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In-situ determination of the spatial variability of hydraulic properties using hydraulic tomography with cross-hole slug tests at the test site Stegemühle, Germany

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Spatial variations in hydraulic properties play an important role in controlling solute movement in saturated flow systems. Conventional hydrogeological approaches, however, have difficulties providing high resolution estimates of these variations. We developed a new hydraulic tomography approach to reconstruct the two- or three-dimensional diffusivity distribution between two or more wells. The approach, which is based on the inversion of travel times, is analogous to seismic ray tomography. The key element of this procedure is a travel time integral relating the square root of the peak travel time to the inverse square root of the hydraulic diffusivity for a Dirac point source.

The great potential of travel-time based hydraulic tomography for high resolution aquifer characterization has already been demonstrated in synthetic case studies, but the practicality of the approach has been limited by the need for relatively closely spaced wells. That limitation can be readily overcome in unconsolidated formations by exploiting the access to the shallow subsurface provided by direct-push (DP) technology. DP technology can be used to install observation points at positions most advantageous for a particular study and then to reposition points between tests.

The potential of hydraulic tomography using DP technology for well installation was investigated at a well-characterized shallow sand and gravel aquifer located in the Leine River valley near Göttingen, Germany. The data base for the inversion con-

sists of 200 cross-hole slug tests performed between five wells in which the positions of the sources (injection ports) and the receivers (observation ports), isolated with packers, were varied between tests. The inversion results of the cross-hole slug tests demonstrate the effectiveness of the proposed inversion technique. It was possible to reconstruct four 2-D diffusivity tomograms with a resolution of 0.15×0.15 m^2. The reconstructions were verified using single well slug tests, grain-size statistics and geophysical well logs. The results of this study show that hydraulic tomography is particularly well-suited for providing information about the structure and spatial variability of hydraulic properties of an aquifer, which is a prerequisite for prediction of contaminant transport.