

# Constitutive relation of serpentine mud from South Chamorro Seamount

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Brace and Byerlee (1966) suggested that stick slip instabilities in laboratory friction experiments were analogous to earthquake rupture. Since then, a number of experiments were performed, and Dietrich (1978, 1979), Ruina (1983), and Perrin et al. (1995) proposed frictional constitutive laws of the slip rate and state variable type. Complex frictional behaviors (e.g. memory effect and history dependence) were successfully modeled by incorporation of state variables. These laws have been widely used to reproduce fault behaviors such as rupture nucleation and coseismic slip.

Although extrapolation of the experimental results to the nature has a problem of difference in scales in dimension of faults (length and width), parameters in these constitutive relations are of great importance to model the fault behavior. Tullis and Weeks (1986) and Reinen and Weeks (1993) described methods to obtain the specific values of the parameters by fitting the experimental data for velocity step tests accounting for the elastic deformation of the apparatus. In this study, low slip rate frictional experiments have been performed using serpentine mud from South Chamorro Seamount (ODP Leg 195 Site 1200) on the Mariana forearc. The data for velocity steps have been fit using slowness law to obtain the specific values of the parameters. XRD analysis reveals that the fine grained fraction of serpentine mud is mainly consisted of chrysotile.

Several studies on metamorphic rocks found at serpentine seamounts (Maekawa et al., 1992, 1993, Shipboard Scientific Party, 2001) reveal that the origin of serpentine seamounts is deeper than 16 to 20 km. Takahashi et al. (1998) analyzed seismic wave velocity structure beneath the Izu-Bonin arc and showed that P wave velocity of the upper mantle reduced towards the trench due to serpentinization. This result implies that the origin of serpentine seamounts is 25 to 30 km deep. So the mechanical behavior of chrysotile-rich serpentine mud is important to model the constitutive relation of plate boundary, because the frictional coefficient of chrysotile is very low (around 0.2) and the deformation may concentrate in the chrysotile-rich portion.

In this work, the sample was disaggregated with adding distilled water not to crush the coarse grains, nor to make asbestos dust. In this process, large amount of fibrous material (chrysotile) came out of serpentine mud. The fine fraction was sifted by #150 (106 microns) mesh cloth, but long fiber material formed fur balls and could not pass it although the grain size (diameter of a fiber) was very small. Double shear frictional experiments were performed using a high temperature biaxial frictional apparatus at Kyoto University. Velocity step tests were performed and the raw data were fit by least square method using numerical simulation with slowness law.

The absolute value of frictional coefficient is around 0.2 which is very low and consistent with frictional experiments of pure chrysotile (Moore et al., 1997). A peak on a velocity step disappears in the velocity steps between 0.0154 micron/s and 0.1554 micron/s as reported by Reinen et al. (1994). At high slip rate (between 15.54 micron/s and 155.54 micron/s),  $b$  becomes very large.  $a-b$  is positive at slip rates less than 1  $\mu\text{m/s}$  and becomes negative at slip rate higher than 10 micron/s.  $dc$  values can not be defined at slip rate less than 0.1 micron /s, and increase with increasing slip rates at the higher slip rates. The negative  $a-b$  can not be explained by 2 mechanism model (Reinen et al. 1994). The conversion rate at Mariana subduction zone is about 9 cm/year, which is equal to  $2.85\text{e-}3$  micron/s. Considering the difference in scale of width of deformation, corresponding slip rate must be much lower. If  $a-b$  value remains positive at lower slip rate than in the experiments reported here, it is consistent with the aseismicity of the Mariana subduction zone.