From microstructure to subsurface characterization
Spectral information from field scale time domain induced polarization

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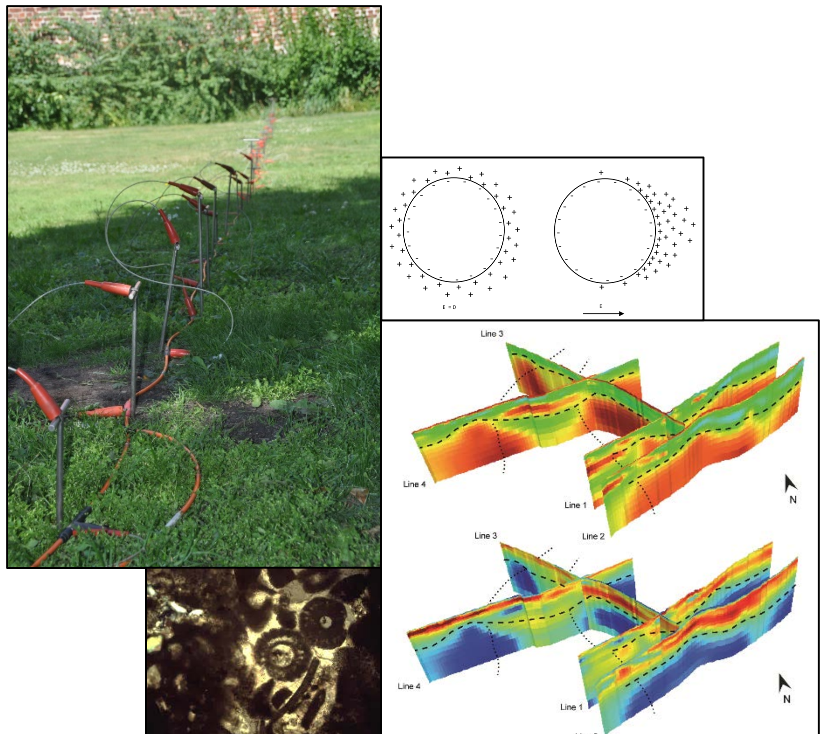

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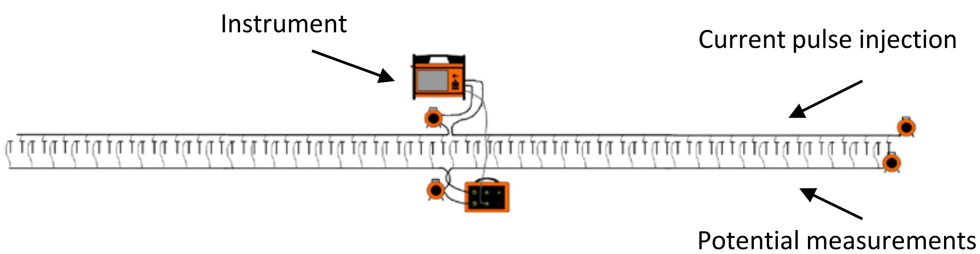
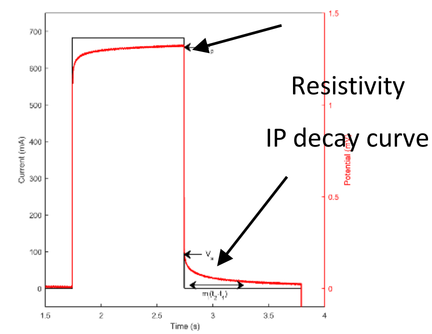
BACKGROUND

- Resistivity and time domain Induced Polarization (DCIP) – geophysical methods used to perform tomographic measurements of subsurface physical properties.
- Valueable pre-investigation tool for many different kinds of infrastructure projects, including planning of tunnels, roads and buildings as well as remediation of contaminated soil.

