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# Experimental study about compaction of simulated fault gouge

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From the friction experiments using simulated fault gouge, it is known that frictional instability is influenced by microstructure development of the gouge (Byerlee et al., 1978; Logan et al., 1979; Marone and Kilgore, 1993; Onuma et al., 2011). Gouge compacts during an initial stage of shear, subsequently unstable slip occurs when shear proceed (Marone et al., 1990). However, the purely deformation process of gouge to unstable slip in detail is not clear, because the point of measurement is far from gouge layers, and sampling rate is slow. Therefore, we attempted to investigate how gouges behave toward unstable slips using strain gages, and how frictional instability is influenced by confining pressure.

We conducted frictional experiments using simulated fault gouge in a gas-medium apparatus at confining pressures ranging from 140 up to 180 MPa at a constant strain velocity of $10^{-3}$ /s. A dry quartz powders (0.1 or 0.2 g) were used as simulated fault gouges, and they were placed between two gabbro cylinders, which were 20 mm in diameter, 40 mm in length, and cut by a 50o to their cylindrical axis. To measure localized strain and fault slip, we used strain gages glued directly onto a gouge layer inclined 45o to saw-cut. Another strain gauge was used to measure axial stress. Sampling rate is 2 MHz. In order to investigate how gouge accommodate strains during a compaction stage, we loaded until the axial stress reaches the set points (190, 450, 640, 800 MPa), then stopped load and relaxed stress. The sample was hold at 30?60 seconds and we load until it reaches the next set point. We repeated this loading cycle until unstable slip occurs.

During the holding stages, we detected three different behaviors of stress relaxation of gouge depending on the magnitude of stress: 1) Compression with little drop of stress. The behavior was confirmed at the lowest axial stress of 190 MPa suggesting that the gouge shows elastic rebound at this stress. 2) Extension and subsequent compression during intermediate stress levels (450 and 640 MPa). 3) Great extension with the decrease in axial stress observed at the highest stress (800 MPa). The behavior can be observed during later stages of the repeated loading. During repeated loading, gouge evolves toward unstable slip from behavior 1 to behavior 3 with stress. It is also revealed that the peak stresses when the unstable slip occurred were lower than those in past load cycles. This indicates that during repeated loading, plastic deformation of gouge occurred under high stress and gouge cannot sustain stress even under progressive loading We suggested fracture and slip of gouge particles happened (behavior 3) under high stress after compaction proceed by repeated load (behaviors 1 and 2). Moreover, plastic strain needed for unstable slip decrease with pressure. From the microstructural analysis of simulated fault gouge, the transition from R1 shear to Y shear has been known to cause unstable slip (Logan et al., 1979; Onuma et al., 2011). We propose that the behavior 3 observed in the present study corresponds to formation and slips of R1shears. From the high-speed data acquisition systems using strain gages, we illuminated the mechanical behaviors of gouge toward unstable slip under various confining pressure.

Keywords: simulated fault gouge, compaction, frictional instability