

Effects of shear displacement and fault zone structure on the frictional behavior of montmorillonite-quartz gouge

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Recent observation of the low frequency earthquakes in the shallow part of the Nankai subduction zone has demonstrated that faulting there is slow yet seismic; suggesting that frictional velocity dependence along the fault would be negative. However, in a widely accepted model, sediments there is expected to exhibit velocity-strengthening frictional behavior. We have reported that the fault material along the megasplay fault in the Nankai Trough exhibited both velocity-strengthening and velocity-weakening frictional behavior [Tsutsumi et al., 2011]. Fault zone structures may be important to understand why the samples exhibited different velocity dependence. In this study, we have conducted frictional experiments on artificial gouges composed of montmorillonite and quartz mixtures, in order to understand the relationship between the fault zone structures and velocity dependent frictional behavior.

We examined frictional behavior and fault zone structure of the artificial gouge samples composed of montmorillonite/quartz mixtures. All of the experiments were conducted under water-saturated conditions at 1 to 5MPa of normal stress, with shear displacement of 30 mm to 14 m, using a rotary-shear friction testing machine. Velocity step tests were conducted in a range of velocities from 0.003mm/s to 30 mm/s, in order to examine velocity dependent frictional behavior.

Results of these experiments reveal influences of normal stress and displacements on frictional behavior. Velocity weakening behavior was observed for the mixtures of montmorillonite/quartz = 20/80 and 40/60 wt%, respectively, at large displacement. In velocity-weakening samples, montmorillonite becomes to be finer-grained and is well mixed with quartz in the gouge layer after long shear displacements and at high normal stresses. These observation demonstrates that frictional behavior of the montmorillonite/quartz gouge changes with the development of the deformation structures. It is suggested that fault zone structure is one of the important factors of describing the frictional behavior along faults at the Nankai Trough.

Keywords: montmorillonite, frictional experiment, fault zone structure