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Measurements of elastic wave velocity and electrical conductivity in a brine-saturated granite under confining pressures

MAKIMURA, Miho[1*] ; WATANABE, Tohru[1]

[1]Graduate School of Science and Engineering, University of Toyama

Geophysical mapping of fluids is critical for understanding crustal processes. Seismic velocity and electrical resistivity structures have been revealed to study the fluid distribution. However, the fluid distribution has been still poorly constrained. Observed velocity and resistivity should be combined to make a quantitative inference on fluid distribution. The combined interpretation requires a thorough understanding of velocity and resistivity in fluid-saturated rocks. We have studied elastic wave velocities and electrical conductivity in a brine-saturated granitic rock under confining pressures.

A fine grained (100-500 ?m) biotite granite (Aji, Kagawa Pref., Japan) was selected as a rock sample for its small grain size and textural uniformity. Cylindrical samples (D=26 mm, L=30 mm) were heated to 100-600oC to increase the amount of crack (open grain boundary), and filled with 0.1 M KCl aqueous solution. A linear relationship was found between the highest temperature and the crack density parameter, which was estimated from velocities measured at atmospheric pressure. Velocity and electrical conductivity were simultaneously measured by using a 200 MPa hydrostatic pressure vessel. The pore-fluid was electrically insulated from the metal work by using plastic devices. The confining pressure was progressively increased up to 150 MPa, while the pore-fluid pressure was kept at 0.1 MPa. It took 3 days or longer for the electrical conductivity to become stationary after increasing the confining pressure.

Velocity and conductivity showed reproducibly contrasting changes with increasing confining pressure. Elastic wave velocities increased by less than 10% as the confining pressure increased from 0.1 MPa to 50 MPa, while electrical conductivity decreased by an order of magnitude. The changes were caused by the closure of cracks under pressure. The steep decrease in conductivity at low pressures suggests that there are more cracks with smaller aspect ratios. Both velocity and conductivity showed no remarkable changes at higher pressures. An empirical relationship between the normalized conductivity and crack density parameter was obtained. This relationship might be applied to a combined interpretation of seismic velocities and electrical resistivity.

Keywords: seismic velocity, electrical conductivity, resistivity, fluid, crack