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Critical evaluation of Direct Push technology for hydrostratigraphic aquifer characterization

Peter Dietrich; Ludwig Zschornack; Thomas Vienken

Helmholtz Centre for Environmental Research – UFZ
Permoserstraße 15, 04318 Leipzig, Germany
e-Mail: **peter.dietrich@ufz.de**

Abstract

Environmental site investigations require high resolution information about lithology and hydraulic properties of the subsurface for understanding and modeling of flow and fluid transport processes. This is especially true for complex structured sedimentary deposits where spatial variability of hydrogeological parameters governs flow processes in saturated aquifer systems. Traditional approaches usually cannot cope with the task of reliable high resolution aquifer characterization of such heterogeneous systems. Hence, adequate field methods for the derivation of subsurface parameters need to be developed and reliably applied to describe subsurface variability. In this regard, Direct Push technologies turn out to be a promising platform for tools and approaches capable for high resolution aquifer characterization. However, to further improve acceptance, these tools need further evaluation using numerical simulations, case studies and field tests.

Key words

Aquifer characterization, Direct-push characterization tools, Hydraulic tests

1 − INTRODUCTION

Environmental site investigations require high resolution information about lithology and hydraulic properties of the subsurface for understanding and modeling of flow and fluid transport processes. This is especially true for complex structured sedimentary deposits where spatial variability of hydrogeological parameters governs flow processes in saturated sedimentary systems.

Many tools for the laboratory and field investigation of hydraulic conductivity (*K)* already exist, e.g. pumping tests, slug tests, laboratory analysis of core samples, geophysical logging, borehole flowmeter tests, direct push methods and hydraulic tomography (see Butler 2005 [1]). These approaches vary significantly in the support volume over which a method measures and integrates the parameter value which is attributed to one measurement point, ranging from aquifer to particles size scale. Especially the traditional site investigation techniques such as the pumping test cannot cope with the task of reliable high resolution aquifer characterization due to a relatively large support volume.

As ongoing research in the field of stochastic and deterministic modeling has lead to the development of increasingly complex flow and transport models for the saturated and unsaturated zone adequate field methods have to be developed and reliably applied to describe soil variability in a way to keep pace with modeling (van Genuchten 1991 [5]). A number of tools have been developed for high resolution aquifer characterization based on Direct Push technologies that reveal the great potential of Direct Push technologies in terms of hydrostratigraphic site characterization (e.g. Butler et al. 2007 [2], Liu et al. 2009 [8], Lessoff et al. 2011 [6]). However, further research and evaluation of these tools are necessary.

2 − EVALUATION OF DIRECT PUSH TECHNOLOGIES FOR HYDROSTRATIGRAPHIC AQUIFER CHARACTERIZATION

Direct Push (DP) technology refers to a growing family of tools used for performing subsurface investigations by driving, pushing and/or vibrating small-diameter hollow steel rods into the ground (US-EPA, 1997 [4]). Multiple tools can be attached at the end of the rod string to obtain e.g. lithological and hydrological subsurface parameters. With the use

of sampling devices, soil, soil gas, and ground water samples can be retrieved from the subsurface. The broad variety of equipment makes Direct Push sensor probes and tools a promising method for site characterization in general.

Thereby, DP tools are used to generate high resolution vertical profiles of soil hydraulic properties of un- or weakly consolidated sedimentary aquifers for a reliable description and parameterization of subsurface structures. Among these DP tools are the DP Slug Test (DPST), Cone Penetration Test (CPT), DP Injection Logger (DPIL) and the DP Permeameter (DPP). However, DP high resolution hydrostratigraphic profiling tools must be carefully evaluated concerning their design, vertical resolution, K resolution and precision of K estimates. In this regard tools like the Direct Push Injection Logger and the Direct Push Permeameter are promising tools for the characterization of highly heterogeneous aquifers (Butler et al., 2007 [2], Liu et al., 2008 [7]). Several studies have shown the high potential of these tools to delineate and characterize hydrostratigraphic facies in a resolution that was never been achieved before. In order to improve the acceptance of these methods the aim is to further evaluate these tools using numerical simulations, case studies and field tests.

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