

# **In search for clay and salt, combining traditional techniques with airborne geophysics (SkyTEM) to optimize the 3D image of the subsurface**

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## **ABSTRACT**

The coastal dune area of North-Holland in The Netherlands has been used for the production of drinking water since the early 1900's. Because of this, the area has been thoroughly researched and measured using traditional measurement techniques such as piezometers, borehole logs, CPT's etc. Additionally in 2011 a large scale airborne geophysics survey (SkyTEM) was carried out in this area (HydroGeophysics Group - Aarhus University, 2012). The area around Bergen was chosen for further interpretation because it is known that a distinct confining layer is present within the fresh aquifer. This paper describes the interpretation of these geophysical measurements based on the large amount of existing information.

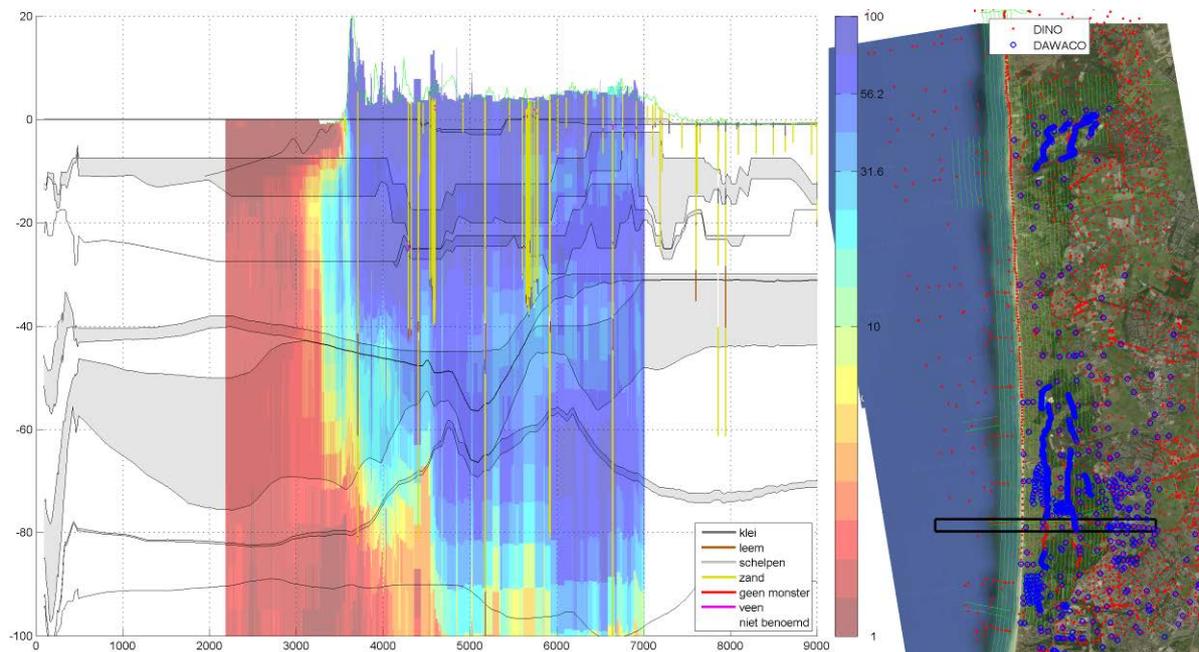
In the coastal dune area near Bergen there are almost 500 boreholes. Geophysical borehole logging has been carried out in 89 of these boreholes. Chloride concentration is measured at 48 locations 4 times a year. At 16 sites 'salt watcher' cables are present, which measure the conductivity of the groundwater at several depths. Recently 5 cone penetration tests (CPT's) with conductivity measurements have been carried out (Rolf and Schaars, 2012). Other sources of information on the fresh-salt interface are the groundwater model and (older) maps of hydrogeological studies. All this data covers the same area which has been measured using airborne geophysics (SkyTEM) and can therefore be used to verify and interpret the geophysical measurements.

