Japan Geoscience Union Meeting 2015
(May 24th - 28th at Makuhari, Chiba, Japan)

SMP44-P01 Room:Convention Hall Time:May 25 18:15-19:30

Permeable-Impermeable or Elastic-Plastic Transition of Granite

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Recently, geothermal energy is attractive in the fields of developing sustainable energy. Conventionally, geothermal reservoirs have some troubles which are loss of injection water or induced earthquakes because of brittle dynamics zone. On the other hand, creating geothermal reservoir at the temperature-pressure zone of supercritical fluid can resolve these troubles and bring high power-producing potential. However, evaluating flow characteristics such as permeability is very difficult because of ductile dynamics zone from the high temperature-pressure zone.

In this presentation, we reported the temperature-pressure condition which shows dynamically semi-brittle or ductile zone and the flow characteristics in each condition for Inada granite. Firstly, we developed experimental system which can carry out hydraulic test at the selectable environment. Secondly, we set experimental condition to temperature was 350, 380, 400, and 450 ℃, effective confining pressure was 5, 10, 20, 30, 40, 50, 60, 70, 80, and 90 MPa. Pore fluid pressure was controlled 1 or 2 MPa in constant pressure. As a result, we revealed that the rapid decreasing permeability clarified stress dependency of the brittle-ductile (or elastic-plastic) transition was different on each temperature condition. In addition, decreasing permeability rate at the brittle and ductile zone provided a way to predict permeability at various combinations of temperature and pressure.

Keywords: geothermal reservoir, granite, elastic-plastic transition, predicting permeability

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Depth estimation and evaluation of geothermal resource by melt inclusion analysis

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Geothermal power generation in Japan has abundant resources. However it requires long periods of time for survey: the amount and distribution of geothermal resource have been estimated by the volumetric method, and by the reservoir layer evaluation method for narrower region. In this study, melt inclusions in volcanic products were utilized for a faster and simple method for evaluation of geothermal resource. As melt inclusions remain the composition of the magma prior to eruption, they provide thermal-chemical conditions of the magma chamber at depth. To evaluate the depth, distribution and amount of geothermal resource, melt inclusions in quartz was analyzed for Shirasawa caldera,Japan.

Shirasawa caldera is located in west of Sendai city and erupted in late Pliocene. Shirasawa layer is composed of mud and sand deposited on the Old Sendai Lake in center of caldera. The high-temperature region (Low-velocity region) in the Shirasawa caldera at 2˜5 km has been confirmed by seismic reflection survey. [1]

Eight samples were collected from the center of the caldera to the south, and 4 samples were collected from north end in Shirasawa caldera. These are classified into tuff sandstone, tuff breccia and pumice tuff.

Quartz crystals were picked up from the samples, and the crystals were encased in resin flake. The compositions of melts included in quartz crystals were analyzed by electron micro probe analyzer (EPMA) for 10 elements (Si, Ti, Al, Fe, Mn, Mg, Ca, Na, K, P). Three samples from north end of the caldera were not analyzed because the crystals were trace amount and small. The depth of crystallization was estimated from percentage of quartz(Qtz)-albite(Ab)-orthoclase(Or) by CIPW norm calculation (Fig.1). As the eutectic line changes position by pressure and the melt in the quartz crystal is located on the eutectic point of the Ab-Qtz phase diagram, the crystallization pressure was decided from the plot and eutectic line on Qtz-Ab-Or diagram [2].

Eight samples from the center and south part of caldera were classified into low-alkali tholeiitic rhyolite, and 1 sample from caldera north(09) was high- alkali tholeiitic rhyolite. The norm percentage of 44 melt inclusions is Qtz: 30˜43%, Ab: 35˜52%, Or: 9˜26%, and forms a straight line on Qtz-Ab-Or diagram, with the exception of some samples. Crystallization pressure is 0.1˜320 MPa, and most of the samples concentrate on 30˜50 MPa. Certain samples (2305) were plotted in 5˜320MPa. Assuming the density of ryholite magma as 2.0 g/cm^3, the crystallization pressure was estimated to be 16˜1.5 km. It is suggested that magma had assent from about 16 km depth, become a gravitational equilibrium at 1.5˜2.5 km, and subsequently erupted. In the other samples, crystallization depth is concentrated at 1.5˜2.5 km. The depth of magma decided by melt inclusion in quartz is consistent with the high-temperature region observed by seismic reflection. Considering the sample location, Or rich sample considered to be derived from another magma reservoir.

