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High-velocity frictional behaviors of dolerite under controlled pore-water pressure

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High-velocity friction experiments on rocks with or without gouge have been conducted mostly under dry conditions and demonstrated dramatic weakening of faults at high velocities (e.g., Di Toro et al., 2011, *Nature*). Recent experiments under wet conditions (e.g., Ujiie and Tsutsumi, 2010, *GRL*; Faulkner et al., 2011, *GRL*) revealed very different behaviors from those of dry faults, but those experiments were done under drained conditions. Experiments with controlled pore pressure Pp are definitely needed to determine mechanical properties of faults under fluid-rich environments such as those in subduction zones. Thus we have developed a pressure vessel that can be attached to our rotary-shear low to high-velocity friction apparatus (Marui Co Ltd., MIS-233-1-76). With a current specimen holder, friction experiments can be done on hollow-cylindrical specimens of 15 and 40 mm in inner and outer diameters, respectively, at controlled Pp to 35 MPa, at effective normal stresses of 3-9 MPa, and at slip rates of 60 mm/year to 2 m/s. An effective normal stress can be increased by about 10 times by replacing a 10 kN pneumatic actuator with a 100 kN hydraulic actuator. We report an outline of the experimental system and preliminary high-velocity experiments with controlled pore pressure on Shanxi dolerite.

High-velocity friction experiments were performed on hollow-cylindrical specimens of Shanxi dolerite at effective normal stresses of 0.13-1.07 MPa and at slip rates of 1, 10, 100 and 1000 mm/sec. Nitrogen gas and water were used of the pore fluid and compared the frictional behavior. In the N^2 tests an axial force was kept at 1 kN and the nitrogen gas pressure was increased in steps from 0 to 5 MPa to change an effective normal stress. In the wet tests the specimens were soaked in distilled water in the vessel and Pp was applied by nitrogen gas in a similar manner as in the dry tests. Nitrogen gas acted as buffer to prevent an abrupt change in the pore-water pressure during experiments. The steady-state friction coefficient of dry dolerite increased from 0.3-0.35 at 10 mm/s to 0.55-0.8 at 100 mm/s and then decreased down to 0.2-0.6 at 1000 mm/s. The results are quite similar to those of dry granite tested under similar conditions (Reches and Lockner, 2010, *Nature*). However, the steady-state friction coefficient of dolerite under a pore-water pressure decreased monotonically from 0.4-0.8 at 1 mm/s to 0.3˜0.5 at 1000 mm/s, and the strengthening from 10 to 100 mm/s disappeared with a pore-water pressure. We plan to conduct more experiments with controlled pore-water pressure and to do textural and material analysis of specimens to gain insight on the weakening mechanisms.

Keywords: High-velocity friction experiment, Pore-water pressure