Evaluation of surface conductivity of unsaturated Berea sandstone and porous glasses

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Electrical conduction of rocks composed of insulating minerals are known to depend on degree of water saturation, distribution of pore water, pore size and pore structure. Electrical conduction in rocks is considered to be composed of conductions in bulk water and on mineral surfaces. The electrical double layer (EDL), a layer with adsorbed ions on mineral surfaces (Stern layer) and gradients of ion concentrations (diffuse layer), has thickness characteristic length of the diffuse layer (Debye length). Surface conduction becomes important, when bulk water in rock pore decreases, such as in unsaturated rocks and less porous rocks with thin grain boundary water. Since quantification of dissolved ions in rocks with thin grain boundaries is difficult, quantitative description of surface conduction remains poor.
In this study, in order to examine surface conduction with known dissolved ion concentrations, electrical conductivity of a sandstone and porous glasses were measured for varying water saturation and ion concentrations. Berea sandstone (predominant pore diameter: about 40 μm) and Shirasu porous glass (SPG) membranes (SPG technology; uniform pore sizes: 1.0, 0.5, and 0.2 μm) were saturated with aqueous solutions having varying NaCl concentrations (0, 0.001, 0.01, 0.1 mol L^{-1}). Electrical conductivity values were measured for frequencies from 0.1 Hz to 1 MHz while drying.
Effects of surface conduction of Berea sandstone and SPG membranes were compared by their specific surface conductivity values, which were evaluated by conduction models using surface complexation model, and were discussed in relation to water film thickness and Debye length.

Keywords: Water saturation, electrical conductivity, ion concentration, Debye length, surface conductivity

