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Difficulties and preliminary results of high-velocity friction experiments on faults with gouge

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High-velocity frictional property of a fault is important for understanding the mechanical processes of faulting during an earthquake. Recent high-velocity friction experiments revealed several important aspects of fault at high slip rates, such as the fault weakening mechanism associated with frictional melting (Tsutsumi and Shimamoto, 1997; Hirose, 2002). However, the previous high-velocity friction experiments were performed on intact rock samples that need no seal. Field studies of the Nojima fault reported that pseudotachylyte layers, which are produced mostly by frictional melting and are often regarded as an evidence of earthquakes, were found in fault gouge layers at Hirabayashi (Otsuki, 2000). Also, it is well known that the shear deformation of a fault often localized to a narrow tabular zone of the fine-grained fault gouge within a wider fault zone. Mechanical property of the fault gouge is thus essential for revealing the mechanical processes of faulting. We thus developed a new seal to keep fault gouge on simulated fault, and examined high velocity frictional properties of Nojima fault gouge.

All experiments were conducted using a rotary-shear, high-speed frictional testing apparatus described by Shimamoto and Tsutsumi (1994). The fault gouge used in the experiments is blue gray gouge derived from granodiorite collected at the Hirabayashi trench along the Nojima fault. The fault gouge is placed between a pair of solid-cylindrical granite specimens. Hollow-cylindrical Teflon (a PTFE material) was used to keep the fault gouge at the artificial fault. A series of experiments were performed at a constant normal stress of 0.61 MPa and a constant equivalent slip rate of 1.03 m/s, with different displacements of 0 - 27 m under room temperature, unconfined and dry conditions.

The representative mechanical behavior and axial shortening of a simulated fault are as follows. At the initiation of a run, friction coefficient rapidly increased to about 0.8 and then gradually decreased. The friction coefficient finally attained to nearly constant (0.2-0.4). Initially, the axial length of the fault gouge decreased rapidly and then became nearly constant. The initial axial shortening is due to compaction and grain size reduction of the fault gouge. The fault gouge did not leak from the artificial fault during the experiments. The overall frictional behavior is reproduced reasonably well in these runs. The megascopical observations of experimental specimens stopped at various displacements indicate that black material became to impregnate into the artificial fault with increased displacement and finally covered the fault surface. The growth of the black material is closely related with stabilization of the friction of the fault. Under the microscope the materials in which planar structures are developed are observed at the boundary between the fault gouge and wall rocks of the artificial fault of which the friction became constant. The materials were the above mentioned black material. The material was found to be Teflon [C_nF_n] as quantified by SEM analysis.

In the present experiments mechanical data of high velocity friction of the fault gouge could not be obtained correctly due to injected Teflon on the fault. However it was reported that the ESR signals of the gouge change during our high velocity friction tests (Asai et al, 2001; Fukuchi et al, 2001). The change of the ESR signals is related with heat. This result suggested the possibility that we can detect frictional heating of a fault by the change of the ESR signal. Estimating the frictional heating is necessary to analyze earthquake mechanisms, such as thermal pressurization. In this study the most important point is that we could keep the fault gouge in the artificial fault during high-velocity friction.