

GEOLOGICAL SETTINGS CHARACTERIZATION OF A CONTAMINATED AREA IN AN URBAN CONTEXT: ASSIMILATION OF ARCHIVES, GEOTECHNICAL AND GEOPHYSICAL DATA

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Introduction. The field site is a metallurgic industry located in the region of Friuli-Venezia Giulia (north East Italy), in an urban context which takes a surface of approximately 34.500 m². Before turning off the main plating activity, the manufacture rejected contaminants into the soil via the open drainage, nowadays still allowed in that area. Soil contamination rate and diffusion depends on the geological features and hydrology of the site. Information about the hydro-geological context of the region is essential but limited. Presence of paleo channels passing through the factory was assumed (this has been further investigate using geophysical interpretation of the cross section). In 2002, a first geophysical (18 profiles inside the factory) and geotechnical survey (more than 50 wells in the south of the factory) had been done to characterize the geological settings of the site. First results highlighted that the site is characterized by thick gravel deposits interrupted by the presence of an impermeable thin clay layer at 7 m depth, which prevents the contaminants to reach the deeper main aquifer. Nevertheless, this clay layer resulted to be discontinuous with several interruptions that threaten the local seal. A short-term remediation plan has been set up using pumping stations to collect and treat the waste water infiltrated in the south part of the manufacture. There is a need for non-destructive imaging of the clay layer discontinuity in order to propose solution such as the implementation of cost remediation devices such as new trench drainage.

Objectives. Our study overcomes the limits identified after the 2002 prospection with the following concrete goals:

- Firstly, there is a need to better define the clay layer discontinuities. A combination of modelling and accurate constrained inversions give new insights to a better understanding of the electrical resistivity variations observed. Calibration of the clay layer electrical behaviour, was also investigate though the implementation of two cross hole ERT devices monitoring under changing condition of water table.
- Secondly, there is a need to compute a 3 dimensional model of the entire manufacture area and of its boundaries (in particular to build the initial model of hydrological simulation). Due to the non-regular spatial location of the geophysical and geotechnical data, new ERT data were collected. In order to use all the available source of inversion possible we aimed to fusion and interpolate the data using a geostatistical analysis.

The originality of the study relies on the use of transversal concepts to geophysical imaging such as data fusion, geostatistical interpolation, cluster analysis and data assimilation via hydrogeophysical modelling.

Results. Documentation from archives allowed us to define a plan for the new acquisition. The wells showed that the soil is horizontally layered with a first layer often composed of gravel. When existing, the clay layered of about 1m thick is located around 7m of depth. Electrical resistivity tomography data from the 2002 acquisition showed that the position of the clay layer correlated with a high electrical conductivity anomaly is difficult to identify. Its depth is rather well defined but its tick is overestimated. Identical feature has been observed for the cross sections acquired during the new campaigns in 2018 using a simple smooth inversion (Binley, 2013). Only the cross-hole prospection using boreholes electrodes was able to derive the same information than the well data. Monitoring the cross-hole sections under the influence of a changing water level table did not show any change in the clay layer identification (although the water table did not change significantly). From these results and additional simulations, it appeared essential to process ERT sections using a dedicated constrained inversion dictated

spatially by the well logs (when available) and qualitatively by the cross-hole (estimation of the clay conductivity) using the open source python code pyGIMLI (Rücker *et al.*, 2017). Simple simulations using a dipole-dipole configuration on a two-layers models were done. Different geological settings were tested using a conductive thin layer (clay) surrounding within a resistive soil (gravel). The results highlighted that the conductivity above the conductive layer are affected. Using a non-constrained inversion did not allow to retrieve the real clay feature while significant improvements on the estimation of the clay layer tick (associate with lower error on the estimated model) were observed using a constrained inversion.

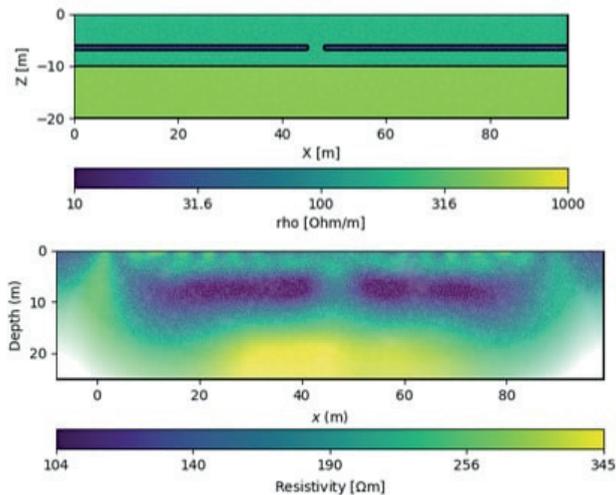


Fig. 1 - (left) Forward modeling of a clay discontinuity (200Ohm.m) for a two layered soil sand (200Ohm.m) over gravel (500Ohm.m). (right) result of the inversion using pyGimli showing the overestimation of the clay layer thickness without constraints during the inversion.

The ultimate objective of the study was to build the 3 dimensional model. To this end, several steps were needed each providing partial results:

- Both geophysical and stratigraphy data from an old report made in 2002 were digitized with a particular care to make the data reusable (georeferenced) and comparable (scaled) with the new data acquired in 2018. Three dimensional projection of wells and geophysical

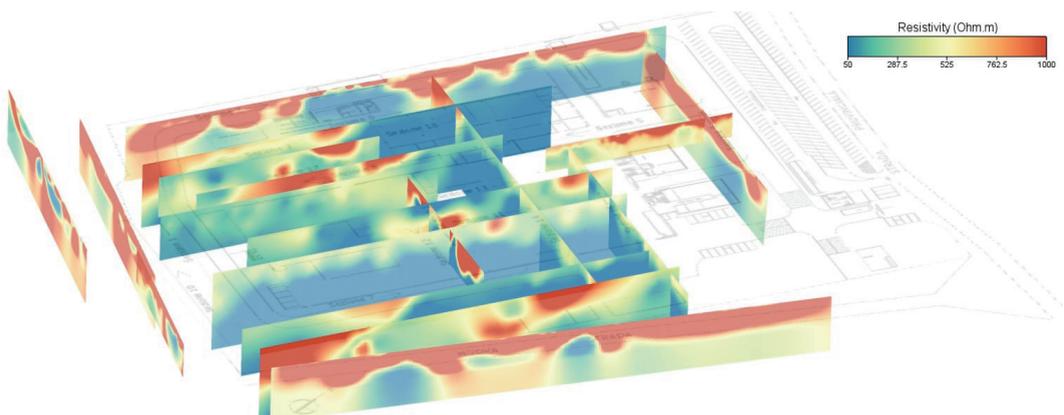


Fig. 2 - 2D ERT inverted data showing different sources of errors (presence of paleochannels, bad inversion) on the estimation of the clay layer depth and thickness . Integration of geotechnical wells and geostatistical analysis using kriging interpolation aims to refine the model.

sections showed a good consistency between wells data and the common ERT sections of the two different campaigns (e.g. figure 2).

- The virtual boreholes created from the geophysical sections, on which a 3 layers manual picking has been done, allowed to artificially correct clay thick.
- Lastly, the geo-statistical analysis allowed to define the best interpolation scheme between data non-uniformly located on the studied area. Two interpolations were tested: kriging (Deutsch et al, 1998) and polynomial interpolation with Voxler®. We kept the 3d model produced via kriging which show more agreement according to the analysis of the variograms as input for the hydrological modelling.

References

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