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Examining the effect of different signal sources on the hydrologic interpretation of self-potential data

Emily B. Voytek (1), Kamini Singha (2), and James Irving (1)

(1) Institute of Earth Sciences, University of Lausanne, Switzerland (emily.voytek@unil.ch), (2) Hydrologic Science and Engineering Program, Colorado School of Mines, USA

The naturally occurring electric potential field at the Earth's surface, measured by the self-potential (SP) method, is the result of many interconnected subsurface processes and properties (e.g., groundwater flow, chemical and thermal diffusion, electrical conductivity). Qualitative analysis of SP measurements is sufficient for determining the general direction of groundwater flow in some field situations, but it does not provide needed quantitative information on flow rates or allow for the consideration of additional signal sources. Multiple potential-generating processes, measurable using the SP method, have been isolated and evaluated at the laboratory scale, but we still lack quantitative knowledge regarding how these processes interact and affect measured SP signals at typical field scales (10-100 m). Using forward modeling based on time-lapse SP data collected in an alpine meadow, we evaluate the most common sources of electric potential in natural systems and their expected SP signal amplitude and variability. We also identify the most important supplementary information (e.g., electrical resistivity measurements, soil characterization) that should be collected alongside SP measurements to best constrain interpretations of field data.