Having this much information available presents several challenges: how to visualize and interpret data which is different in so many ways, yet all contains information on the fresh-salt interface? Some information is tens of years old so might not represent the current state of the fresh-salt interface. Combining similar data from different sources (databases) sometimes shows contradictions or differences caused by erroneous conversions. Even when all errors are removed the data still consist of different entities and units: resistivities (airborne geophysics, borehole logs), conductivities, chloride concentrations, and so one, all measured using different techniques.

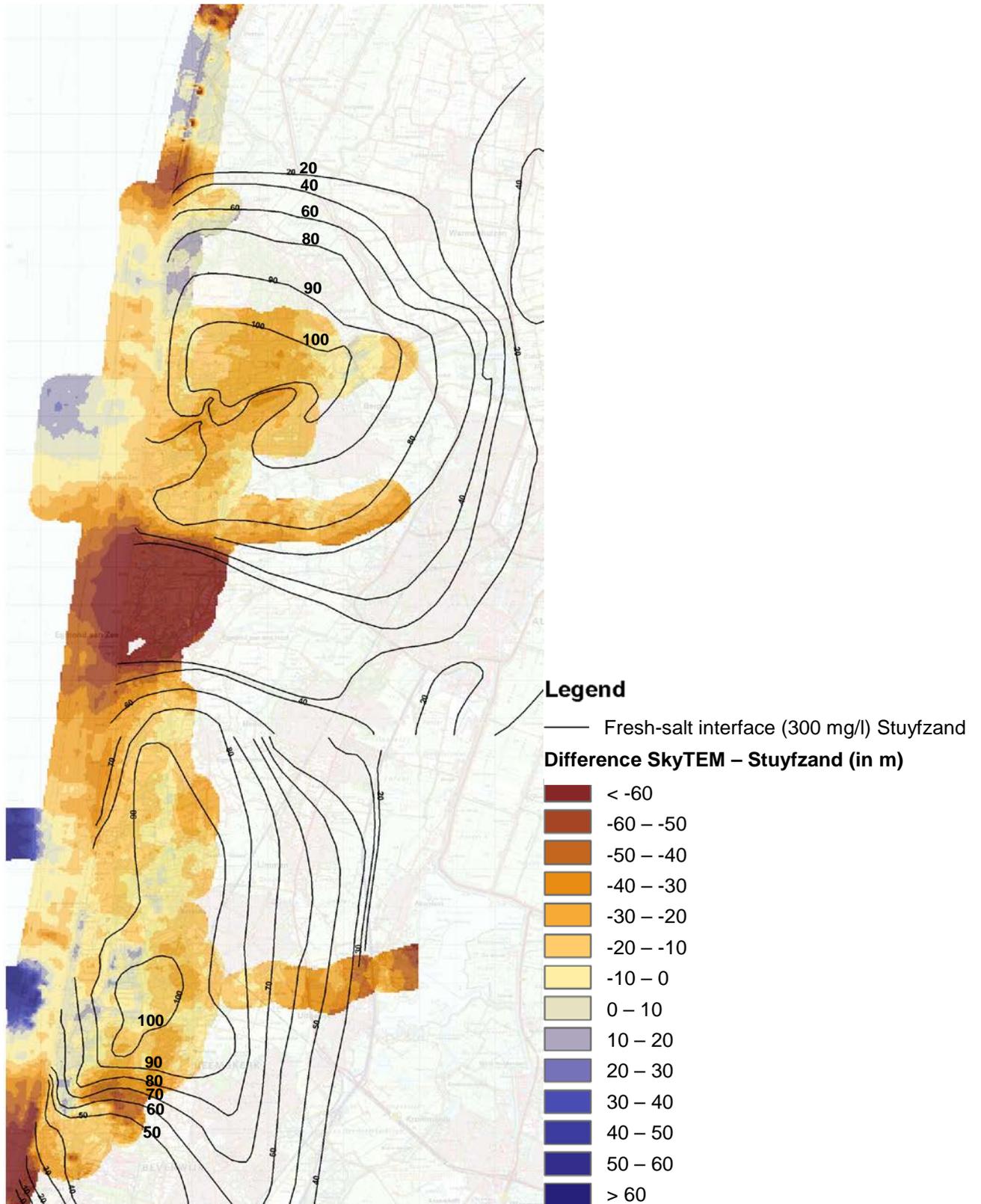
The major step in the interpretation and validation of the data is the combined visualization. Several techniques have been used to jointly view and interpret different data types. Using MATLAB and GIS software (ESRI ArcGIS, ArcScene, Google Earth) many different maps, images and interactive maps and charts have been developed. Figures 1 to 3 show some examples of these.

