Multi-disciplinary perspectives on a natural attenuation zone in a PCE-contaminated aquifer

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Introduction

The organic solvent tetrachlorethene (PCE) has been used world-wide as the primary solvent for dry-cleaners. PCE is classified as a Dense Non-Aqueous Phase Liquid (DNAPL) and has a density greater than water. After a spill event PCE is released into the environment and sinks through the groundwater table driven by the gravitational force and pools up at the bottom of the aquifer. Due to its low solubility in water (200 mg/L) and toxicity at low concentration, even a small spill of PCE can contaminate an aquifer for hundreds of years. This makes cleanup activities (remediation) far more difficult than for e.g. oil spill.

In recent research focus has shifted from the common excavation technique to bioremediation which has shown to be successful in degrading PCE to non-toxic products. But still it lacks a monitoring system as it is hard to verify the degree and degradation status based on geochemical parameters alone.

It has been suggested in earlier studies that the geophysical technique Direct Current Induced Polarization (DCIP), has the capacity to detect free phase PCE. In theory it is possible to detected zones of natural attenuation (bioremediation) with the DCIP technique.

In my study we have applied high-resolution DCIP analysis at a PCE-contaminated site in Sweden, where the geochemical data indicate that natural attenuation is an ongoing process. A photo of the study area is shown in Figure 1, where the purple lines correspond to the locations of the DCIP lines in DCIP 3D-model result are shown in Figure 2.

