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# Metasomatic fault-zone weakening of subduction plate boundary faults

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Fluid influx along faults triggers stress-induced dissolution and precipitation processes, leading to syntectonic growth of weak phyllosilicates. In subduction zones, slab-derived Si-rich fluids may infiltrate into the forearc wedge and transform primary mantle minerals into hydrous phases such as serpentines and talc, changing the mechanical and seismogenic properties of subduction plate boundary faults. However, it remains unclear how frictional strength and sliding stability of the plate boundary faults evolve via Si-metasomatism.

Hirauchi et al. (2013, *Geology*) performed frictional sliding experiments on antigorite (70%) plus quartz (30%) gouges at a pore fluid pressure ($P_f$) of 200 MPa, an effective normal stress ($\sigma_{eff}$) of 200 MPa, temperatures ($T$) of 20, 300, 400, and 500 ℃, and sliding velocities ($V$) of 0.1-30 $\mu$m/s, using a hydrothermal ring shear machine. At temperatures of 300-500C, the gouges exhibited a peak friction coefficient ($\mu$) of 0.40-0.62, followed by strain weakening towards a quasi-steady-state $\mu$ of 0.25-0.47. The weakening was mainly due to the development of through-going, talc-rich boundary shears. The steady-state $\mu$ of the gouges decreased systematically as the talc-rich layer widened.

At central California, there are several boundary faults that separate serpentinite bodies from shale-matrix melanges of the Franciscan accretionary complex. The serpentinite body is overprinted by anastomosing development of crack-seal veins of talc, serpentine, and calcite, suggesting that intense water-rock interaction took place in connection with faulting. The serpentinite along the faults represents a cataclastic shear zone that records brittle deformation, consisting of angular fragments that are suspended in fine-grained, randomly-oriented talc matrix. Frictional sliding experiments conducted at $P_f$ = 40, 80, and 120 MPa, $\sigma_{eff}$ = 60, 120, and 180 MPa, $T$ = 20, 150, and 300 ℃, and $V$ = 0.3-100 $\mu$m/s showed that the serpentinite has friction coefficients that agree with Byerlee's law ($\mu$ 0.6), while the cataclasite is much weaker with friction coefficients as low as 0.2. Examination of the velocity dependence of friction revealed that the serpentinite exhibits both velocity-weakening and velocity-strengthening behavior, whereas the cataclasite is velocity strengthening under all conditions investigated.

Our results demonstrate that in the lowermost part of the forearc wedge, where silica-saturated fluids infiltrate from the dehydrating slab, metasomatically produced talc will form in the intensely sheared serpentinite, causing a much larger weakening effect than expected for serpentines, even if the total amount of talc formed is minor ($<$10 vol%). The continued reaction with Si-rich fluid will also result in a transition from seismic to aseismic behavior of the plate boundary faults.

Keywords: subduction zone, serpentinite, metasomatism, fault