Japan Geoscience Union Meeting 2011
(May 22-27 2011 at Makuhari, Chiba, Japan)

SSS029-16 Room:104 Time:May 23 12:30-12:45

Effects of shear-induced dehydration of serpentine on the mechanical behavior

Miki Takahashi[1*], Shin-ichi Uehara[1], Kazuo Mizoguchi[2], Koji Masuda[1]

[1]Geological Survey of Japan, AIST, [2]CRIEPI

The frictional properties of serpentinite are of particular interest in the study of earthquake generation processes along subducting plates and transform faults. Previous studies showed that the rheology of serpentinite is quite complicated, but that complicated rheology is not yet fully understood. We were not able to pinpoint the role of serpentinite in fault behavior and/or earthquake occurrence. Currently it becomes imperative to investigate the rheology of serpentine-bearing fault comprehensively. Serpentine accompanied by high pore water pressure at wedge mantle has a possibility to affect occurrences of slow earthquakes and/or non-volcanic tremors [e.g., Obara, 2002] at a place where a subducting plate contacts a serpentinized mantle wedge. Here we will report results of experiments the transient behaviors of the serpentine gouge to stepwise change in slip velocity under high temperature condition. We conducted the shear-sliding tests on the serpentine gouge (almost pure antigorite) using a gas-medium, high-pressure, and high-temperature triaxial testing machine. Sliding deformation was applied on the thin zone of the gouge (c.a. 0.8 mm) between two alumina blocks with oblique surfaces at 30? to the cylindrical axis, under various temperature conditions. The experiments were carried out using a constant confining pressure (100 MPa), a constant pore-water pressure (30 MPa), and a range of temperatures (from room temperature to 600 deg.C). The transient responses of mechanical characteristics following stepwise changes in the slip velocity were documented at each temperature. Slip rates varied between 0.0115 micron/sec (~36 cm/yr) and 11.5 micron/sec (~1.0 m/day).

Both the strength and the shear behavior showed the drastic change at around 450 ~ 500 deg.C. The average strength at 1.4 mm of the displacement showed a sharp rise of c.a. 0.15 of the friction coefficient between 400 deg.C and 450 deg.C, which friction increasing was quite large. The transient behavior to the stepwise change in the velocity also indicated change in the type of the behavior drastically, from the creep-type behavior at 400 deg.C to the frictional (or stick-slip) behavior at the temperature higher than 450 ~ 500 deg.C.

Although only a limited volume of the serpentine was involved in the dehydration reaction, X-ray diffraction analyses and scanning electron microscopy observations showed that forsterite had nucleated in the experimental products at the temperatures higher than 450 ~ 500 deg.C that were associated with frictional behavior. Sub-micron-sized, streaky forsterite masses in shear-localized zones may be evidence of shear-induced dehydration that caused strengthening and embrittlement of the gouge (refer to Takahashi and Shimizu, 2011, in S-IT39 at this year JpGU Meeting for details of the microscopic observations).

Our observation revealed that the serpentine at the shear-localized zone were reacted preferentially, implying a possibility of shear-induced dehydration reaction at the fault having the hydrous minerals. Moreover, this localized reaction can control the deformation style of the fault even though the dehydration was limited. At the outset of the dehydration, both the strength and shear behavior are already controlled by physical properties of the reaction products. Owing to the drained condition, the mechanism of embrittlement was not due to the pore pressure increasing. Thus it also suggests that the fault with hydrous minerals becomes brittle once the dehydration reaction starts even if the P-T condition and/or poroelastic condition do not allow the pore pressure increasing.