What is between These Two Wells? Cross Borehole Georadar for Identifying Migration Pathways at Contaminated Sites

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Background/Objectives. A large part of the northern hemisphere has quaternary deposits consisting of glacial clay till. The till often has a complex hydrogeological structure consisting of networks of fractures, sand stringers and sand lenses each contributing to a transport network where water, free phase and dissolved contaminants migrate. Understanding the nature and structure of these networks is crucial in developing conceptual models of contaminant transport.

In the last decades, cross borehole Georadar (Ground penetration radar-GRP) has been used to determine the type and water content of sediments but seldom at contaminated sites. However, knowledge of water saturation and orientation of sand and clay units between boreholes is valuable information for understanding contaminant transport. At urban or industrial sites, accessibility is often limited by utilities and structures, and as such, tools to determine the geology between boreholes are valuable. Moreover, methods that can provide information between investigation wells reduce the cost and time spent on drillings.

The aim of this project was to investigate whether GPR can be used at urban/industrial sites to examine the composition of the subsurface between two boreholes.

Approach/Activities. We examined at what distance the method was applicable, the applicability and necessity of large and complex versus short and simple measuring routines (multioffset-MOG versus zero offset-ZOP) and how the method improve the conceptual understanding at contaminated sites. Field work was performed at a complex contaminated site with a variable geological setting consisting of three sandy aquifers and interfering clay units.

Results/Lessons Learned. The project showed that GPR was applicable in existing boreholes, cased with bentonite in an urban setting at distances of less than 7 meters. Results showed a good agreement with previous borehole and geological interpretation for the area.

The method is considered to be operational at large site investigations. Simple ZOP measurement routines were completed in 10-15 minutes while MOG measurements required 90 minutes and a more complex data interpretation. While ZOP could show whether the space between two boreholes was dominated by high- or low permeable and wet or dry layers, the MOG measurements were necessary to get information on orientation and extension of these layers.

At most sites a combination of ZOP and MOG measurements to refine uncertain zones would therefore be preferable.

GPR enabled the understanding of the hydrogeological setting and migration pathways at the site. At the specific site, aquifer-pumping tests had been necessary to determine the contact between the different sandy layers. Such tests were costly and practically difficult, and we believe GPR is an excellent alternative to those.