Experimental measurements of transport pore radius of thermally cracked granite and the relationship of pore structure to permeability

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Fluid flow in rocks plays a key role in many geological processes such as geothermal reservoirs. Permeability is known to be dependent on porosity and pore radius (Walsh and Brace, 1984), while direct determination of pore radius is usually more difficult than determination of permeability. Water expulsion method (Yokoyama and Takeuchi, 2009) is a way to determine the radius of transport pore from gas pressure at which gas breaks through a water-saturated sample (ΔP_{break}). Although several previous studies investigated the relationship between permeability and ΔP_{break} of impermeable rock such as mudstone, those of granite have not been reported. In this study, we develop the water expulsion method under confining pressure and aim to evaluate the relationship between permeability and pore characteristics such as porosity and transport pore radius under high pressure up to 30 MPa.

Thermally-cracked Aji granites were prepared to cylindrical shape (20 mm long and 20 mm in diameter). Thermal cracking was introduced by heating up to 600 ℃ and porosity of a heat-treated sample was about 2.4 % . The transport pore radius was determined by a manner similar to those reported in Yokoyama and Takeuchi (2009), which is an experimental method measuring gas pressure ΔP_{break} (Pa) at which gas breaks through a water-saturated sample. From ΔP_{break} and interfacial tension γ (N m^{-1}), transport pore radius r (m) can be estimated as follows: $r = 2\gamma / \Delta P_{break}$. Permeability was determined from the flow rate at a constant pore pressure (P_p = 0.5 - 3 MPa). The flow rate was measured by a flow method using water as a pore fluid and permeability was calculated following Darcy's law. Porosity was estimated using the gas porosimeter, where the grain volume and pore volume of a sample were determined by using Boyle's law. Experiments were performed under confining pressure ranging 5 to 30 MPa at room temperature.

Transport pore radius and permeability of thermally-cracked Aji granite were 0.74 μm and 5.5×10^{-17} m^2 under confining pressure of 5 MPa. These values decreased with increase in confining pressure and were 0.14 μm and 2.0×10^{-18} m^2 under confining pressure of 30 MPa. Permeability k (m^2) of granite can be approximated by pore radius r and porosity ϕ according to the relation: $k = 5.32\times10^{-3}\phi r^2$. This indicates that permeability is primarily dependent on transport pore radius. These results are consistent with the conventional permeability model (Simpson et al., 2003) and estimation of transport pore radius is important for understanding permeability of granite.

Keywords: permeability, transport pore radius, water expulsion method

