Structure of pores in a fracture under pressure

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Aqueous fluids must play important roles in crustal dynamics including seismic activity. Geophysical mapping of fluids is critical for understanding crustal processes. Interpretation of geophysical observations requires a thorough understanding of the pore structure that governs physical properties of rocks under high pressure. There should be cracks with various sizes in the crust: from grain boundary to large faults. Since crack surfaces have rough surfaces, the contact of asperities splits a crack into small segments under pressure. Some segments with large aspect ratios remain open under pressure to form an interconnected path for electrical conduction and fluid flow. In order to understand the pore structure in a cm-scale fracture under pressure, we measured elastic wave velocity and electrical conductivity in a brine-saturated fractured granitic rock and observed the microstructure of fracture through X-ray CT.

A cylindrical rock sample (D = 26 mm, L = 30 mm) with a single fracture was cored from a block (20 cm × 20 cm ×20 cm) of Aji granite (Kagawa Pref., Japan), which was artificially fractured. The fracture goes through a sample from the top to bottom. A shear displacement was made along the fracture surface by placing stainless steel plates at the ends. The pore fluid was 0.1 mol/L KCl aqueous solution and its pressure was kept at atmospheric pressure. Compressional wave velocity and electrical conductivity were measured in a pressure vessel. Compressional wave velocity was measured in the direction perpendicular to the fracture, while conductivity in the axial direction.

Compared with an intact sample, the fractured sample shows significantly lower velocity and remarkably higher conductivity at atmospheric pressure. A larger shear displacement makes larger differences in velocity and conductivity. As the confining pressure was increased, velocity increases and conductivity decreases, reflecting the closure of fracture under pressure. A sample with a larger displacement shows lower velocity and higher conductivity. The shear displacement increases the pore space that remains open under pressure. The analysis of X-ray CT images also shows that the shear displacement increases the average aperture at atmospheric pressure. Electrical conductivity can be calculated based on the constructed 3D images of fracture. In this presentation, the comparison between measured and calculated conductivities will be also reported.

Keywords: Fracture, Structure of pores, Electrical conductivity, Elastic wave velocity

