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Frictional behavior of fault surface and elastic-wave velocity measurements at high-pressure and high-temperature conditions

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Fault zones are formed from fault rocks with properties different from those of the rocks distributed around the fault zones. In order to understand the slip and flow processes in and below the seismogenic region, we need to understand the physical and rheological properties of fault zone materials under 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. Laboratory experimental data on physical and rheological properties of fault zone materials provide useful information on the fault zone rheology.

We carried out a series of conventional triaxial compression tests of mylonite at constant displacement rate. The strain rate of deformation was 5.5x10-6 s-1;the temperature was raised at a rate of 10 C/min for all experiments. We analyzed the stress-strain relation and the frictional behavior of the fault surface formed in the tests. Mylonite samples taken from an exposed brittle-ductile transition zone, the Hatagawa fault zone, northeast Japan, are tested under the confining pressure up to 200 MPa and temperatures up to 800C both in the dry and wet conditions. In the wet conditions, pore water pressure was applied up to 70 MPa. The sample shape was a cylinder of 16.0 mm diameter and 40.0 mm length. The sample axis of the mylonite samples was 30 degrees from the orientation of the foliation structure of the mylonite block.

Under the dry condition of 200 MPa confining pressure at 800C, samples show the ductile behavior. The yield stress of mylonite sample is much smaller than that of granite sample under the same condition. The internal structure of fault rocks such as foliation structure may significantly affect the deformation process under the high-pressure and high-temperature regime. Even under the same effective confining pressure, presence of pore water dramatically reduces the peak shear stress at the temperature regime higher than 600C. Frictional properties of fault surface formed during the deformation tests are investigated. In the dry conditions, stick-slip behaviors were observed at the room temperature and 200C. For the temperature range up to 600C, frictional forces are almost same level. In the wet condition, we didn't observe stick-slip behavior for all temperature ranges. The frictional force decreased as the temperature increased. Fluid such as water in the deep crust may play an important role in deformation process.

We are developing the method to measure the velocity of the compressional wave (Vp) of fault materials with the gas-medium high-pressure and high-temperature apparatus at AIST.