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Laboratory experiments on physical and rheological properties of fault zone materials: Strength and slip behavior

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Fault zones are formed from fault materials of which properties are different from those of the rocks distributed around the fault zones. In order to evaluate the physical process in the fault zones and seismogenic process, firstly we need to understand the physical and rheological properties of fault materials under the high-pressure and high-temperature conditions. Although its importance is well recognized, only limited amounts of data on the deformation process and the physical properties of fault materials are available. We focus on the strength and slip properties of fault materials measured under the high-temperature and high-pressure conditions.

We carried out a series of systematic experiments on time-dependent rock strength. For comparison, failure strengths of homogeneous granite have been measured under various conditions of strain rate and confining pressure both in the dry and wet states. The strain rate varied from 10^-4 to 10^-7 /s and effective confining pressures from 0 to 200 MPa. The failure strength decreased linearly as the logarithm of the strain rate decreased. The strain rate dependence of the failure strength is increased at higher confining pressures. The strain rate effect is more apparent on the failure strengths of wet samples than dry samples in lower confining pressure ranges. Because the physico-chemical effect seems to play an important role, the weakening of the fracture strength may be greater, especially at greater depth and in fault zones, than current strength model of the lithosphere.

Then, in order to test the effects of heterogeneity of the fault zone rocks, mylonite samples taken from the exposed brittle-ductile transition zone are also tested under the confining pressure of 50 MPa and temperatures up to 500C. Mylonite samples showed the similar deformation curves to those of granitic rocks. However, compared with the granite data, the peak shear stress needed to cause the fracture/sliding along the foliation structure is smaller. The foliation structure of mylonite rocks dramatically affects the value of the peak shear stress. The shear stress values that initiate the fault movement along the fault surfaces may be small under the high-pressure and high-temperature conditions in the seismogenic region.

Laboratory experimental data on physical and rheological properties of fault materials provide useful information on the fault zone rheology.