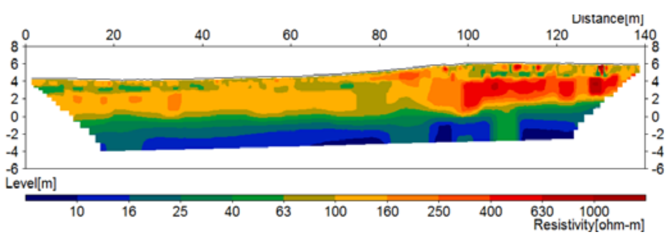
Measurements of resistivity and time domain induced polarization (DCIP)

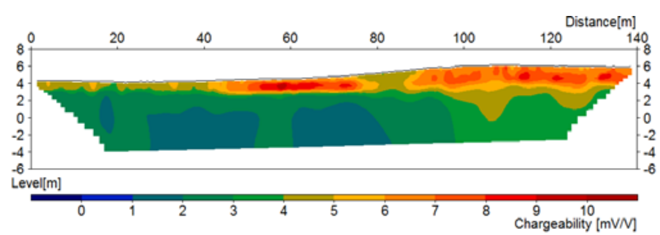


Measured potential signal



Models of resistivity and IP distribution in the ground



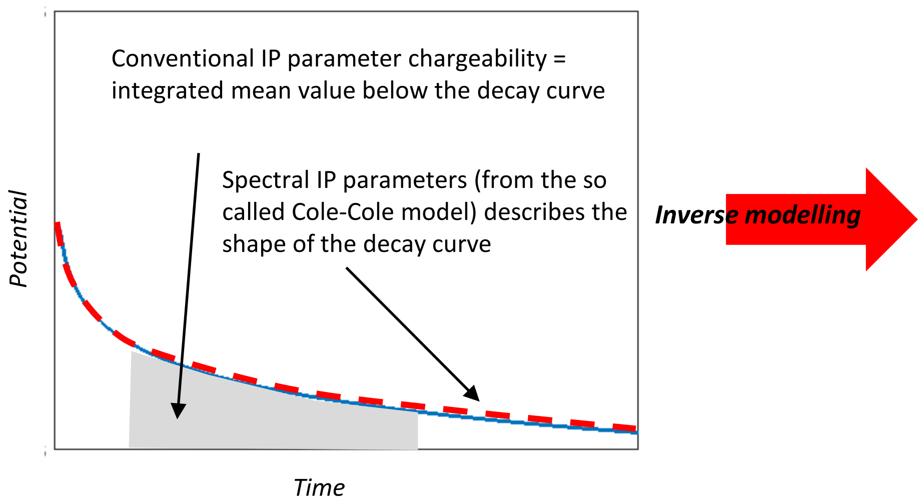


Inverse modelling

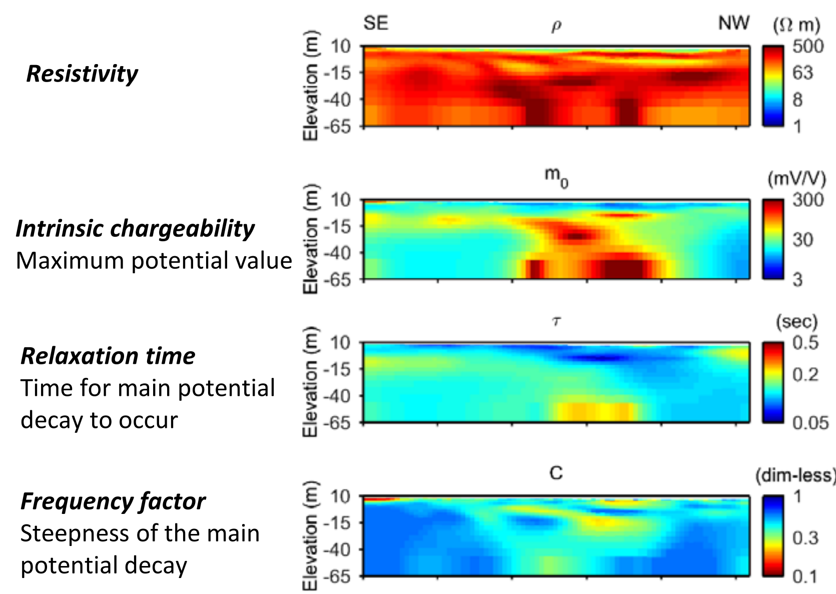
BACKGROUND

- Technical developments of time domain IP equipment and new inversion algorithms have led to the possibility of collecting large amounts of data and invert for so called spectral IP parameters.
- The so called Cole-Cole model is fitted to the measured decay curves, and inverse modelling of the decay data results in four models of subsurface showing the distribution of different geoelectrical properties

Extraction of spectral IP parameters from decay curve



Cole-Cole inverted DCIP data



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OBJECTIVES

- Much remains to be known about how to analyse and interpret spectral IP parameters from field scale time domain IP measurements.
- It is known that spectral IP effects arise due to ion distribution at the pore scale in geological media and that spectral IP parameters can be linked to microscale surface chemical and structural properties.

