Water migration in deforming halite rocks – Constraints from resistivity measurements

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Intercrystalline fluid can significantly affect rheological properties of rocks through mechanical and/or chemical effects. The influence of fluid is strongly dependent on the fluid distribution. The fluid distribution affects deformation, and the deformation can modify the fluid distribution by turn. Such an interplay between fluid distribution and deformation is thus essential to understand rheological properties of fluid-bearing rocks.

Watanabe and Peach (2002) performed resistivity measurement on plastically deforming halite rocks containing a small amount of water. The electrical resistivity sensitively reflects the water distribution in halite samples. They found the resistivity change reflecting the closure of fluid paths due to axial compression and the widening of fluid paths accompanying dynamic recrystallization (grain boundary migration). The redistribution of water accompanying deformation, however, was not understood quantitatively. In this study, we evaluate the redistribution of water during deformation.

Water is assumed to exist at edges of NaCl grains in a narrowed tube shape, based on studies on the dihedral angle of the NaCl-H2O system (e.g., Holness and Lewis, 1997). The geometrical model of fluid distribution is a cubic lattice of fluid-filled tubes. The radius of a tube is assumed to vary parabolically along its length. For simplicity, the direction of tubes is perpendicular or parallel to the compression direction. During axial compression, water is squeezed from tubes perpendicular to the compression direction, and flowed into tubes parallel to the compression direction. The bulk resistivity is calculated through the effective medium theory.

The radius ratio (maximum radius/minimum radius) is estimated to be around 500 before deformation. The amount of water migrating before the first stress drop is estimated to be around 0.1%. Because of the closure of fluid paths perpendicular to the compression direction, the increase rate of the resistivity becomes larger during deformation.