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Constraining 3-D electrical resistance tomography with GPR reflection data for improved aquifer characterization

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Abstract

Surface-based ground penetrating radar (GPR) and electrical resistance tomography (ERT) are common tools for aquifer characterization, because both methods provide data that are sensitive to hydrogeologically relevant quantities. To retrieve bulk subsurface properties at high resolution, we suggest incorporating structural information derived from GPR reflection data when inverting surface ERT data. This reduces resolution limitations, which might hinder quantitative interpretations. Surface-based GPR reflection and ERT data have been recorded on an exposed gravel bar within a restored section of a previously channelized river in northeastern Switzerland to characterize an underlying gravel aquifer. The GPR reflection data acquired over an area of 240Â Ã—Â 40Â m map the aquifer's thickness and two internal sub-horizontal regions with different depositional patterns. The interface between these two regions and the

boundary of the aquifer with the underlying clay are incorporated in an unstructured ERT mesh. Subsequent inversions are performed without applying smoothness constraints across these boundaries. Inversion models obtained by using these structural constraints contain subtle resistivity variations within the aquifer that are hardly visible in standard inversion models as a result of strong vertical smearing in the latter. In the upper aquifer region, with high GPR coherency and horizontal layering, the resistivity is moderately high (>Â 300Â Î©m). We suggest that this region consists of sediments that were rearranged during more than a century of channelized flow. In the lower low coherency region, the GPR image reveals fluvial features (e.g., foresets) and generally more heterogeneous deposits. In this region, the resistivity is lower (~Â 200Â Î©m), which we attribute to increased amounts of fines in some of the well-sorted fluvial deposits. We also find elongated conductive anomalies that correspond to the location of river embankments that were removed in 2002.

Research highlights

â–° Structural 3-D GPR constraints improve 3-D ERT results. â–° Reflection GPR detects different fluvial depositional patters in 3-D. â–° ERT models display a higher clay content in the older sediments. â–° River channelization affects the aquifer structure and this structure persists even after river restoration.

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Keywords

GPR; ERT; Aquifer characterization; Constrained inversion

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