Identification of slip weakening mechanisms: first results from high-velocity experiments on natural fault gouge.

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Many exposures of or trenches across active faults show that the most recent co-seismic displacements took place in a narrow (1-10 cm thick) clayey gouge zone called central slip zone (CSZ), thought to exist down to depths of about 5 to 8 km. Hydratation of the CSZ varies with depth in relation with permeability properties, the geothermal gradient and the regional stress. The true frictional properties of the upper part of CSZ-bearing active faults will therefore depend on the clayey gouge moisture condition.

In order to identify the role played by water on slip weakening mechanisms, several experiments have been conducted for the first time on the high-speed rotary-shear apparatus of Kyoto University (Japan), for different gouge water contents (wet or dry), distinct rotation velocities (0.09 $m.s^{-1}$, 0.9 $m.s^{-1}$ and 1.3 $m.s^{-1}$) and a fixed applied normal stress (0.6 MPa). The used gouges were prepared from a natural gouge exposed along the Usukidani fault, a potentially active fault of SW Japan. They are composed of a clay matrix (interstratified illite/smectite) and of quartz, feldspar and calcite clasts (clast size ranging from 0.375 to 53 micrometers). A weight of 0.5 g of fault gouge was placed between two granite cores. Both types of gouges were precompacted for several hours before shearing, in order to obtain the same homogeneous bulk gouge and to prevent a pore pressure build-up when testing for the wet gouges. The initial thickness of the reconstituted gouge ranged between 0.6 and 0.8 mm (Fig. 1). In order to prevent gouge expulsion, the simulated fault was coated by a Teflon sleeve. Total achieved displacements are comprised between 4 and 64 m (wet gouges) or between 4 and 43 m (dry gouges).

Both slip rate and water are found to have some important controls on the deformation textures. Detailed examinations of resulting gouge microstructures (Fig.2) in correlation with gouge frictional behaviour and calculated temperature (Fig.3) permitted to isolate two major types of texture implying at most two wear mechanisms of deformation. Timing evolution of material exchange between these two mechanisms is thought to be critical on the determination of the degree of fault instability during faulting.

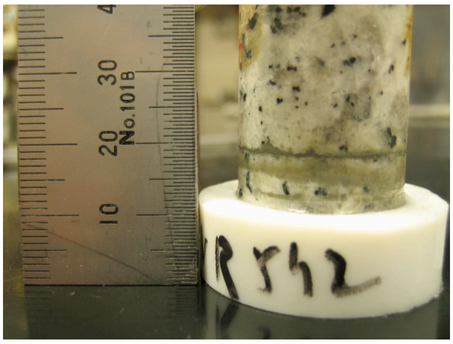

Figure 1. The picture shows sample assembly configuration at the end of a run at high slip velocity.

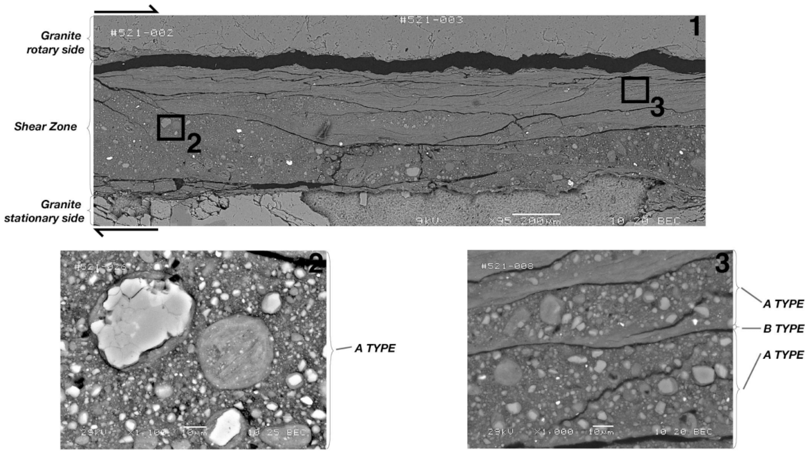

Figure 2. Detailed observation of gouge microstructures allow to noticed two types of particle friction with two resulting microstructures: an A-Type corresponding to a random fabric composed of snow-ball-like clay-clast aggregates and rounded calsts, and a B-Type corresponding to a foliated gouge composed of extremly fine clasts showing a strong LPO of phyllosilicates.

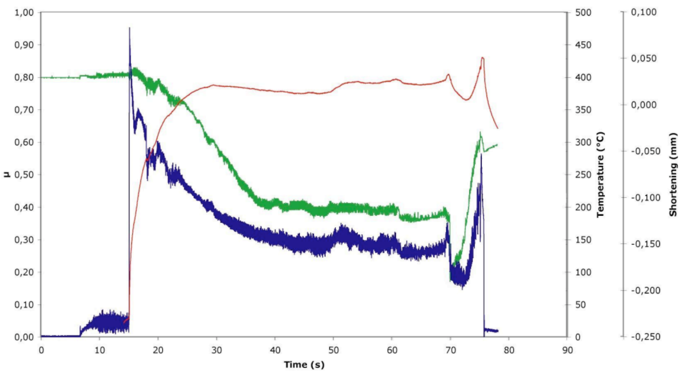

Figure 3. The graph shows the concomitant evolution of calculated temperature and sample assembly dilatancy during a frictional slip weakening at 0.9 m/s in wet conditions.