G061-006 Room: C409 Time: May 29 10:45-11:00

Experimental study of the shear failure process of rock in seismogenic environments

Aitaro Kato[1], Shingo Yoshida[1], Hiromine Mochizuki[2], Mitiyasu Ohnaka[3]

[1] ERI, Univ. Tokyo, [2] Earthquake Research Institute University of Tokyo, [3] ERI, Univ. of Tokyo

There is commanding evidence that the earthquake rupture process combines frictional slip failure on a pre-existing fault with fracturing of intact rock. It is thus crucial to investigate the constitutive properties concerning the fracturing of intact rock in seismogenic environments as well as slip failure on pre-existing surfaces. In order to investigate the constitutive properties of intact granite in simulated seismogenic environments, we have conducted a series of fracture experiments using a triaxial apparatus which enable us to independently control the rate of loading piston, temperature, confining pressure, and interstitial pore water pressure in seismogenic environments. Tsukuba-intact granite (length=40mm, diameter=16mm) was deformed under temperature-pressure conditions that simulate crustal depth down to 17 km at various strain rates ranging from 10^(-5) /s to 10^(-7) /s (the slip velocity ranges from 10^(-4) mm/s to 10^(-6) mm/s).

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. It was found that the critical slip displacement Dc for intact Tsukuba-granite remains almost constant below 300C while Dc increases with increasing temperature above 300C, and the increasing rate of Dc against temperature tends to be large at higher effective normal stress. The breakdown stress drop for intact granite is roughly constant (80 MPa) below 300C, while it decreases linearly with temperature. The reduction rate of breakdown stress drop against temperature becomes large at higher effective normal stress. Although the peak shear strength increases linearly with increasing effective normal stress below 300C, the increase in the rate of peak shear strength against the effective normal stress (internal frictional coefficient) becomes small above 300C. These variations of constitutive law parameters are consistent with the microscopic observation that the mechanical behavior of Tsukuba-granite in the temperature range above 300C is mainly brittle and slightly plastic at a strain rate of 10^(-5) /s. The plastic deformation in shear zone is attributed to thermally activated processes such as dislocation glide of bioite and quartz grains.

After clarifying how constitutive properties depend on temperature and effective normal stress, the effect of slip velocity on constitutive properties was investigated by experiments conducted in wet seismogenic environments at strain rates ranging from 10^(-5) /s to 10^(-7) /s (the slip velocity ranges from 10^(-4) mm/s to 10^(-6) mm/s). It was found that the peak shear strength logarithmically diminishes with decreasing slip velocity, and shows similar results under dry conditions observed in previous studies. Both Dc and breakdown stress drop also decrease logarithmically with decreasing slip velocity. It was found that the effect of slip velocity on constitutive properties is not greatly significant and is barely affected by temperature and effective normal stress in seismogenic environments.

As a whole, it was revealed that the stability of shear failure is enhanced by the increase of temperature, effective normal stress, and slip velocity above 300C. The effect of slip velocity on the stability is not strong by comparison with the effect of temperature and effective normal stress on the stability. The increase in stability above 300C is probably one of mechanisms that govern the lower limit of seismicity in the crust, and one of the factors that prevent a slow slip event from becoming a catastrophic rupture.