

Simultaneous measurements of elastic wave velocity and electrical conductivity in brine-saturated rocks under confining pressures

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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 made measurements of elastic wave velocities and electrical conductivity in brine-saturated rocks under confining pressures, and examined pore structures with SEM.

Measurements and observations were made on two granite (Aji and Ohshima), one peridotite (Horoman) and one serpentinite (Hakuba). Cylindrical rock samples (D=26 mm, L=30 mm) were filled with 0.1 M KCl aqueous solution, and velocity and 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.

Two granitic samples showed moderate increase in velocity and large decrease in conductivity under confining pressures. Electrical conductivity steeply decreased at low pressures (<20 MPa) and then showed gradual decreases. Grain boundary cracks are pervasive in granite rock samples. The increase in velocity and decrease in conductivity at low pressures is caused by the closure of grain boundary cracks with small aspect ratios ($<10^{-3}$). SEM images show that the aperture of a grain boundary crack varies along its width. Large aperture parts can be open even under high pressures to be conduction paths. The difference in conductivity at high pressures must reflect the difference in the amount of large aperture parts. Peridotite and serpentinite samples showed small increase in velocity and small decrease in conductivity. Compared with granite samples, there must be a few cracks in these rock samples. Large aperture parts provide interconnected paths for electrical conduction.

Keywords: elastic wave velocity, electrical conductivity, crack