Dependency of crack distributions in granite on elastic velocities

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Technologies relating to enhanced geothermal systems (EGS) have recently been developed, such as hot rock geothermal power generation in ductile deformation regime, or supercritical geothermal power generation. In these systems, it is planned to create artificially fractured geothermal reservoirs by injecting water into hot rock mass and cooling it. Properties of crack distributions caused by cooling rocks are still not clear. To estimate non-destructively induced fracture distributions at the EGS development, it should be useful to investigate the relationship between elastic wave transmission properties and properties of crack distribution in rock.

In this study, we generate cracks in granite specimens by heating them up to 550℃ or 650℃ then rapidly cooling with ice water, and we clarified the relationship among the crack distribution, porosity and elastic wave transmission properties. Cylindrical specimens (25 mm in the diameter and 30 mm in the length) of granite from Oshima, Ehime Prefecture (initial porosity: 0.46±0.02 %, P and S wave velocity (V_P, V_S) under water saturated condition: 6.12±0.06, 3.17±0.10 km/s, respectively), and granite from Inada, Ibaraki (initial porosity: 0.68±0.02 %, V_P, V_S under water saturated condition: 6.06±0.04, 3.07±0.09 km/s, respectively) were used for the experiments. Average mineral size of Inada granite is larger than Ohshima granite. We operated experiments to transmit P and S wave through the granite specimens which is dry or saturated with water, under atmospheric pressure.

Porosity is increased as a heating temperature is increased. Porosity of Inada granite is approximately 1.3 to 1.5 times larger than that of Ohshima granite for intact and heated rocks. There is no clear difference on the relationship between porosity and V_P, V_S between Inada and Ohshima granite. V_P and V_S are negatively correlated with porosity: in the case of water saturated specimens, as porosity is increased from 0.4% to 4.3%, V_P and V_S is decreased approximately 32% and 55%, respectively. We are planning to evaluate crack distributions in the specimens, and investigate the relationship between the crack distribution and the measurement results.

Keywords: elastic wave velocity, granite, laboratory experiment, cracked rock

