Fundamental study on the changes in mechanical/hydraulic properties of granite fracture during pressurization for the development of supercritical geothermal resources

*Takuya ISHIBASHI[1], Hiroshi Asanuma[1], Satoru Ishikawa[2]

1. Fukushima Renewable Energy Institute, National Institute of Advanced Industrial Science and Technology, 2. Graduate School of Environmental Studies, Tohoku University

Hydraulic stimulation for the geothermal reservoirs is now a well-known operation for enhancing or maintaining the reservoir permeability [*Evans et al.*, 2005; *Häring et al.*, 2008]. In this operation, as a massive amount of pressurized fluid is injected into the targeted reservoir, preexistent fractures undergo slip/shearing and new fractures are also created. As a result of these events, mechanical, hydraulic, and seismic properties of the geothermal reservoir evolve. For the success of developing supercritical geothermal resources, it is essential to precisely understand how mechanical, hydraulic, and seismic characteristics of rock fracture evolve during pressurization (i.e., pore pressure increase), and how these characteristics are linked in each other.

Here, we report the laboratory experiments, where we concurrently monitor the strength, permeability and acoustic emission (AE) of rock fracture during shearing triggered by pressurized water injection. Cylindrical sample of Inada granite (diameter and length are 5 cm and 10 cm), which have a single tensile fracture with rough surfaces, is prepared and is set in the triaxial pressure vessel at Fukushima Renewable Energy Institute, AIST. In this system, we can control the confining pressure (0-40 MPa), axial pressure (0-250 MPa), pore pressure (0-25 MPa), and temperature (20-250℃) independently. In our experiment, we first simulate the critically stressed state of rock fracture, where the normal stress and the shear stress on the fracture are set to 54 MPa and 51 MPa respectively. Then, we gradually increase the pore pressure from 2 MPa to 8 MPa. As soon as the pore pressure reaches to 8 MPa, slow/aseismic slip is first triggered (3 AE events, 3 micron/sec), and then transit to fast slip (29 AE events, 51 micron/sec). Slip distance is 12 microns during aseismic/slow slip, whereas it is 155 microns during fast slip. Due to the self-propped mechanism by surface roughness, fracture permeability is enhanced by ~12 times of the initial permeability before slip/shearing. Interestingly, 57% of the permeability gain is acquired during the slow/aseismic slip, and this fact may suggest the slow/aseismic slip is interpreted as the mixed mode of fracture failure between opening and shearing. Such findings from laboratory experiments are well consistent with those obtained through the meso-scale (over a few hundred meters) experiment of fault re-activation, which is recently reported by *Guglielmi et al.* [2015]. Through the detailed comparison between laboratory and field experimental results, we try to explore the possible links between the hydraulic, mechanical, and seismic characteristics during the hydraulic (pore pressure driven) shearing.

Keywords: deep geothermal resources, permeability, rock fracture/fault, pore pressure, rough surface