Mechanical and Hydraulic Characteristics of a Rock Material under Brittle-Ductile Transition

Sho Takeyama

Abstract

A new concept of Enhanced Geothermal System (EGS), in which geothermal fluids are produced from a fractured reservoir created artificially within an originally semi-brittle or ductile basement, has been proposed. This new geothermal system potentially has a number of advantages including: (a) simpler design and control of the reservoir, (b) nearly full recovery of injected water, (c) sustainable production, (d) lower cost when developed in relatively shallower zones in compression tectonic settings, (e) large potential quantities of energy extraction from widely distributed semi-brittle or ductile zones, (f) the establishment of a universal design/development methodology, and(g) suppression of felt earthquakes from/around the reservoirs. To assess the potential of the new geothermal system, the “Japan Beyond-Brittle Project (JBBP)” has also been recently initiated, and the author have conducted fundamental investigations on mechanical and hydraulic characteristics of the new type of reservoir, in which the rock is first experiences hydraulically and/or thermally induced brittle failure, and then subjected to the temperature and pressure conditions where the rock exhibits semi-brittle or ductile stress-strain behavior at the natural condition. Gypsum aggregate specimens have been used in the present study, because brittle, semi-brittle and ductile stress-stain behaviors of the specimen may be controlled only with confining stress level at the room temperature. At confining stresses up to 40 MPa, tri-axial compression and fluid flow experiments have been conducted on the specimens without and with a fracture. It has been indicated that stress-strain behavior is independent of existence of fracture. Moreover, permeability with fracture is approximately one order of magnitude higher than that without fracture at brittle zone. On the other hand, the difference of permeability is much smaller at a transition zone between semi-brittle and ductile zones. However, permeability with fracture is again one order of magnitude higher than that without fracture at ductile zone.