封圧下での含水砂岩の弾性波速度と電気伝導度の同時測定
Simultaneous measurements of elastic wave velocity and conductivity in a brine-saturated sandstone under confining pressures

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Pore-fluid pressure is a critical parameter that governs geodynamic processes including seismic activities. Its evaluation through geophysical observations provides us insights into these processes. The quantitative evaluation requires a thorough understanding of the influence of pore-fluid pressure on geophysical parameters, such as seismic velocity and electrical conductivity. We have studied elastic wave velocities and electrical conductivity in a brine-saturated sandstone under different confining and pore-fluid pressures.

Berea sandstone (OH, USA) was selected as a rock sample for its high porosity (~20%) and permeability (~10^{-13} m^2). It is mainly composed of subangular quartz grains, with small amounts of feldspar grains. Microstructural examinations showed that clay minerals (e.g., kaolinite) and carbonates (e.g., calcite) fill many gaps between grains. The grain size is 100-200 micrometers. Cylindrical samples (D=26 mm, L=30 mm) were saturated with 0.1 M KCl aqueous solution. Measurements have been made using a 200 MPa hydrostatic pressure vessel, in which confining and pore-fluid pressures can be separately controlled. An aqueous pore-fluid is electrically insulated from the metal work by using plastic devices. Elastic wave velocity was measured with the pulse transmission technique (PZT transducers, f=2 MHz), and electrical conductivity the two-electrode method (f=40 - 100 kHz).

Confining and pore-fluid pressures work in opposite ways. Increasing confining pressure closes pores, while increasing pore-fluid pressure opens them. For a given pore-fluid pressure, both compressional and shear velocities increase with increasing confining pressure, while electrical conductivity decreases. When confining pressure is fixed, velocity decreases with increasing pore-fluid pressure while conductivity increases. The closure and opening of pores can explain observed changes of velocity and conductivity. For a given differential pressure, velocities show no significant change with increasing confining pressure, while conductivity decreases. The decrease in conductivity might be caused by irreversible compaction of clays under confining pressures.

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