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Clast-clay aggregates as new indicator of shallow crustal seismic slips

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Exposures of mature seismogenic faults reveal that the near-surface co-seismic slip is accommodated by a few mm-thick clayey gouge layer called the principal slip surface (PSS). This PSS is partly composed of phyllosilicates resulting from hydrothermal alteration of rock cataclasis product. This PSS gouge is thought to control earthquake instability. Thus, understanding its mechanical properties is central to understand earthquake processes.

The strain energy released during an earthquake is partitioned between the fracture energy (E_G), the frictional heat (E_H) and the radiated energy of seismic waves (E_R). E_G and E_H play a fundamental role in earthquake rupture dynamics

To determine E_G and E_H of the Usukidani fault, an active fault of SW Japan, fourteen representative rotary-shear experiments were conducted at seismic slip rates (equivalent to 0.9 and 1.3 m/s) at 0.6 MPa normal stress on a natural clayey gouge for saturated and non-saturated initial conditions. The mechanical behavior of the simulated faults shows a reproducible slip-weakening behavior, whatever initial moisture conditions.

E_G is usually estimated from grain size distribution of the PSS gouge, considering that grain size reduction develops by fragmentation and comminution. However, examination of our post-experiment gouge at the residual friction, regardless of initial moisture conditions, does not exhibit the common cataclastic appearance for E_G estimation, but two peculiar types of microstructures: a foliated type observed along one or both granite-gouge boundaries and reflecting strain localization, and a non-foliated type composed of spherical aggregates, named clay-clast aggregates (CCAs) distributed in the remaining space.

Boutareaud et al. (2008) showed that, using a simple slip-weakening model for an experimental fracture energy estimated in the range 1.4 to 4.1 $MJ.m^{-2}$, increase of pore fluid pressure in a smectite-rich slipping zone during the first meters of slip displacement allowed to create the excess space necessary for grain rolling in a turbulent fluid-solid mixture in suspension, and subsequently formation of CCAs as a complex interplay of electrostatic forces and capillary forces. But the exact timing of formation of such microstructures remains uncertain.

The aim of this contribution is first, to give new informations on the way CCAs form during shearing, using SEM mapping and infra-red microscope observations, and second, to give a preliminary comparison between experimental CCAs and natural CCAs from gouge slip zones of the Chelungpu fault, in order to better understand energy dissipation rupture process of smectite-rich PSS gouge.