Thermal pressurization and strength reduction of a fault : an example of Hanaore Fault

Hiroyuki Noda[1], Toshihiko Shimamoto[2]

[1] Earth and Planetary Sci., Kyoto Univ, [2] Dept. of Geol. & Mineral., Graduate School of Science, Kyoto Univ.

During an earthquake, excess pore pressure generated by frictional heating may cause strength reduction of a fault with presence of water. As permeability varies by orders depending on lithology and effective pressure, permeability of deformation zone and the surrounding is one of the most important physical properties to estimate how large strength reduction is caused by this process. In this work, permeability of natural fault gouge of Hanaore fault in Central Japan was measured. The samples were picked up from an outcrop located in Tochudani area, west of Imazu. In this area trench surveies have been carried out by Togo et al. (1997) and Yoshioka et al. (1998), and they estimated that the right-rateral displacement of 2-5 meters had occurred during the last event. The basement is mixed rock facies of Mukugawa Comprex, one of the Sedimentary comprexes of Tamba Terrane, which is a Jurassic accretionary complex. The mixed rock has lenticular blocks of sandstone and chart embeded in dark gray - black mudstone matrix which has a strong cleavage.

A straight layer of black clayey fault gouge (less than 5cm thick) is found in the outcrop. Deformation was localized here. And there is a gray fine-grained zone (about 1m) on the east side of it. In this zone, thin layers of localized deformation were found through microscope. On the east side of this zone, fractured host rock is exposed.

We measured Permeability using a gas rig of Kyoto University, and a pore pressure oscillation method, with nitrogen gas as a pore fluid and pore pressure of 20MPa. Permeability of black clayey fault gouge ranges 1.9*10^-19 - 6.1*10^-18[m^2] at 80MPa of effective pressure, 1.4*10^-20 - 3.5*10^-20[m^2] at 180 MPa. Permeability of samples from the gray fine grained zone ranges 7.1*10^-19-3.4*10^ - 18[m^2] at 80MPa and 9.3*10^-20-6.2*10^ - 19[m^2] at 180MPa. A sample with the lowest permeability in this zone has a thin layer of localized deformation. Permeability of fractured host rock ranges 3.8*10^-17 - 6.2*10^-17[m^2] at 80MPa, and 1.5*10^-18 - 1.8*10^-18[m^2] at 180MPa. Using these permeability data, strength reduction of a fault and temperature rise due to thermalpressurization of pore fluid were calculated. In the calculation a mathematical model of Mase and Smith (1987) and finite differences method were used. We chose the permeability structure that permeability changed uncontinuously between deformation zone and the surrounding. From the result of calculation under a condition of 5km depth with a deformation zone of 5cm thick, when the displacement reaches 1m, strength of a fault decay to several percent of the initial value and temperature rise reaches 50-60K.

The weakening distance of a fault, Dc, is one of the important parameter in a field of seismology. From frictional experiments in laboratory Dc ranges from tens to hundreds of micro meter, while Dc from analysises of seimic wave ranges from tens of sentimeters to around one meter. This several orders of difference have been a problem for a long time. From the result of calculation in this work, Dc ranges about one meter, which agrees with Dc from analysises of seimic wave very well.