The first objective of this project is to achieve an ***understanding of the physical mechanisms*** *governing spectral induced polarization based on previous research. The second objective is to investigate* ***how to analyze spectral induced polarization parameters from field scale time domain IP measurements****. More specifically, the objective is to investigate if the distribution of contaminants in soils can be imaged with time domain spectral IP, exemplified by free phase dense non-aqueous phase liquids (DNAPLs). Furthermore, if spectral IP parameters can be used to obtain information of varying bedrock properties.*

The overall methodology used in this licentiate thesis is to ***combine field scale DCIP measurements with microgeometrical studies****, since IP effects are known to arise at the microscale regardless of the measurement scale used.*

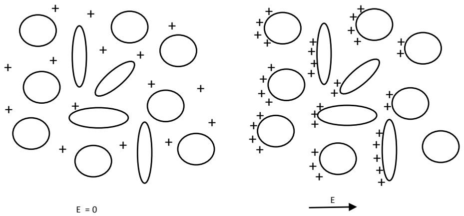


Figure 4.4. Conceptual sketch of the interfacial (Maxwell-Wagner) polarization mechanism.

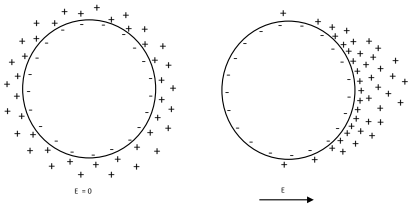
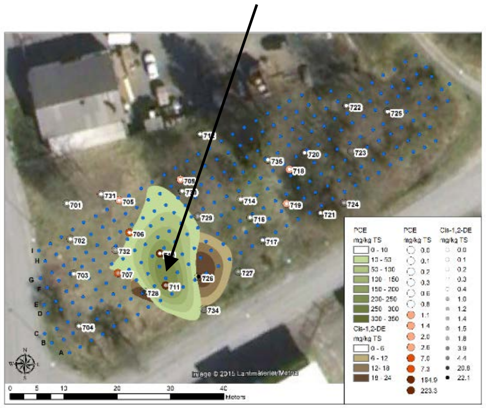


Figure 4.3. Conceptual sketch of the electrochemical polarization mechanism. Ions in the EDL are displaced under the influence of an electric field.

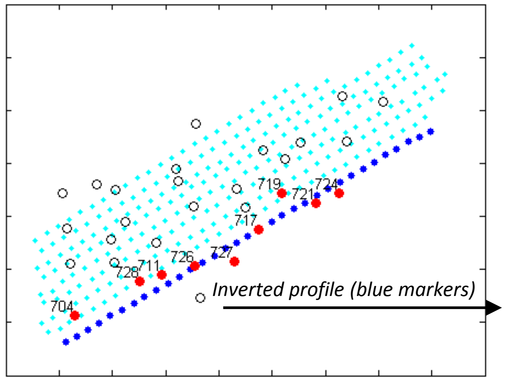
RESULTS – CONTAMINATED SOIL

Johansson, S., Fiandaca, G. & Dahlin, T., 2015. Influence of non-aqueous phase liquid configuration on induced polarization parameters: Conceptual models applied to a time-domain field case study. *Journal of Applied Geophysics*, 123, pp.295–309.

