evolution of localized shear texture on a simulated fault surface of quartz rocks during slip-weakening process at a intermediate slip velocity

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Siliceous rocks such as novaculite and quartzite display dramatic weakening of frictional strength at slip velocities of >1 mm/s [Goldsby and Tullis, 2002; Di Toro et al., 2004]. It is known that hydrated amorphous silica gouges form on the fault surface in the intermediate-high velocity frictional slip [Hayashi and Tsutsumi, 2010]. Goldsby and Tullis [2002] suggested that the silica gel layer made of very fine amorphous silica particles causes the frictional weakening. However, there are few reports focused on the state of these silica gouges during the slip-weakening process. In this study, to better understand the state of the fault surface during the slip-weakening, SEM observations of the fault surface and section and XRD analyses of the silica gouge were performed.
All the experiments in this study were conducted using a rotary-shear, intermediate-to high-velocity friction testing machine in Kyoto University. The samples used for the friction experiments were single crystal of quartz (a synthetic crystal). A pair of solid cylinders with a ring-shaped end surface (inner and outer diameter of 5 mm and 25 mm) was cored from the samples. Experiments were carried out at a constant normal stress of 1.5 MPa and a slip velocity of 105 mm/s condition.
As an experimental result, slip-weakening occurred at the initial 0.2–0.3 m of the sliding and the value of friction coefficient dropped from the peak value 0.6 to residual value 0.2. The peak friction showed log(t) healing [Dieterich, 1972]. Whole of the fault surfaces of the specimens were completely covered with white, fine-grained gouges after the experiments. SEM observations showed that 100–300 μm size of plate-like structures had been formed on the surface. The surfaces of these structures were very smooth and flat. These structures were teared from the surface into a shear direction. SEM observations of the fault section revealed that a continuous shear plane had been formed at the center of the fault zone. Along and parallel to this shear plane, approximate 1.5 μm-thick layers had piled up and formed foliation structures. Similarities in size and direction of the planes suggest that these piled layer structures should correspond to the plate-like structures found on the fault surface.
XRD analyses of the fault gouge revealed that amorphization of gouges had already been occurred during the slip-weakening.

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