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Effects of pore pressure changes on frictional behaviors of talc

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Since the discovery of low frequency earthquake, several classes of physical mechanisms have been proposed to explain this events. Several models and geophysical observations have suggested that the overpressurized fluid along the subducting plate interface have an important role in triggering such events. In addition, the existence of hydrous minerals along the plate boundary at fore-arc wedge may also be important for the seismogenic properties of the slab-mantle interface. Especially, serpentine minerals are generally expected to be the main hydrous mineral present in the fore-arc minerals, and the existence of serpentine in the wedge mantle has suggested by seismological studies. However, talc may also be important in fault mechanism at the plate boundary in the fore-arc wedge mantle, because slab-derived fluids are likely to lead replacement of serpentine by talc at the slab-mantle interface in the fore-arc wedge mantle, and talc is one of the weakest minerals that constitute natural fault zones. However the quantitative influences of pore pressure on the frictional properties of talc are not well constrained. We conducted friction experiments using pre-cut samples of talc with controlling pore pressure P_p and confining pressure P_c adopting several kinds of stress paths during an experiment.

Cylindrical samples of talc (Gvangjsih, China), 20 mm in diameter, were cut at an angle of 30^o to the sample axis. The sliding surfaces were ground with carborundum (#400). A small hole (3 mm in diameter) through the center of each piece ensured adequate communication of the water between the precut surfaces with the rest of the pore pressure system. The specimen was loaded by a triaxial apparatus and sheared under an axial displacement rate of 1 μm/s. We used water as a pore fluid. All measurements were performed at room temperature. Experiments were conducted under several paths of P_c (up to 110 MPa) and P_p (up to 100 MPa). During steady axial loading, either P_c or P_p was changed stepwise.

The stepwise changes of effective normal stress σ (= σ_t - P_p, where σ_t is total normal stress) resulted in a linear elastic response of shear stress followed by a transient evolution of friction. In the case that σ was decreased, friction coefficient μ was temporally increased and then decreased back to steady state, and the normalized transient change of μ to the logarithm of normalized amplitude of σ change ranged from 0.2 to 0.28, which is comparable to that for quartz and Westerly granite reported by previous studies (Linker and Dieterich, *J. Geophys. Res.*, 1992; Hong and Marone, *Geochem. Geophys. Geosyst.*, 2005). While in the case that σ was increased (μ was temporally decreased then increased), the values were smaller (less than 0.12, and negative in some cases), which means that a transient change of μ was less dependent on a change of σ than that for quartz and granite, which may reflect ductile deformation of contacts on fault surfaces during the evolutional transition.

This frictional property might cause slow slip phenomena. After an initiation of a fault slip, possibly triggered by an increase of pore pressure, partially undrained conditions on the slip surface may cause dilatancy hardening, and therefore σ may be increased during the slip. The results of this study suggest that, in the case that a fault plane is covered by talc, the temporal decrease of μ following an increase of σ might be smaller than the case that fault planes are covered by other ordinary minerals. Consequently, a frictional resistance might act more effectively than faults covered by other ordinary minerals and an acceleration of fault slip rate might be mitigated, and therefore a slip rate might be smaller than regular earthquakes.

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Keywords: talc, friction experiment, pore pressure, low frequency earthquake