SCG60-14 会場:201A 時間:5 月 25 日 15:45-16:00

シリカ溶解・析出によるき裂閉塞と透水率変化
Fracture sealing and permeability change induced by silica dissolution and precipitation

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Solubility of silica significantly varies with depth within the crust; therefore, dissolution and precipitation of silica minerals control the hydrological properties of the crust (Saishu et al., 2014), and may affect earthquake cycles (Audet and Burgmann, 2014). However, permeability is usually measured as a static property of a rock, and it is unclear how porosity structure of a fracture and permeability changes during dissolution or precipitation of minerals (i.e., silica); especially the effects of saturation index and effective confining pressure. In this study we conducted two-types of the hydrothermal experiments; (1) silica precipitation in porous media and (2) dissolution of granite with a fracture. For both experiments, we used novel flow-through reactors with tube-in-tube vessel, which make possible, after the experiments, to analyze porosity structure by micro X-ray CT (revolution is 10 micron/boxel).

The silica precipitation experiments were conducted under the supercritical (420 degreeC, 30 MPa) and vapor conditions (380 degreeC, 20 MPa). The inner tube of the precipitation vessel (4 mm diameter, ~200 mm long) was filled with alumina balls (1 mm diameter). The input solution was made by dissolution of granite + quartz sands under liquid conditions, and thus, high supersaturated solutions were brought into the precipitation vessel. In both conditions, nucleation of silica minerals occurred but showed the contrasting porosity patterns. In the supercritical condition, amorphous silica was surrounded the surfaces of alumina balls and walls, and discrete quartz grains and cristobalite formed within the amorphous silica. In contrast, in the vapor condition, fine-grained quartz crystals were nucleated, and settled on the bottom. As the results, the developed porosity in the supercritical fluids was more tortuous that in the vapor. At the end of the experiments under the supercritical condition, the oscillation of upstream fluid pressure (and thus permeability) was observed; such an oscillation was probably caused by repeated sealing and break of the bottleneck of the pore network.

In the granite dissolution experiments, the granite core (Aji granite, 8 mm diameter, 45 mm long) with a tensile fracture was input into the inner SUS jacket with 0.1 mm thick. The P-T condition for the dissolution was 350 degreeC and 25 MPa, under the effective confining pressure of 0 ? 15 MPa. The X-ray CT images revealed that (1) quartz was preferentially dissolved to form the convex surfaces, whereas that (2) mean fracture aperture decreased with time. The decrease in the mean aperture was consistent with the decrease in permeability from 10^{-13} to 10-15 m^2 during experiments. According to the solution chemistries, feldspars (Pl + Kfs) dissolution also occurred, which volume was about one-third of that of quartz. The dissolution of feldspars at the contact regions (pressure solution) is critical for the permeability decrease in the granite fracture under confining pressure.

References

Saishu, H., Okamoto, A., Tsuchiya, N., 2014. Terra Nova, 26, 253-259.
Audet, P., Burgmann, R., 2014. Nature, 510, 389.

キーワード: シリカ, 花崗岩, 溶解・析出, 間隙構造, X 線 CT, 透水率
Keywords: silica, granite, dissolution/precipitation, porosity structure, X-ray CT, permeability