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Spectral induced polarization of quartz sand

Philippe Leroy (1), Alexis Maineult (2), Johannes Lützenkirchen (3), Odilia Esser (4), Egon Zimmermann (5), Mohamed Azaroual (6), Fritjof Fagerlund (7), André Revil (8), Damien Jougnot (2), and Johan Alexander Huisman (4)

(1) French Geological Survey (BRGM), Water, Environment and Ecotechnologies Department, Orléans, France (p.leroy@brgm.fr), (2) Sorbonne Université, CNRS, EPHE, UMR 7619 METIS, Paris, France, (3) Karlsruhe Institute of Technology, Institute for Nuclear Waste Disposal, Karlsruhe, Germany, (4) Institute for Bio- and Geosciences (IBG-3), Forschungszentrum, Jülich, Germany, (5) Central Institute of Engineering, Electronics and Analytics (ZEA-2), Forschungszentrum, Jülich, Germany, (6) Université d'Orléans, CNRS, BRGM, UMR 7327 ISTO, Orléans, France, (7) Uppsala University, Department of Earth Sciences, Uppsala, Sweden, (8) Université Savoie Mont Blanc, CNRS, IRD, IFSTTAR, ISTerre, Chambéry, France

The complex conductivity method is a very powerful technique to monitor the transport properties of soils, sediments and rocks because it has a real and imaginary part sensitive to conduction and polarization processes, respectively. In the mHz to kHz frequency range, the complex conductivity of water-saturated quartz sand is controlled by the polarization of the electrical double layer (EDL) surrounding the grains. Pure quartz grains exhibit a very weak polarization response that can only be measured by a high-precision impedance spectrometer. Furthermore, a thorough understanding of the physico-chemical processes occurring in the EDL is required to be able to extract pore structural properties from complex conductivity measurements. In this study, the zeta potential of very fine F36 quartz sand in contact with a NaCl aqueous electrolyte and its complex conductivity in the 1 mHz to 45 kHz frequency range were measured using the streaming potential (SP) and the spectral induced polarization (SIP) method, respectively. Two classes of models to describe the complex conductivity of quartz sand packings were tested: i) polarization model based on the generalized Schwarz theory with Stern layer polarization only or a combination of Stern and diffuse layer polarization, and ii) polarization models based on the Dukhin and Shilov theory with diffuse layer polarization only or a combination of diffuse and Stern layer polarization. We found that the generalized Schwarz model may overestimate imaginary conductivity spectra increasing with salinity and the broadness of the grain size distribution. On the other hand, the Dukhin and Shilov model may underestimate imaginary conductivity spectra but better reproduces the grain size distribution. These findings have strong implications for estimating permeability from SIP.