Change in electrical conductivity in a brine-saturated granite under uni-axial compression

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Geophysical observations have shown that fluids exist pervasively within the crust. Fluids fill intergrain cracks (open grain boundaries) and intra-grain cracks at the upper and middle crust conditions. Since the opening of cracks strongly depends on the stress state, electrical conductivity should be anisotropic under a stress state. We have conducted uni-axial compression tests on a brine-saturated granitic rock and studied the change in electrical conductivity in the directions parallel and perpendicular to the compression.

The loading system is composed of a hand press (Maximum load: 20 kN), a load cell and stainless steel end-pieces. A fine grained (100-500 mm) biotite granite (Aji, Kagawa Pref., Japan) was selected as a rock sample for its small grain size and textural uniformity. A cube sample with the edge length of 25 mm was filled with 0.1 M KCl aqueous solution and loaded up to 20 MPa. Electrical impedance was monitored during a compression test with two-electrode method (Ag-AgCl electrodes). Separate compression tests were made for measuring electrical impedance in two directions.

Electrical conductivity decreased with increasing axial stress in the directions parallel and perpendicular to the compression. When the axial stress was increased from 0 MPa to 10 MPa, the magnitude of decrease in conductivity was 5% both in the direction parallel and perpendicular to the compression. The decrease in conductivity was much smaller than that observed in hydrostatic compression tests (e.g., Watanabe and Higuchi, 2015). The decrease in conductivity must be caused by the closure of cracks, which were perpendicular or subperpendicular to the compression. Electrical conduction paths in the direction parallel and perpendicular to the compression are both composed of these cracks. Electrical conductivity in two directions thus shows similar changes. A differential stress will not lead to an anisotropy in electrical conductivity.

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