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Thin share localization in matured mylonitic rock

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Textures of deformation in fault rock are the results from every history of deformation they had been conducted, and the textures correspond to these deformation conditions, such as pressure, temperature and strainrate. In nature, deformation mechanism at earthquake preparation (aseismic) stage is of ductile forming the mylonite. Therefore, to reproduce more realistic fault behavior at the brittle-ductile transition regime, we carried out large jump experiment in the sliding velocity on brine saturated halite (80 wt.%) - muscovite (20 wt.%) mixed gouges after making the mature mylonitic texture in the gouges, using a rotary shear testing machine set at Utrecht University, Netherlands.

In mylonite, one of the fault rocks formed under ductile deformation condition (high temperature and low strainrate), we often found narrow strain localized zones, such as pseudtakylite with mm-scale of width. Our question from the nature is how to generate the strain localization in the mylonite, in order to know how deformation style changed from ductile (aseismic) to brittle (coseismic). Here we experimentally investigated the strain localization process in rocks having ductile, matured mylonitic structure. We carried out rotary shear experiments on brine saturated halite - muscovite mixed gouges (5 g in weight, c.a. 1 mm in thickness) under 5 MPa in normal stress, room-temperature and various strainrate (from $3{*}10^{-5}$ sec^{-1} to 0.1 sec^{-1}) conditions, which were well-known analog of the fault rock consisting of quartz and phyllosilicate (e.g., Bos and Spiers, 2002; Niemeijer and Spiers, 2006). Additionally, deformation features on the mixed gouges were well-known to show very various on both the strength and the texture, depending on the stranirate. At lower strainrate ($<1{*}10^{-3}$ sec^{-1}), the deformation feature was characterized by velocity-strenghtening and mylonitic texture. On the other hand, at higher strainrate ($>1{*}10^{-3}$ sec^{-1}), that showed velocity-weakening and chaotic texture.

In our experiments, we gave a large jump in sliding velocity after forming matured mylonitic texture on the mixed gouge. That large jump of 2.5- or 3.5-digit increases in the sliding velocity simulated earthquake nucleation or propagation in the mylonite. Microstructural observations on the experimental products indicated possible evidences of the strain localization caused by the high-speed rotation. The strain localization occurred only at 10 μm zone near a boundary surface of the ring shear. In that thin localized zone, grains of halite were crushed. Except the thin localized zone, the mylonitic texture has been completely remained. It was similar to the natural mylonite associated with narrow zones of the pseudtacylite.

We also measured changes in frictional strength after the velocity jump, showing abnormally large increase in the strength at instantaneous response and some delay to start evolutionally-weakening in the strength. It means that the rate and state friction law (RSF law) could not hold for a case changing the deformation style from the ductile to the brittle.

The strainrate during long term aseismic period is very low. Therefore domestic texture controlling mechanical behavior in a seismic-aseismic cycle is “mylonite” at the brittle-ductile transition regime. We revealed, in this experiment, that the matured mylonite texture never be completely broken (not chaotic), but localizes the deformation in one or several narrow shear zones at earthquake nucleation or rupture propagation. This feature is consistent with the natural observation, narrow pseudtakylite zones developed in the mylonite. The mechanical behavior of the mylonite at the earthquake would not obey the RSF law.