SALINE GROUNDWATER IN THE QUAKENBRÜCK BASIN VERIFIED BY AIRBORNE GEOPHYSICS

Jennifer Klimke[1]; Gabriele Ertl[2]; Jörg Elbracht[2]; Helga Wiederhold[1]
helga.wiederhold@liag-hannover.de
[1]- Leibniz Institute for Applied Geophysics (LIAG), Hannover, Germany;
[2]- State Authority for Mining, Energy and Geology (LBEG), Hannover, Germany

Abstract. *A large scale airborne geophysical survey was conducted 2008 and 2009 in the German North Sea coastal areas. Beside saltwater intrusions from the North Sea the occurrence of saline groundwater due to salt structures was investigated. A test area for this was the Pleistocene Quakenbrück Basin in Lower Saxony, Germany.*
The survey was done with the transientelectromagnetic SkyTEM system. SkyTEM data and borehole data are the basis for a geological-geophysical 3D-model of the Quakenbrück basin. The sediment fill is of Saalian to Weichselian age.
For the interpretation of SkyTEM data resistivity borehole log data were used showing the correlation of electrical resistivity and grain sizes of sediments for the investigation area. Most stratigraphic units of the model area can be identified in the SkyTEM data by characteristic resistivities for freshwater filled sediments. The distribution of Eemian sediments dividing lower and upper aquifers can be mapped by this survey. Groundwater salinization in the deeper aquifer is clearly identified.
The combination of airborne electromagnetic data and geological data improves the resolution of the geological model and enables the partition of freshwater and saltwater filled sediments.
Keywords: *airborne electromagnetics, geological model, inland salinization, glacial sediments*

1. INTRODUCTION

In 2008 and 2009, large areas of Lower Saxony were surveyed with the aeroelectromagnetic system SkyTEM (Wiederhold et al. 2010). Besides mapping freshwater-saltwater interfaces in the coastal area a strip of 2 km width with 9 parallel flight lines (250 m spacing) and 160 km length extends from the coast in the north to the highlands in the south to evaluate the efficiency of the method in mapping glacially affected sediments. The area of the Quakenbrück basin was surveyed with additional flight lines to investigate the basin and the striking salinization of the groundwater in detail (Fig. 1). The Quakenbrück basin is part of an ancient hill-hole pair with thickness of Quaternary sediments in the basin of about 130 meters (van der Wateren 1994). Two aquifers are separated by Eemian clay.

