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Fracturing of granite under pore pressure and evolution of permeability

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Hot Dry Rock (HDR) geothermal power generation, which is included in Enhanced Geothermal System (EGS) is characterized by making artificial geothermal reservoir and this is different from conventional geothermal power generation. This system does not require natural hot water and steam. In this system, artificial reservoir is made by hydraulic fracturing in the basement due to high-pressure water injection, and water circulates in the system. Evolution of permeability is important factor in reservoir assessment. To assess this type of geothermal system, we measured effect of pore pressure compared with permeability during triaxial deformation experiment.

Aji granite was used as experimental sample, which is dense and fine, consists of mainly plagioclase, quartz, and biotite. Permeability was measured by intra-vessel deformation and fluid-flow apparatus (IVA) at Hiroshima University. Aji granite was saturated water before triaxial deformation experiments. Confining pressure (Pc) was fixed 20 MPa and pore pressure (Pp) was ranged from 0 MPa (undrain condition during triaxial deformation) to 15 MPa by 5 MPa at room temperature in triaxial deformation. The recovered samples after deformation experiments were fixed by resin and observed by polarizing microscopes and scanning electron microscope (SEM).We discussed relation between permeability and pore pressure - fracture strength from triaxial deformation experiments.

In original sample, permeability is $2.0X10^{-19}$ m^2 at Pc = 20 MPa. Permeability of fractured samples increased against that of original samples. Permeability proportionally increased from $2.5X10^{-18}$ m^2 at Pp = 0 MPa to $7.0X10^{-17}$ m^2 at Pp = 15 MPa. Fracture strength decreased with Pp decreased, from 400 MPa at Pp = 0 MPa to 350 MPa at Pp = 15 MPa. In fractured sample, there are macro fracture surface and microcracks.

The increase of permeability depends on pore pressure suggests that increase of microcrack width and acceleration of crack-connection and propagation in large Pp. And fracture strength relates crack sharps. Therefore, crack sharp and distribution are important parameter in assessment of permeability. We plan to further experiments which try to reproduce hydraulic fracture and high temperature condition.

Keywords: granite, pore pressure, permeability