Permeability measurements and precipitation sealing of basalt in an ancient exhumed subduction-zone fault

Aitaro Kato[1], Arito Sakaguchi[2], Shingo Yoshida[3], Hiromine Mochizuki[4], Yoshiyuki Kaneda[5]

[1] IFREE, JAMSTEC and ERI, Univ. Tokyo, [2] JAMSTEC, [3] ERI, Univ. Tokyo, [4] Earthquake Research Institute University of Tokyo, [5] JAMSTEC,Frontier,IFREE

The Nankai Trough region is considered as the candidate site for the drilling program into the seismogenic zone. As preliminary study for the drilling program, we have conducted a series of permeability measurements and shear failure experiments of alternated basalt sampled at the exhumed ancient fault zone in the Cretaceous Shimanto accretionary complex in Japan. This study aims to investigate the permeability structure and the evolution after the shear failure. The investigation of the transporting properties in subduction zone fault is an important issue in the study of the understanding the shear strength and slip-stability or instability of the subduction zone fault.

The alternated basalt is located in the shear zone between the sandstone-dominant coherent unit of the Nonokawa Formation and the Okitsu Melange, and includes the mineral vein networks composed of ankerite, quartz, chlorite, calcite etc. Thermal conditions around this area, which have been measured by the vitrinite reflectance, reveals that the maximum temperature in the past ranged up to 230 C on average. The average porosity, and density of the basalt are estimated to be 0.1 %, and 2.73 g/cm^3 respectively. Cylindrical test specimens (length = 40 mm, diameter = 20 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. The permeability has been evaluated by the transient pulse method.

The permeability of the basalt showed the strong reduction against increase in effective confining pressure and temperature. The pressure-sensitivity of permeability ranges from 0.01 to 0.028 within the measured effective confining pressures at room temperatures. After measuring the permeability, the shear failure experiments have been conducted under the conditions (Confining pressure:Pc, Pore water pressure:Pp, Temperature:T) = (140 MPa, 105 MPa, 250 C or room temperature). The peak value of the differential axial stress for each sample ranges from 280 MPa to 450 MPa at the strain rates of 10^(-5) /s. The shear failure experiment was finished, then, the shear load was unloaded from the specimen and kept under the conditions (Pc, Pp, T) = (140 MPa, 105 MPa, 250 C or room temperature) for the permeability evolution measurement. It was found that the rapid sealing at elevated temperature (250 C) occurred during the hold experiments after the shear failure (The permeability reduction is approximately 2 ~ 3 orders over about 50-hour). Conversely, the permeability at room temperature has an almost constant value against hold time, or shows the slight decrease. It is thus found that the permeability reduction at higher temperature is more significant than that at lower temperature. The present study suggests that the permeability of the subduction megathrust fault would rapidly decrease due to the precipitating clay-like minerals and other minerals, and shows the potential of high fluid pressure in the fault zone.