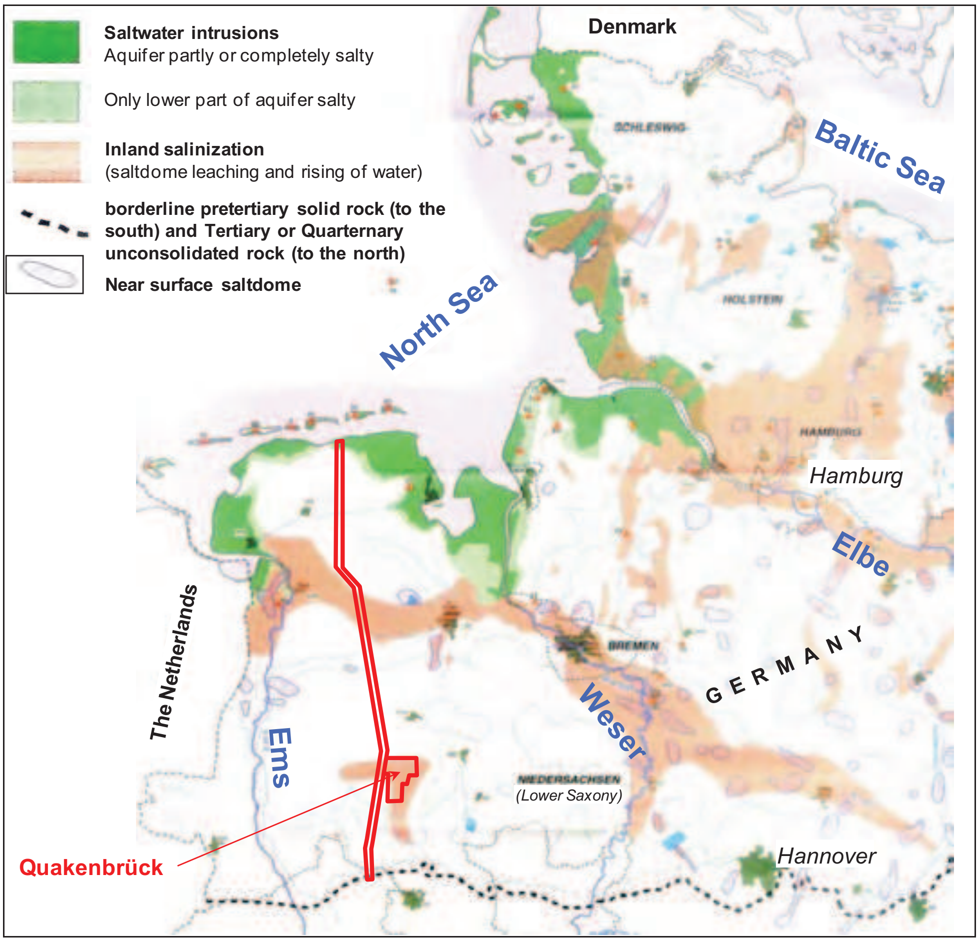

Figure 1. Location map: groundwater salinity in the North German Basin after Grube et al. (2000).The airborne electromagnetic SkyTEM survey area in Lower Saxony is marked in red.

2. DATABASE AND METHODS

The survey was operated by SkyTEM ApS using the time domain electromagnetic system SkyTEM (Sørensen & Auken 2004); the processing and inversion was carried out by Aarhus

Geophysics. The result is a 3D cube of resisitiviy data. To guarantee a reliable interpretation of the resistivity data a careful examination of borehole resistivity logs was done. Data of resistivity logs from 164 boreholes were analyzed leading to a resistivity-grainsize distribution for 24 lithologic classes. Prior to the final interpretation and set up of the 3D geological-geophysical model a model only based on borehole information was set up (GOCAD software). 420 boreholes were used with depths of about 20 to 100 m, only few have depths of about 150 m.

