Analysis of Lab-Scale Infiltration Experiments with ERT and High Resolution CCD Imaging

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Field-scale studies have shown Electrical Resistivity Tomography (ERT) to be an effective tool for imaging resistivity anomalies such as those caused by infiltration events or migration of conductive solutes. However, the actual distribution of parameters of interest (e.g., saturation or ion concentration) is rarely known at field sites, and therefore the accuracy of ERT inversion results is difficult to assess quantitatively. Lab-scale experiments provide the opportunity to test ERT in controlled environments, where the true parameter distributions can be better constrained and even measured in real time. We present results from analog bench-scale experiments aimed at evaluating the ability of ERT to quantify the spatial distribution of water injected into a uniform porous medium at residual saturation. Our experiments represent a well-controlled analog for field-scale infiltration. We inject measured volumes into translucent chambers filled with quartz sand and lined with electrodes. The chamber is initially saturated, then partially drained, resulting in residual saturation in the upper ~2/3 of the chamber and a water table below. During injections, a CCD camera captures high-resolution images, and an ERT data acquisition system scans the chamber. Processing of the CCD images using quantitative visualization techniques results in high-resolution measurements of the spatial distribution of the injected fluid, which are compared directly to inverted resistivity fields to quantitatively evaluate the accuracy of the ERT inversions. Results from recent ERT data analyzed with the widely-used Occam's inversion methodology, and taken during gas injection experiments into a brine-saturated background, showed reasonably high sensitivity to the spatial distribution of electrically resistive gas targets, and to small saturation changes within them. Infiltration

experiments provide an alternative scenario, where the target is more electrically conductive than the background. They may also capture evidence of anomalously high conductivity at transitional saturation zones, a phenomenon that has been described in the hydrogeophysics literature. Lastly, our sand-chamber experiments provide the opportunity to directly quantify the accuracy of various inversion approaches, including coupled, joint inversions where hydrologic models are used to constrain ERT inversions. The quasi-2D nature of our system is conducive to exploring inversion routines that may currently be too computationally intensive at field scales.

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