zimbabwe gabbro of unknown locality. The gabbro consists of plagioclase, clinopyroxene, hornblende, biotite and is free from visible fracture and grains of them have no crystallographic or shape-preferred orientation. The average grain size of gabbro is about 0.5 mm. The solid-cylindrical specimens with outer diameter of about 25 mm and axial length of 20 - 25 mm were prepared and then the ends of them were ground with 80# SiC powders. Specimen ends were made parallel to after being set to the apparatus by pre-sliding them for the same slip rate and normal stress of the friction test. Wear materials on the surfaces produced during pre-sliding were cleaned up by ethanol-wetted papers. The experiments were performed at a constant normal stress of about 0.62 MPa, at an equivalent slip rate of about 0.085 m/s, and under room temperature and humidity. Friction of initially bare gabbro increased rapidly with slip to show a peak friction coefficient of 1.1, followed by a dynamic weakening of friction to a constant level of 0.2 - 0.3 after 20 m of slip. Several transient strengthening in friction occurred during slip. The initial slip resulted in the maximum rate of the axial shortening. Subsequently, the rate decreased with displacement to attain a constant rate at a displacement which friction achieved steady state. After the experiment, the fault contains an about 50 um thick layer of wear material. During slip the fault surface was to be covered with the wear materials.

Although the specimen initially containing the wear material at the same condition showed the similar slip weakening curves to that for the fault including no gouge, the initial peak friction is closely related to the hold time required since the previous sliding is stopped and humidity condition. A series of experiments was conducted at a normal stress of 0.62 MPa and a slip rate of 0.085 m/s. Each experiment was paused for time interval varying from 2 to 3600 s after the fault was sheared to attain a low constant friction of about 0.2. The peak friction at the end of a desired interval was then measured by shearing the fault again. The normal stress was not applied during the intervals. The change of the peak stress with time was measured under both room humidity and dry nitrogen gas. The friction under air increased dramatically at 200 - 400 sec intervals, followed by a constant level of 1.2. The friction under dry nitrogen gas was held constant of 0.4 for intervals as long as 1200 seconds. The strengthening of the peak friction under room humidity was to occur after the temperature of the fault came down to room temperature.

The results indicate that moisture controls friction of the fault with wear material. Under dry condition, the friction of the fault with wear material was constant during slip. Under room humidity, the friction increased during stick interval and decreased with slip. The absorption process of moisture into the wear material results in the recovery of friction. The release process of moisture from the wear material due to frictional heating results in weakening of friction. Temperature measurements agreed to the above process. Here, we would like to suggest the importance of moisture for frictional strength of faults.