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Transient behaviors of antigorite gouge following stepwise changes in slip velocity at elevated temperature

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There are many arguments on seismic activity and/or physical properties of faults related to serpentinite. The well-known, longstanding issues are whether the serpentinite is a cause of creeping and weakness of the San Andreas fault, and whether the serpentinite is a cause of intermediate-depth earthquakes in subducting slabs due to the dehydration. For example, an issue on the San Andreas fault, many experimental studies, were carried out to ensure that the weakness of the serpentine. Reinen et al., [1994] observed the transient behaviors of friction at the stepwise changes in the slip velocity, and one of their important results was that the serpentinite showed two types of frictional behaviors: state-variable dominated behavior at relatively higher velocity (0.1-10 um/sec) and flow-dominated behavior at lower velocity (less than 0.1 um/sec). Additionally, the chrysotile-bearing serpentinite was found to have lowest friction coefficient (~ 0. 2) at lower sliding velocity and to become a candidate to explain the San Andreas fault weakness. They also suggested that the low strength and stable flow behavior on the chrysotile-bearing serpentinite could be easier observed at elevated temperature. However, contrary their expectations, the chrysotile at a condition corresponding to the 9 km depth showed substantially stronger [Moore et al., 1996]. Those previous studies proved that the rheology of the serpentinite would be quite complicated, but its rheology study was not enough to reveal the role of serpentinite to the fault properties and/or earthquake occurrences. Our challenge is to reveal how the rheology of the serpentine is complicated and what mechanism controls each behavior, using a technique of deformation experiment. Then, we first conducted sliding deformation tests on the simulated serpentine (pure antigorite) gouge at various temperature, from room-temperature to the high temperature inducing the dehydration under a set of constant pressure condition, confining pressure = 100 MPa and pore pressure = 30 MPa. At each temperature, we observed the transient behaviors of friction at stepwise change of the slip velocity. We provided 4 orders of magnitude for the axial shortening velocity from 0.01 um/sec to 10 um/sec, corresponding to the slip velocity ranging from 0.0115 um/sec (~36 cm/yr) to 11.5 um/sec.
The transient behavior following stepwise change in the velocity gives information what mechanism works in the fault zone and how the mechanism depends on the deformation condition. The sliding behavior to a step change in sliding velocity at brittle (friction) regime was well studied for various rocks and minerals to understand the seismogenic process. That transient behavior can be mainly described by a direct effect and an evolution effect, so-called as rate- and state-dependent friction constitutive law, developed by Dietrich [1981]. The direct effect is appeared as an instantaneous response with a positive proportionality coefficient, a, to the change in magnitude of the velocity, while the evolution effect is appeared as a decay, b, towards next steady-state friction to the change in magnitude of the velocity. On the other hand, we here suggest that the mechanical model at ductile (plastic flow) regime could be similar to the visco-elastic model, but non-linear. In Reinen et al., [1994], they adapted only the rate-strenghening constitutive law to depict a flow behavior. On our results, various transient behaviors were observed depending on the experimental conditions, the slip velocity V and the temperature T. We would like to show those transient behaviors, and to discuss on that the rheology of the antigorite

serpentine was not simple.

<References>
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