Japan Geoscience Union Meeting 2010
(May 23-28 2010 at Makuhari, Chiba, Japan)

SIT037-P15 会場:コンベンションホール 時間: 5月26日17:15-18:45

熱水流通実験による鉱物析出にともなう透水率変化

The change of permeability in the rocks during mineral precipitation by hydrothermal flow-through experiments

最首 花恵[1*], 岡本 敦[1], 土屋 範芳[1]

Hanae Saishu[1*], Atsushi Okamoto[1], Noriyoshi Tsuchiya[1]

[1]東北大学大学院環境科学研究科

[1]Tohoku university

Fractures (faults) play as dominant fluid pathways in the upper crusts, and they are commonly sealed by minerals, such as quartz veins. Thus, the knowledge of dissolution and precipitation processes of minerals in fractures is important for constraining the temporal and spatial variations in rock permeability and strength. Various geophysical observations suggested the role of fluids on generation of earthquakes (e.g., Abe and Sakai, 1999; Obara et al. 2004; Kitagawa et al. 2002); however, the detailed mechanism of fracture sealing is still unclear. Fault-valve behavior was proposed as a mechanism which occurs by highly permeable channel ways of faults and causes abrupt fluctuations in fluid pressure linked to the earthquake system (Sibson, 1990).
In this study, we conducted the hydrothermal flow-through experiments to understand evolution of permeability during mineral precipitation in the porous media. The reaction vessel has the double internal structure. The quartz sand (grain size = 0.8-1.5mm, porosity = 53-56 %) was set within the main flow path inside the inner tube, and quartz precipitated from Si-saturated solutions at 430 C and 32 MPa. The outer tube was filled with static solutions connected with the flow path, which realized the same pressures between the inside and outside of the inner tube. The input solutions were prepared by dissolution of granite sand in the distilled water at 360 C and 32 MPa. The Si concentrations of input solutions were 380-450 ppm (the saturation index was 3-4). Upstream and downstream pressures and the fluid flux from the outlet were monitored for each minute, and permeability was calculated from Darcy's Law. The experiments were stopped when the upstream pressure raised to the limit of the high pressure pump (50 MPa).
We carried out two experiments with different flow rates, v = 0.25 g/min (Exp-0.25) and 1.0 g/min (Exp-1.0). The upstream pressure raised to 50 MPa after 114 hours in Exp-1.0 and 10 hours in Exp-0.25, respectively. For these experiments, the total amounts of quartz precipitates were 1.1 g and 0.33 g, which corresponds to the porosity decrease of 9 % and 6 %, respectively. The significant increase in pressure differences (28 MPa) with small changes in the porosity indicates that precipitation of silica minerals was localized along the flow path, and this localization was more evident in the experiments with high flow rate (Exp-1.0).
The sealing process was divided into three stages. Stage 1 showed a nearly constant permeability, whereas permeability decreased with different rates at stages 2 and 3. During stages 2 and 3, the permeability decreased in two orders; from 3.7×10^{-12} to $3.6 \times 10^{-14} m^2$ (10.5 hours) in Exp-0.25 and from 1.4×10^{-11} to $1.2 \times 10^{-13} m^2$ (1.5 hours) in Exp-1.0, respectively. Because the flow rate was constant, the decrease in permeability mainly reflected the increase in the upstream pressure and the slight decrease in the downstream pressure.
In both experiments, permeability did not decreased monotonously, but a characteristic oscillation

of permeability was clearly observed only at stage 2. The frequency of this oscillation was 8.3 x 10^{-4}Hz and 3.3 x 10^{-3}Hz in Exp-0.25 and Exp-1.0, respectively, and caused by periodic oscillation of the pressure difference. Also, this oscillation was different from the noise due to the experimental apparatus, which showed the frequency 3-5 times larger than that of the oscillation. The cause of this characteristic oscillation is not clear, but one possibility is the elastic deformation of inner tube or deformation of quartz sands. The permeability changes during sealing probably depends on the kinetics of mineral precipitation, fluid flow and deformation of the host rocks, and thus our observation in the analogue experiments would be comparable to the fault-valve model during fracture sealing in the crustal conditions.

キーワード:浸透率,シリカ鉱物析出,熱水流通実験,き裂閉塞,地震

Keywords: permeability, precipitation of silica minerals, hydrothermal flow-through experiment, fracture sealing, earthquake