Transition of frictional velocity dependence of subduction zone fault material as a function of effective normal stress

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Frictional experiments of gouge material in the presence of pore fluid pressure should provide valuable information for the stability of slip in the shallow parts of subduction zone faults. However, most of the previous experiments are limited by the amount of displacement that can be achieved and the frictional behavior at large displacements remains poorly understood. In this study, we have conducted large displacement friction experiments on subduction zone fault materials with a fluid pressure-controlled testing system.
We have performed a series of rotary-shear large displacement (>150 mm) friction experiments on the following two types of shallow fault-simulated material; one is the clayey fault material form the shallow megasplay fault zone within the Nankai accretionary prism (Site C0004, IODP Expedition 316) and the other one is from the input pelagic siliceous to calcareous sediments (ooze) to the Costa Rica subduction zone (Site U1318, IODP Expedition 334). In the experiments, a sequence of velocity stepping by a factor of 10 was imposed to examine the velocity dependence of friction, for loading velocities of 0.0028–0.028 mm/s. In this study, the velocity stepping was imposed to the sample continuously while changing effective normal stress in a range from 1 to 5 MPa by changing pore fluid pressure slowly at a constant increasing or decreasing rate at 500 Pa/s.
Experimental results reveal that frictional velocity dependence changes as a function of pore pressure. For both the clayey fault material and the siliceous to calcareous ooze samples, frictional velocity dependence was slightly negative or almost neutral at a range of relatively higher effective normal stresses (>2.5 MPa). When the level of pore fluid pressures was increased further to reduce the effective normal stress, frictional velocity dependence changed into velocity strengthening behavior.
The SSEs are often described as conditionally stable sliding of faults [e.g., Shelly et al., 2006]. Pore pressure increase will make weakly velocity-weakening fault conditionally stable [Scholz, 1998]. Our experimental results show that velocity-weakening behavior changes into velocity-strengthening behavior when pore fluid pressure is increased. This could be an alternative role of pore fluid to stabilize otherwise unstable (velocity weakening) faults.

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