Geophysical Research Abstracts,
Vol. 11, EGU2009-844-1, 2009
EGU General Assembly 2009

Streaming potential and electrical measurements in unsaturated sand

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The characterization of the vadose zone is a main challenge in hydrogeophysics. Electrokinetic phenomenon and particularly Self-Potential (SP), its field application, could be a useful technique to understand shallow transport and hydrological processes. Indeed, the electrokinetic potential results from the coupling between the water flow and the electrical current, so that it is proportional to the pressure gradient. The electrokinetic coupling is well described in fluid-saturated media, however its behaviour under unsaturated flow conditions is still discussed. Theoretical studies have been proposed to describe the electrokinetic coupling variations with water content but few experimental studies exist to validate or invalidate them. We propose here an experimental approach the aim of which is to describe SP signal variations in unsaturated conditions. Several drainage experiments have been performed within a column filled with a clean sand. Each 10 centimeter along this column, streaming potential measurements are combined to capillary pressure, water content and electrical resistivity measurements. Our interpretation of hydrodynamics during each experiment involves solving Richards equation in an inverse way, allowing us to establish hydraulic conductivity and water content relation. Electrical resistivity measurements as a function of water saturation are compared to several models, and lead to a good description of this parameter, which is crucial for the electrokinetic coupling. We try to deduce a robust law for the electrokinetic coupling as a funtion of the water content, and compare the experimental results to the theory.