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Time-lapse ERT monitoring of DNAPL Source Zone Remediation

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Successful remediation of sites contaminated with dense non-aqueous phase liquids (DNAPLs) represents a major geoenvironmental challenge. Electrical resistivity tomography (ERT) exhibits significant potential to provide rapid and non-intrusive spatio-temporal information for monitoring the evolution of DNAPL mass during remedial efforts at contaminated sites. However, this potential has not been realized due to challenges in interpreting the results at real sites where the initial condition (DNAPL mass and distribution, subsurface heterogeneity) is generally unknown. The objective of this study is to evaluate the effectiveness of time-lapse ERT to monitor the remediation of DNAPL source zones in near subsurface environments. A recently developed coupled DNAPL-ERT model was employed to generate realistic DNAPL release and remediation scenarios and calculate the corresponding resistivity response. Varying DNAPL types, ranging from high density to low density DNAPLs, were released within different heterogeneous clayey sand environments, with the resulting three-dimensional DNAPL source zone distributions exhibiting a wide range of complexity. Complete DNAPL mass removal by natural dissolution was then simulated, with simultaneous mapping via periodic ERT surveys. A newly developed four-dimensional ERT inversion algorithm was used to generate time-lapse imaging of the evolving DNAPL source zones and subsequently predict the DNAPL volume remediated over time. Results demonstrate that time-lapse ERT may provide valuable spatio-temporal information to inform and assess DNAPL remedial strategies. Delineation of the DNAPL volume remediated, in terms of the outline and center of mass, is promising with time-lapse ERT exhibiting the ability to map the treatment zone to within a few meters in each direction. Although ERT generally underestimates the temporal reduction of DNAPL volume, particularly for deeper source zones, it is evident that these measured DNAPL volume estimates can still provide valuable information for quantitatively monitoring the remediation of DNAPL source zones. In general, this study demonstrates that time-lapse ERT may be a valuable non-invasive site tool during DNAPL site clean-up.