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Relationships between Hydrological Parameters obtained from Multi-Step Outflow Experiments and Induced Polarization Spectra of Soil Samples

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The investigation of relationships between complex electrical parameters and hydrological properties of soil samples is necessary to allow an interpretation of spectral induced polarization (SIP) data in terms of soil hydrological properties. Therefore, laboratory SIP measurements in a frequency range between 0.01 Hz and 100 Hz and hydrological multi-step outflow (MSO) experiments are performed on different samples of unconsolidated sediments. The investigated material includes a fine sand sample with a narrow grain size distribution between 0.1 and 0.3 mm and soil samples from different locations in the vicinity of Braunschweig.

The SIP measurements were performed on samples fully saturated with a sodium chloride solution and a calcium chloride solution, respectively. Both solutions had a salt concentration of 0.001 mol/l. From the measured SIP spectra the mean relaxation time, the normalized total chargeability and a parameter describing the spreading of the relaxation time distribution were derived with the Debye decomposition approach. After finishing all SIP measurements, the MSO experiments were carried out to obtain the retention curves and hydraulic conductivity functions. The parameters of these functions, obtained by fitting the van Genuchten-Mualem model to the MSO data, were then compared with the parameters resulting from the Debye decomposition of the SIP spectra to find relationships between the electrical and hydrological properties.

Evaluation of the first measurements indicates a correlation between the mean relaxation time and the van Genuchten-Mualem parameter α. In literature, the mean relaxation time or equivalent parameters of models fitted to SIP spectra are often related to a characteristic pore size of the investigated material. The van Genuchten-Mualem parameter α correlates with the inverse of the air entry pressure head of soils and thus can also be related to a pore size. The evidence for a relationship will be further studied by extending the number of investigated soil samples.

A second pair of electrical and hydrological parameters promising a correlation is the so called non-uniformity parameter U_τ resulting from the Debye decomposition of SIP spectra and the van Genuchten-Mualem parameter n. Both parameters are related to the distribution of relaxation times and pore sizes, respectively.