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EFFECT OF PORE PRESSURE ON THE FRICTIONAL BEHAVIORS OF SERPENTINITE

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Slow earthquakes (e.g., slow slip events, very low frequency earthquakes and non-volcanic tremors) have been detected in subduction zones where relatively young and hot slabs are subducting, such as southwest (SW) Japan. Low velocity anomaly and high Poisson's ratio have been detected in these regions, suggesting a possible role of serpentinite and high pore fluid pressure triggering these events [1,2]. However, the physical mechanisms of slow earthquakes are not fully understood, although the slow earthquakes are characterized by a different scaling law to the regular earthquakes [3].

In this study, we focus on the effect of pore fluid pressure on the frictional behaviors of serpentinite, and discuss a possible role of high pore pressure on the asperity model and enhancement of slow earthquakes at the subducting plate interface.

In order to test frictional behaviors of serpentinite at high fluid pressure, we used a gas confining medium triaxial deformation apparatus at our institute. In this system, serpentinite samples are grinded cylindrical shape with precut at an angle of 30 degrees. One piece of the samples is drilled through to the slip surface for fluid conduit. Stating material is highly dense and isotropic antigorite serpentinite from Nishisonogi metamorphic belts, Nagasaki, Japan. In the experiments, argon gas and distilled water are used as a pore fluid for dry and wet experiments, respectively. Deformation experiments are conducted at a constant rate (0.001 mm/s) at a constant Pc of 150 MPa and room temperature.

At initial stage, shear stress increases lineally with displacement and reaches a steady value after the yield points. We then stepped pore fluid pressure (Pp) to test frictional response on the serpentinite sliding surface. Initial value of Pp ranged from 50 to 145 MPa, and the magnitude of step changes of Pp ranged from 7.8 to 71.0 MPa. Step changes in Pp were accomplished within $<$0.3 s. Shear stress has been sifted simultaneously with Pp steps and reached a new steady state condition. The stress weakening was observed after increasing Pp (decreasing effective pressure), and the stress strengthening was seen after decreasing Pp. The shear stress shows lineally correlation to the effective stress, suggesting that Coulomb's law is applicable for the sliding test due to pore fluid injection and ejection.

The steady-state shear stresses at wide range of Pp were converted to frictional coefficient f. Under dry conditions (Ar gas was used as a pore fluid), friction coefficient is estimated to be ˜0.66, which is similar value of Byerlee's law. However, under wet conditions (distilled water as a pore fluid), the friction coefficient is slightly smaller, f ˜ 0.51, compared to the dry experiments. The difference in frictional coefficient can be caused by charged water on the crystal surface, which might reduce frictional resistance on the sliding surface under wet environments. Molecular dynamics simulation has shown that sheet-structure minerals, such as mica, tend to adsorb more water on grain surface [4].

Our experimental results indicate that migration of aqueous fluids in subduction zone setting can cause mechanical weakening on the subducting plate interface. Consequently, asperity on the plate boundary might be controlled by heterogeneous distribution of fluids and its significant role of frictional strength on the serpentinized sliding surface.

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