Experimental investigation of dehydration weakening and embrittlement of antigorite serpentinite and possible mechanisms to induce various fault slip behaviors in subduction zones

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The frictional behavior of phyllosilicates dramatically changes during dehydration reaction due to phase change of minerals and increasing of pore fluid pressure. Especially, the presence of serpentinite has stimulated interest in their relationship to various slip behaviors in subduction zones such as regular/slow earthquake and creep along plate boundaries and intermediate-depth earthquakes within subducting slabs.
Recent high-pressure deformation experiments using Griggs apparatus and D-DIA on antigorite serpentinite at mantle conditions show a stable sliding with shear localization without acoustic emission (Proctor and Hirth 2016; Okazaki and Hirth 2016), while temperature ramping experiments on antigorite show dramatic weakening during dehydration reactions due to the build-up of the pore fluid pressure (Proctor and Hirth 2015). The weakening rate during the dehydration reaction is controlled by the temperature ramping rate and the strain rate. In contrast, low-pressure friction experiments on antigorite serpentinite under hydrothermal conditions demonstrated that slip behavior of antigorite varies from stable sliding to unstable stick-slip via slow stick-slip with increasing temperature (Okazaki and Katayama 2015).
We analyzed fault stabilities at natural and laboratory conditions assuming a spring-slider configuration based on the dehydration kinetics, the far field (i.e., the load point) sliding velocity, the pressure and the temperature with various stiffness values. Initial result indicates that the fault is more unstable if the dehydration reaction occurs at higher temperature and solid pressure-medium apparatuses (Griggs apparatus) is too stiff to induce an unstable slip by the dehydration weakening. Generally solid pressure-medium apparatuses tend to have very high stiffness to compare with the apparent stiffness of natural fault zones (orders of kPa/mm to MPa/mm). Such high stiffness may inhibit unstable slips in dehydrating antigorite layer in laboratories, while we need to conduct further analysis to evaluate whether dehydration weakening and embrittlement really induce seismicity in natural fault zones especially within the subducting slabs.

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