The effects of water on the shear failure of intact rock

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In order to model the rheology of the crust in brittle and brittle-plastic transition regime, it is crucial to elucidate the effects of water on the shear failure of intact rock. We have conducted a series of shear fracture experiments for dry and wet intact granites in seismogenic environments at the strain rates from 10^(-5) to 10^(-7) /s. The average porosity, and density of the Tsukuba granite are estimated to be 0.9 %, and 2.65 g/cm^3, respectively. Cylindrical test specimens (length = 40 mm, diameter = 16 mm) were cored in the same direction from the sampled block, to an accuracy of within 0.02 mm. All experiments have been conducted in a triaxial pressure apparatus at the Earthquake Research Institutive, University of Tokyo.

Based on the experimental results conducted at a strain rate of 10^(-5) /s, we successfully evaluated the dependence of constitutive law parameters prescribing the slip-dependent law on temperature and effective normal stress in a quantitative manner. The peak shear strength increases linearly with increasing effective normal stress below 300C for dry and wet conditions. The internal frictional coefficient tested at dry is slightly larger than that at wet. Above 300C, the increase in the rate of peak shear strength against the effective normal stress (internal frictional coefficient) becomes small. The reduction in the internal frictional coefficient at wet is significantly larger than that at dry, and the internal frictional coefficient of dry sample slightly decrease above 300 C. The difference in the internal frictional coefficient between wet and dry samples suggests that the weakening effect of water on the peak shear strength is enhanced above 300C.

Whether a portion of a fault zone breaks down stably or unstably depends on the relationship between crustal stiffness at that portion and the maximum slip-weakening rate. Hence, the maximum slip-weakening rate is a crucial parameter for determining the instability or stability of the breakdown process. The maximum slip-weakening rate below 300C does not show the clear discrepancy between dry and wet samples within the experimental error. On the other hand, above 300C, the maximum slip-weakening rate for wet sample largely decreases by comparison with dry one, which indicates that the stability of the breakdown process is more enhanced under wet conditions than dry conditions.

The effect of strain rate on shear failure process was investigated by experiments conducted at strain rates ranging from 10^(-5) /s to 10^(-7) /s below 300C. It was found that the peak shear strength logarithmically becomes small with decreasing strain rate for dry and wet samples. This character is similar to the results observed in previous experimental researches under dry and room temperature conditions. The dependence of the peak shear strength on strain rate, however, is stronger under hydrothermal conditions than that under dry and room temperature conditions. This difference is supposed to be due to the enhancement of the bond-breaking reactions induced by pore water pressure or elevated temperature. Since the effects of water on shear failure will be enhanced at slow strain rates and elevated temperatures, we need to elucidate the mechanism controlling the effect of water on the shear failure in terms of quantitative way.