G007-009 Room: C409 Time: May 30 11:27-11:39

Permeability and pore structures of fault rocks in a granite body

Ichiko Shimizu[1], Celia Tiemi Onishi[2], Shin-ichi Uehara[3], Kazuo Mizoguchi[3], Toshihiko Shimamoto[4]

[1] Geological Inst., Univ. Tokyo, [2] TGC-JNC, [3] Earth and Planetary Sci., Kyoto Univ, [4] Dept. of Geol. & Mineral., Graduate School of Science, Kyoto Univ.

The relation between porosity, pore structures and permeability were investigated, using drill core samples of the Toki Granite in Gifu Prefecture. The core samples used for the microstructural analysis and permeability measurements were taken from a borehole penetrating a reverse fault of the Tsukiyoshi Fault at the depth of 1000 m. The Toki Granite suffered various degrees of cataclasis and alteration by hydrothermal activities, from the country rocks of fresh biotite granite to foliated cataclasite at the center of the fault zone. In the vicinity of the fault zone, most quartz and feldsper are cut by microcracks and calcite veins. The central part of the Tsukiyoshi Fault is constitute of foliated ultra-cataclasite with fine grained matrix, and are injected by numerous veins related with hydrothermal activity. Microstructural observation indicates that grain size reduction in the matrix is due to fragmentation of crystals. Chlorite and clay minerals were identified by XRD analysis.

The permeability in rocks is considered to be governed by topology and connectivity of pores. In fault zones where brittle deformation dominates, width and connectivity of cracks is most important factor to control the fluid permeability. The effective porosity of bulk samples measured by a Helium pycnometer varies from 0.54% for an unaltered country rock to over 5.4% for a foliated cataclasite at the central part of the fault zone. The pore structures in the granite samples were visualized by a method assisted by a confocal Laser Scanning Microscope (LSM). The samples were impregnated with low viscosity (1.5 mPa) fluorescent resin under vacuum, and then observed by a LSM. Pores (microcracks) were mainly observed as open grain boundaries, but intracrystalline fractures were also visible for plagioclase and biotite. The SEM observation confirms the existence of intergranular open fractures along grain boundaries. The crack density under the microscope increases towards the fault zone.

Permeability measurements were performed by a HPT gas apparatus developed by one of the author (T. Shimamoto). The samples were cut to cylindrical shape with diameter of 20-25 mm and the length of 10-40 mm. All experiments were done under room temperature with Nitrogen gas as a pore fluid. Confining pressure Pc was increased and then decreased in the range of 10 - 200 MPa. The flow method was used in the low Pc range (up to 10 MPa), whereas the oscillating pore pressure method (Kranz et al., 1990; Fisher & Paterson, 1992) was used in the higher Pc range, with pore pressure kept around 20 MPa.

In all experimental runs, permeability was decreased with increasing effective pressure and came close to steady values at the highest Pc (=200 MPa). Permeability increased again in the reversed paths, but was not completely rebound to the initial values during increasing Pc. For a fresh country rocks of granite, permeability is about 10^{-15} m^2 at the initial confining pressure (Pc=105MPa), and is gradually decreased to 10^{-18} m^2 at the highest Pc. Permeability of cataclastic granite is, however, about one order of magnitude lower than that of fresh granite. This may be due to the reduction in crack width by granulation and by crack sealing in hydrothermal activity. The permeability of nitrogen gas was lower in the direction parallel to the fault zone than the vertical direction. It is possible that the aspect ratio of cracks parallel to the fault was larger and thus are more easily closed when confining pressure was increased.