Combining all this info it proved possible to map the extent of the confining clay layer and to determine the fresh/salt interface that corresponds well with most other sources. Besides this the combined interpretation of all these sources gave many insights in the

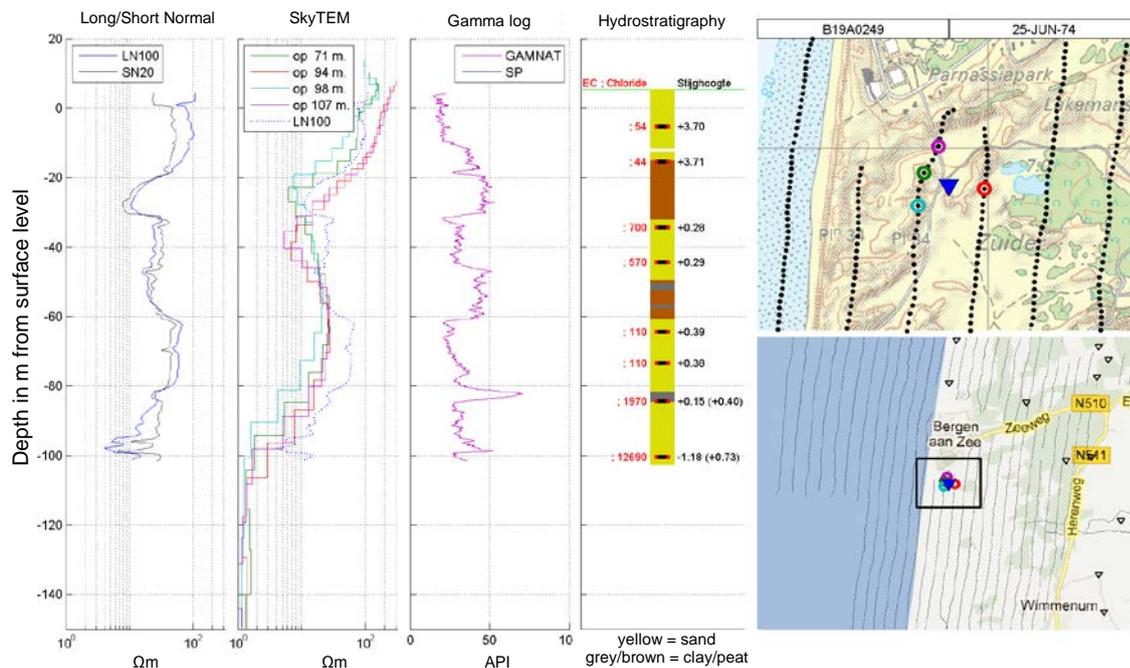
hydrogeological system and the developed tools, figures and maps are a great resource for other hydrogeological projects.



**Figure 1** Cross-section (left) showing the resistivities from airborne geophysics (red = low resistivity, blue = high resistivity), geological information from boreholes in the bars (yellow = sand, brown/grey = peat and clay) and aquitards (gray) from the groundwater model in the background



**Figure 2** Difference in depth of the fresh-salt interface as determined by Stuyfzand (1985) and based on the SkyTEM data



**Figure 3** Several sources of hydrogeological information combined in one figure. From left to right: borehole logging (Long Normal/Short Normal), SkyTEM (time-domain electromagnetics) data for 4 nearby sites, borehole logging (Gamma ray logging), hydrostratigraphy and maps showing the location

## References

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