Based on these data, the depth, distribution and amount of geothermal resource associated with the magma chamber will be discussed.

[1] Sato et al. (2002) Earth Planets Space,54,1039-1043.
[2] Blundy and Cashman (2001) Contributions to Mineralogy and Petrology,54,631-650.

Keywords: melt inclusion, Shirasawa caldera

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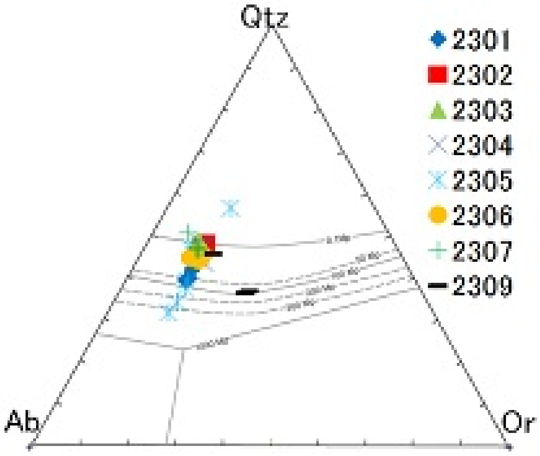

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Porosity structure and permeability reduction by mineral dissolution in a fracture

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Fractures act as dominant fluid pathways within the crust. Fluid usually control transport of energy and heat. Silica solubility generally increases with increasing pore pressure and temperature, and thus dissolution and precipitation of silica would provide significant effects on fracture permeability. Even by dissolution of minerals within a single fracture, dissolution at free (non-contact) areas increases the aperture, whereas dissolution at the contact areas decreases the aperture, therefore it is not clear how fracture permeability evolves by mineral dissolution under confining pressure.

In this study, we conducted the hydrothermal flow-through experiments at 350 ℃, 20~34MPa under confining pressure 10~15MPa to understand the evolution of porosity structure of a fracture and permeability change in granite by mineral dissolution. For this purpose, we developed a novel reactor, which has a inner tube in the vessel. Two types of granite core (Aji granite, ϕ10mm) were used, first one (85mm length) contained a slit with thickness of 0.5mm as parallel prates flow path. The other one contained the tensile fracture with no shear displacement. During the experiments under constant flow rate, we monitored the fluid pressures, and periodically sampled the solutions. After the experiments, we analyzed the porosity structure by X-ray CT (resolution was 10μm/pixel).

In slit-core experiment, the concentrations of Si was 100~120 mg/kg, whereas the concentration of Al, Na, K were 7, 5 and 8 mg/kg respectively, indicating that the ration of dissolved volume of quartz, plagioclase and K-feldspar are 10:2:1. The X-ray CT also revealed that preferential dissolution of quartz, and that the average aperture increases especially near the inlet.

In tensile fracture experiment, fracture permeability decreased continuously from 10^{-13} to 10^{-15} (m^2) during the experiment of 90h. An increase in flow rate did not enhance the reduction whereas that in confining pressure accelerated the permeability reduction. The X-ray CT images revealed the complex structure of porosity: quartz dissolution made the local increase in the aperture, but the overall aperture decreased by dissolution of quartz and feldspar at contact areas, which is responsible the permeability reduction.

Keywords: permeability, fracture, hydrothermal experiment, dissolution

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Natural Analogue of Supercritical Geothermal Reservoir

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To understand the geological properties of a supercritical geothermal reservoir, we investigated a granite?porphyry system as a natural analog. Quartz veins, hydrothermal breccia veins, and glassy veins are present in Neogene granitoids, Tohoku Japan. The glassy veins formed at 500-550 C under lithostatic pressures, and then pressures dropped drastically. The solubility of silica also dropped, and the quartz veins formed under hydrostatic pressures. Connections between the lithostatic and hydro-static
pressure regimes were key to the formation of the hydrothermal breccia veins, and the granite?porphyry system provides useful information for understanding supercritical geothermal reservoirs.

Keywords: Supercritical fluid, Geothermal reservoir, Granite-Porphyry system