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Geoelectrical monitoring of dense non-aqueous phase liquids with surface-to-horizontal borehole ERT

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Geoelectrical methods, particularly electrical resistivity tomography (ERT), have long been proposed to improve characterization and monitoring at sites contaminated with dense non-aqueous phase liquids (DNAPLs). However, ERT has not become a common tool for mapping such contaminants or tracking their remediation, due to the complexity of the DNAPL target coupled with the inherent limitations of traditional (surface and cross-hole) ERT configurations. Horizontal boreholes are being increasingly incorporated into remedial strategies at contaminated sites. This work presents a novel surface-to-horizontal borehole (S2HB) ERT configuration and explores the benefits and performance of 2D S2HB ERT (i.e., surface line to horizontal borehole) for mapping the spatio-temporal evolution of DNAPL mass during remediation. A coupled DNAPL-ERT model was employed to simulate a realistic, field scale DNAPL remediation scenario, and this initial theoretical evaluation demonstrated improved imaging of S2HB ERT over surface ERT, particularly at depth. A laboratory experiment was then performed to validate the S2HB ERT approach in a physical system involving a changing NAPL distribution over time. The experiment confirmed that S2HB ERT provides significantly improved monitoring of NAPL changes relative to surface ERT. Confirmation of the actual NAPL distribution was obtained by excavation of the tank at the end of the experiment, increasing confidence in the ERT responses. Independent simulation of the experiment with the DNAPL-ERT model also demonstrated that the model is a reliable tool for simulating real systems. Four-dimensional ERT inversion (applied to the 2D monitoring datasets) was employed throughout for both numerical and experimental data. Current work is investigating the S2HB ERT configuration in 3D mode (i.e., 2D surface grid to single horizontal borehole), with preliminary results again demonstrating the improved performance of S2HB ERT for time-lapse monitoring of DNAPL mass changes during remediation.