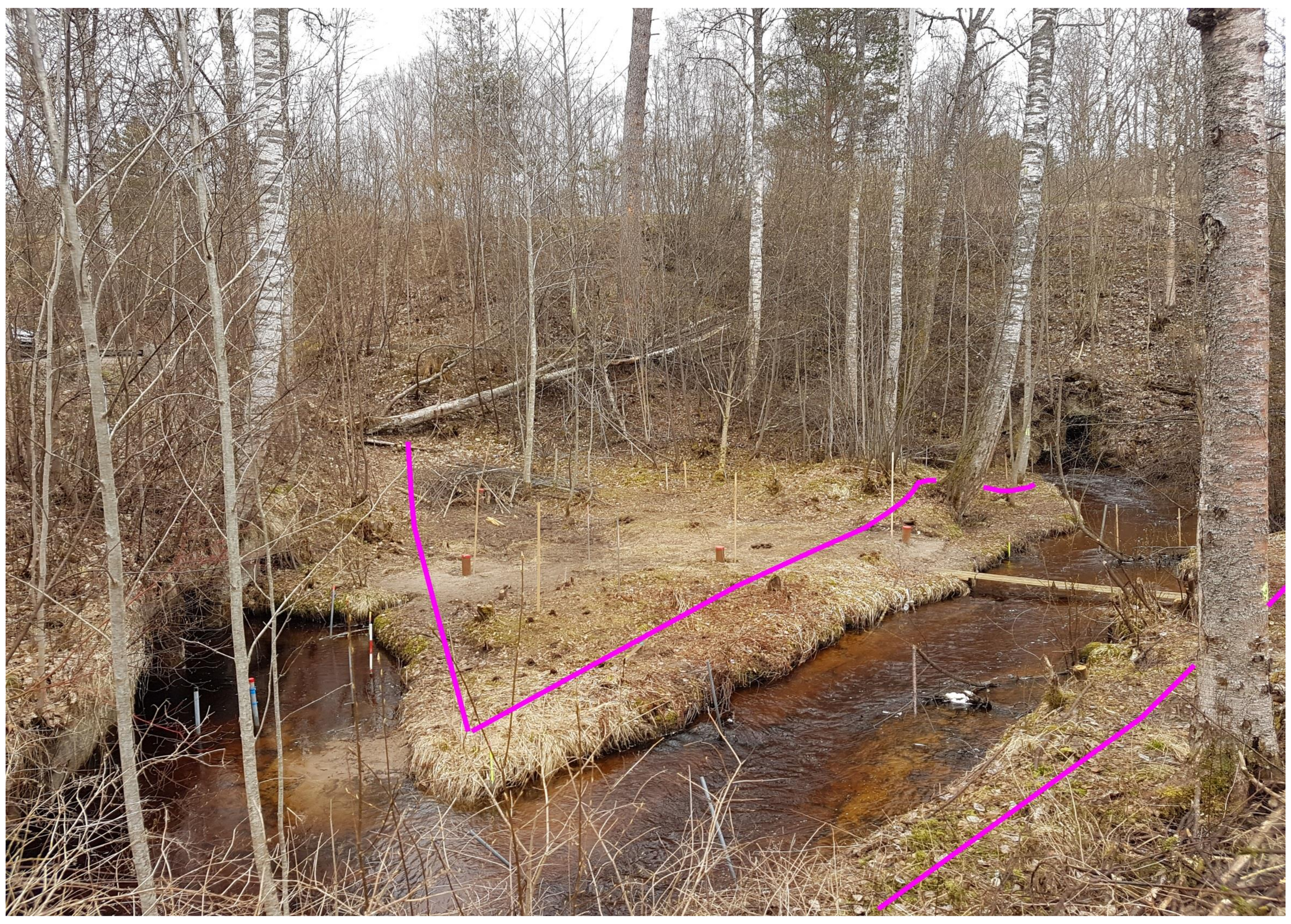

Figure 1

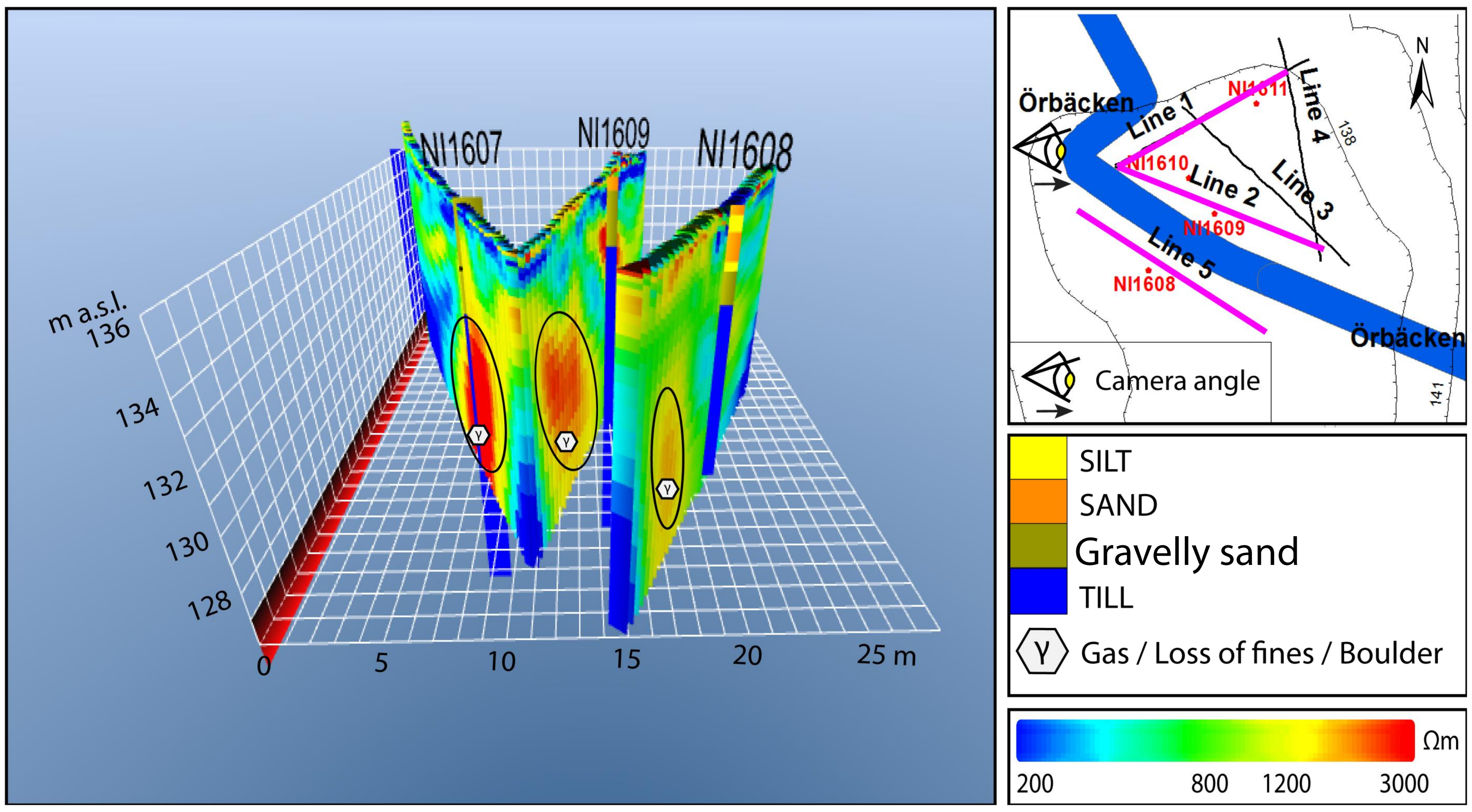

Figure 2

Discussion and interpretation

Resistivity of the subsurface is strongly influenced by grain size, porosity, water saturation and dissolved ions. The occurrence of natural attenuation of PCE should in theory cause a decrease in resistivity, as every step of degradation releases a chloride ion.

In Figure 2 the continuous γ-anomaly (high resistivity) marks a zone where the geochemical parameters indicate that natural attenuation occurs. Thus so my DCIP result are contradictive, instead the γ-anomaly might indicate the existence of a zone of biodegradation indirectly, if biogas is occupying the pores. But with the limitations in our dataset we have identified three reasonable explanations for the γ-anomaly.

1. Biogas (methane and/or carbon dioxide) occupies the pore space where biodegradation occurs.
2. Internal erosion of fine-grained sediments in the till.
3. Presence of a huge boulder (5-10 m).

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