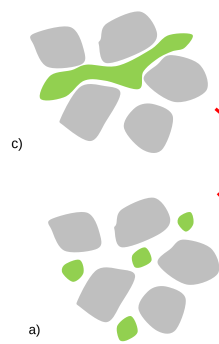
Can plumes of NAPLs (tetrachloroethylene, PCE) be detected with DCIP?

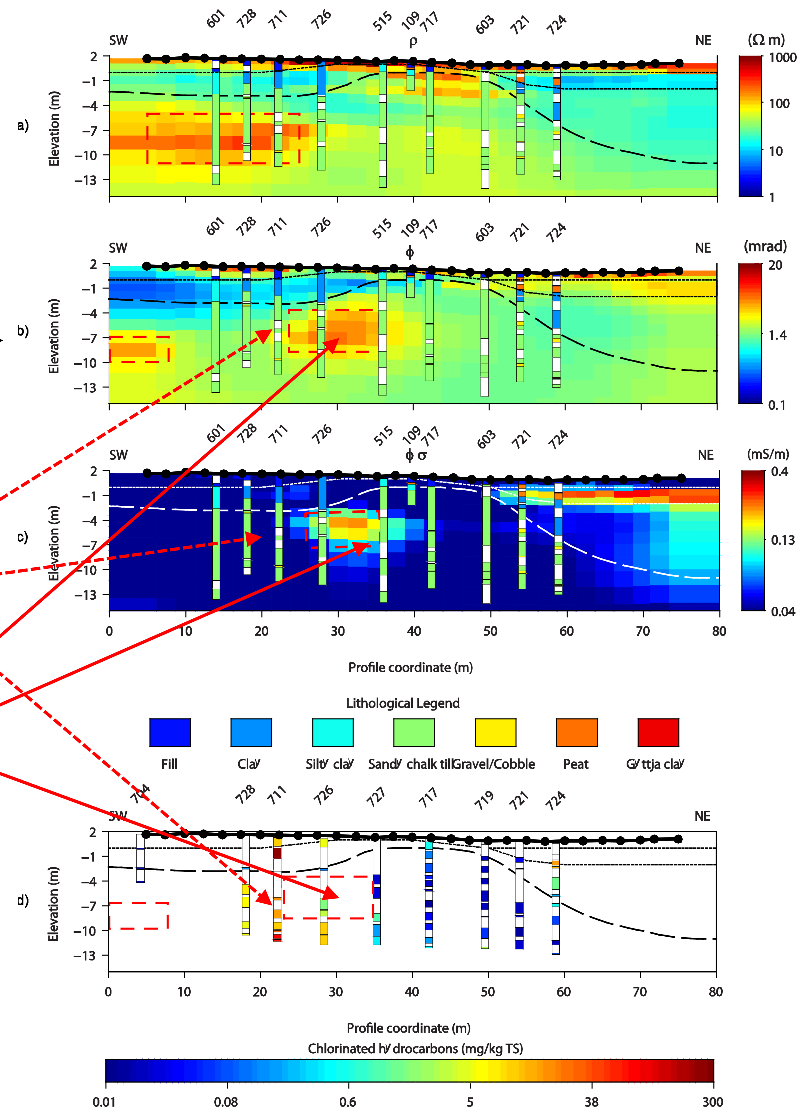


Free-phase contaminant plume (green) and indications of degradation (brown) based on soil sampling



