Mechanical and hydrological properties of granite under supercritical fluid conditions

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To extract geothermal energy effectively and safely from magma and/or adjacent hot rock, we need to tackle many issues which require new technology development. One of them we are targeting on is to develop a technology to mitigate induced-earthquakes. It is required to understand roles of factors on occurrences of the induced-earthquake (e.g., strength, crack density, and fluid-rock reaction) and their intercorrelations (e.g., *Asanuma* et al., 2012).

Our purpose of this series of experiments is to clarify a relationship between the rock strength and the fracture density under hydrothermally supercritical conditions. We conducted triaxial deformation test on intact granite rock strength under high-temperature (250 –750˚C), high-pressure (104 MPa) condition at a constant load velocity (0.1 μm/sec) using a gas-rig at GSJ, AIST. We used Oshima granite, which has initially ~0.55% of the porosity, 4.95±1.01 km/s in Vp at dry condition (dry). All experimental products showed brittle feature having several oblique fracture surfaces, but both value of peak stress and amount of stress drop became smaller at higher temperature. Additionally, Young's modulus decreases with increasing the temperature from 57.4 GPa at 250˚C to 32.3 GPa at 750˚C. At 400˚C, the stress drop accelerated the deformation with ~98 times faster velocity than that at load-point. In contrast, at 650˚C and 750˚C, the velocity during stress drop kept the same order of the load-point velocity. Therefore, the deformation feature may start to be of ductile when the temperature exceeds 650˚C. The microstructures of samples deformed at 400˚C and 550˚C showed the shear zone with the grain reduction. In contrast, for the samples deformed at 650˚C and 750˚C, we partly observed the sintered structure at grain boundaries among feldspar gouge. The sintered structure at >650°C might be the cause of the slow stress drop. Highly dense cracked granite specimens were formed by a rapid decompression test (RDT) using an autoclave settled at Tohoku University (*Kitamura & Takahashi*, 2017AGU; *Takagi* et al., 2017GRC Trans.), caused by a reduction of the fluid pressure within 2 seconds from vapor/supercritical state pressure (10 –48 MPa, 550 ˚C) to ambient pressure. X-ray CT scanning on the specimens after RDT showed that numerous microcracks were generated in them (see details in *Takahashi & Kitamura*, 2018, annual meeting of Geological Soc. Japan). The RDT imposed the porosity increasing towards 3.91 % and Vp decreasing towards 1.46±0.22 km/s (dry). We conducted the permeability measurement on fractured granites after RDT with the porosity of 2.1 –2.7% under a combined condition of 400 ˚C in temperature, 104 MPa in confining pressure, 39 –99 MPa in pore fluid pressure (P_p). Permeability measured by pore pressure oscillation method decreases from 1.3×10^{-16} m^2 at P_p of 99 MPa to 2.6×10^{-18} m^2 at P_p of 39 MPa for the permeable case. Permeability on fractured granite of 2.1% in porosity at room temperature (RT) show relatively lower permeability than those at 400°C except for at P_p of 99 MPa. Permeability at RT rapidly decreases from 1.0×10^{-15} m^2 at P_p of 99 MPa to 1.0×10^{-18} m^2 at P_p of 84 MPa, and then reaches 5.8×10^{-19} m^2 at P_p of 99 MPa. In the meeting, we will show additional results of permeability tests on fractured granites under various high temperature conditions.

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