



Dependence of the Spectral Induced Polarization Response of Sands on Salinity, Grain Size and Saturation

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The spectral induced polarization (SIP) response of soils and sediments contains structure and state information which can be linked to flow and transport parameters. Electrical polarization phenomena are caused by the electro-diffusive interaction of the soil matrix with the pore fluid. In order to examine the connection of SIP characteristics with hydraulic properties we conducted impedance measurements on sands in dependence of salinity, grain size and saturation in the frequency range 1 mHz to 42 kHz using a newly developed experimental setup. Assuming a superposition of Cole-Cole dispersion terms, from the spectra relaxation time, polarizability and Cole-Cole exponent were determined for different identified dispersion ranges.

Increased electrical fluid conductivity leads to smaller polarizability and a decrease of the largest observed relaxation time. The latter corresponds to a decrease of the relaxation diffusion length, which can be related to the spatial scale significant for the hydraulic properties. An increased electrical conductivity is connected with a thinner electrical double layer, which in turn leads to smaller relaxation lengths, i.e. smaller relaxation times. The associated Cole-Cole exponent increases, which might be explained by a higher uniformity of the material at the smaller scale. For the largest relaxation time an increase with grain size of the examined material is observed. This is in conformity with the relations between relaxation time, relaxation diffusion length, grain and pore size.

For the variation of the water saturation a multi-step outflow setup is used. It likewise serves for the determination of (unsaturated) hydraulic properties. In contrast to the approach based on evaporative drying, the multi-step outflow approach allows the adjustment of a certain water content while keeping the electrical conductivity of the pore water practically constant. The drainage reduces and ultimately removes the free pore water. Thus the water layer at the fluid-matrix interface exerts a relatively higher contribution to the total electrical conductivity, i.e. the influence of the surface conductivity becomes stronger and the polarizability increases. Correspondingly, an inverse relationship between saturation and chargeability is observed.

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