DCIP measurement lines (cyan) and reference boreholes





Results

- Source zone: PCE interconnected along pores ➔no IP anomaly
- Degradation zone: PCE droplets in pores ➔elevated IP

Conclusions:

- IP response not linearly related to NAPL concentrations
- Spectral IP response of NAPL contaminated soil is probably related to geometrical factors
- Conceptual models enhanced field data interpretation

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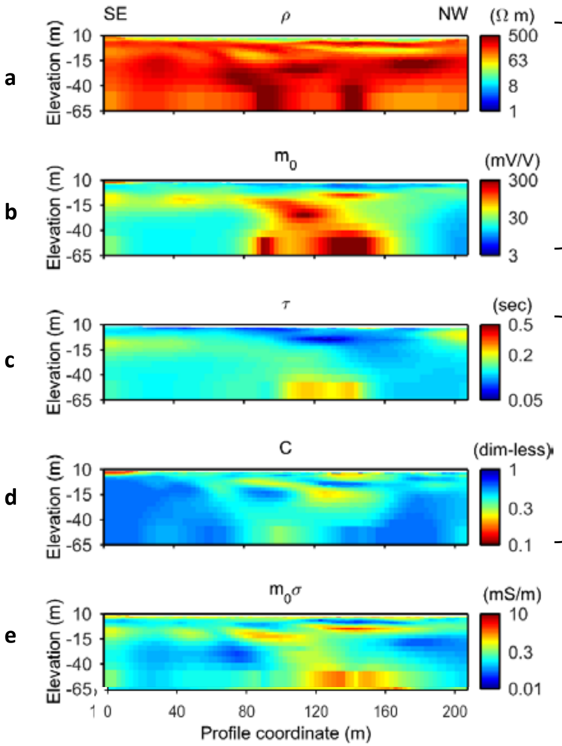
RESULTS – TEXTURAL, STRUCTURAL AND COMPOSITIONAL VARIATIONS IN LIMESTONES

Johansson, S., Sparrenbom, C., Fiandaca, G., Lindskog, A., Olsson, P.-I., Dahlin, T., & Rosqvist, H., 2016. Investigations of a Cretaceous limestone with spectral induced polarization and scanning electron microscopy. *In review (Geophysical Journal International).*

DCIP models inverted for spectral IP parameters

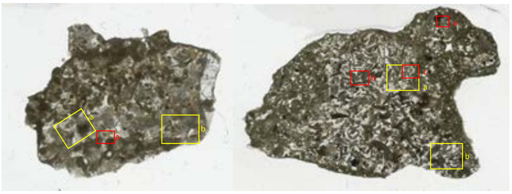


Indicate either variations in groundwater content or composition/structure

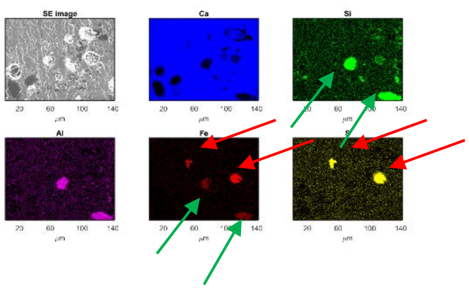
Indicate textural variations in the limestone, e.g. grain and pore structure

Indicate variations in composition of the limestone, e.g. presence of polarizable minerals (pyrite)

Thin section analysis and Scanning electron microscopy (SEM) and Energy Dispersive Spectroscopy (EDS)



Different microgeometrical texture and structure at different borehole levels due to e.g. fossil composition and cement/matrix/grain ratios



Strongly polarizable pyrite (FeS) minerals in the limestone
Glauconitic grains in the limestone, probably polarizable

Conclusions:

- Similar IP responses can indicate different rock properties depending on the mineral constituents of the rock. For example, geological weathering processes affect the physical properties of silicate and calcium carbonate rocks differently.
- The SEM and EDS-analysis gave an important insight into the microgeometry and mineralogical content of the investigated *limestone.*