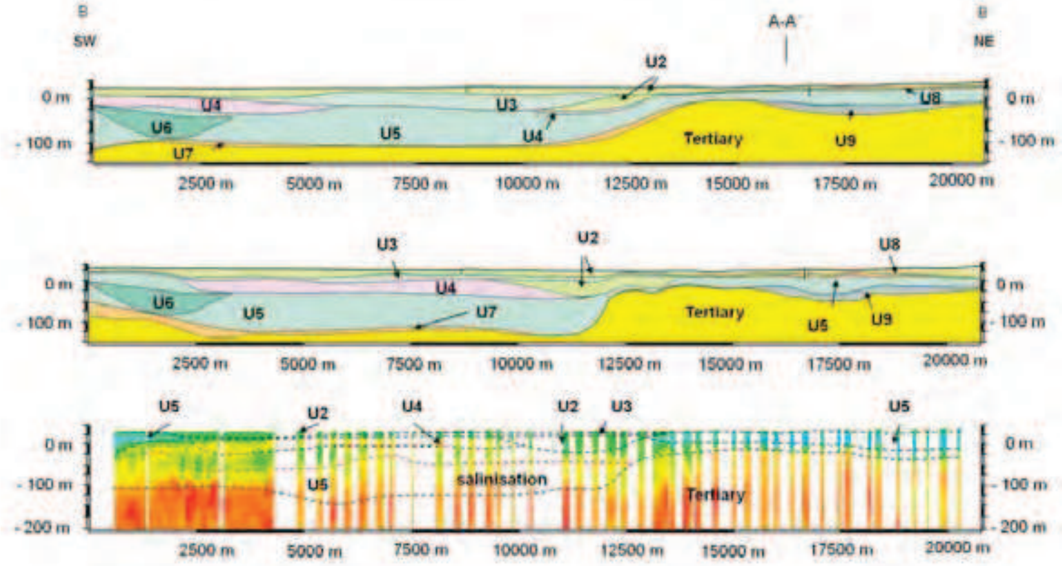

Figure 2. Cross section BB' extracted from the 3D-model (for location see Fig. 3). Top: geological (only based on boreholes), middle: geological-geophysical cross section (including resistivity interpretation). Bottom: corresponding resistivity section. Vertical exaggeration of the upper sections is 10. U2, U3 Weichselian sands (aquifer), U4 Eemian clay (aquitard), U5 Saalian sand (aquifer).

3. RESULTS

The resistivity-grainsize distribution shows a positive correlation between grain size and resistivity. Clayey sediments show resistivities of ~ 30 Ωm, silt 50 to 70 Ωm, fine-grained sand 130 to 150 Ωm, medium-grained sand 150 Ωm and gravel 170 Ωm.

Most of the defined stratigraphic units can be identified in SkyTEM data and can be modeled with a high resolution (Fig. 2). The combined model shows that Eemian sediments (aquitard) occur in the whole western and central part of the basin.

With the SkyTEM information it is possible to define the area with salinized water in the lower aquifer. The resistivity cross section (Fig. 2) shows areas where the Saalian meltwater sand does not show the characteristic resistivities of about 100 – 200 Ωm. This fact is used to define the distribution of this salinity zone (Fig. 2 and 3).

The groundwater salinization can clearly be identified and distinguished from non-salinized regions in the basin due to the low resistivites of about 10 Ωm, which are non-characteristic for Saalian meltwater sediments in the lower aquifer. Realizing that the salinization is limited to the lower aquifer, one can make the assumption that it is caused by the Permian salt-rich fluids and that faults in the anticline below the basin acted as pathways.

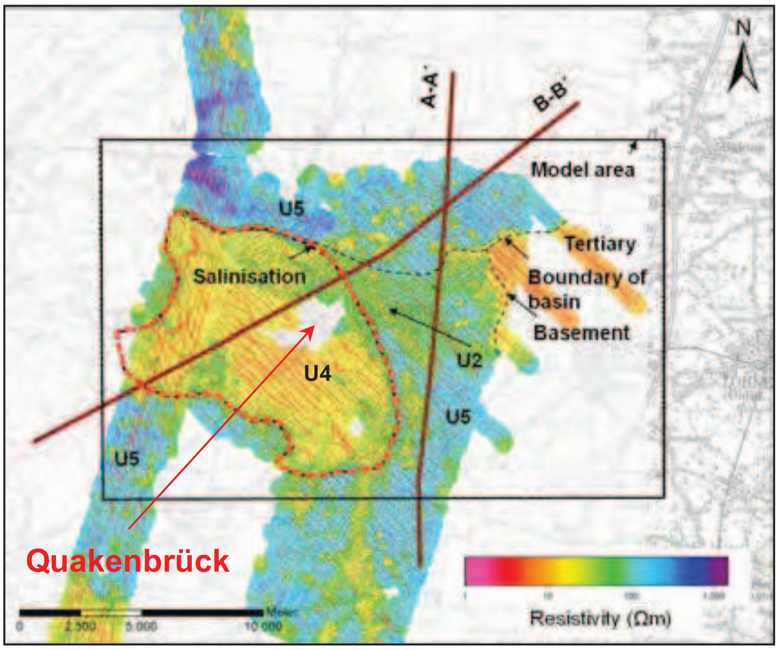

Figure 3. Resistivity depth slice for -20 to -10 m. Various stratigraphic units can be identified by their characteristic resistivity: Saalian meltwater sand (U5, 100 - 200 Ωm), Weichselian fine-grained sand (U2, 30 - 120 Ωm) and Eemian silt/clay (U4, 10 to 20 Ωm). The extent of the subjacent salinization is marked by red line.

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