Contribution of brucite nanoparticles to velocity-weakening

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Nanometer scale particles are observed in natural faults and friction experiments (e.g. Chester et al., 2005) and known to affect frictional characteristics (e.g. Han et al., 2011). In addition, natural faults often contain sheet-structure minerals (e.g. Chester et al., 2013), which have lower friction coefficients than general rocks (Byerlee, 1978), therefore the frictional characteristics of sheet-structure nanoparticle are important for understanding the dynamics of natural faults. Sheet-structure rich materials which friction coefficients are lower than 0.55 are known to shoe velocity-hardening (Ikari et al., 2016). However, brucite, one of the sheet-structure minerals, shows lower friction coefficient then 0.55 and stick-slip motion representing velocity-weakening (Moore & Lockner, 2004). In this study, we conducted friction experiments with brucite nanoparticle and investigated its mechanism of velocity-weakening from the microstructure of experimental gouges and the variation of friction coefficients.
Friction experiments were conducted with chemically synthesized brucite nanoparticles (purchased from WAKO; purity: 99.9%; grain size: 70 nm & 600 nm). Biaxial testing machine in Hiroshima University was used and two gouges of brucite were formed with three gabbro blocks which surfaces contacted to gouges were roughened with abrasive.

Experimental results showed that friction coefficients are 0.44 (stable slip) and 0.34 (small stick-slip) for grain sizes of 70 nm and 600 nm, respectively. Velocity stepping test showed that both brucite nanoparticles were velocity weakening. Although the amplitude of roughened surfaces of gabbro blocks was >10 μm, optical observation showed brucite nanoparticle filled up those roughness and there were clear straight boundary shears on both sides of gouge. In the near region of these boundary shears, orientation of particles was observed within ~1 μm.

Shear localization to boundary shear or Y-plane parallel to shear direction is thought to be one of the reasons of velocity-weakening (Scruggs & Tullis, 1998). On the other hand, sheet-structure minerals were observed to be oriented mainly along P-shear (e.g. Haines et al., 2013). Considering the grain size we used in this study, shear localization can be generated only with some scores of nanoparticle. Therefore, it is implied that velocity-weakening is caused by the shear localization with the orientation of nanoparticles along boundary shear other than macro particles.
In this presentation, we will discuss the effects of gouge thickness and the displacement-dependent formation of smooth shear planes.

Keywords: Sheet-structure nanoparticle, Friction experiments, Velocity-weakening