Saline groundwater in the Quakenbrück Basin verified by airborne geophysics

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INTRODUCTION

In 2009 large areas of Lower Saxony were surveyed with the aeroelectromagnetic system SkyTEM. A strip of 2 km width with 9 parallel flight lines and 160 km length extends from the coast to the highlands 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 (Figs. 1 and 2).

GEOLICAL BACKGROUND

The Quakenbrück basin is an overdeepened glacial basin that is fronted by a composite thrust ridge, composed of deformed pre-Pleistocene and Pleistocene sediments (Fürstenau and Dammer Berge in Fig. 1). The basin and associated glaciotectonic complex formed during the Saalian Drente glaciation. The basin is filled with Saalian to Weichselian deposits (Fig. 3). The maximum depth is about 130 m.

SkyTEM is a transient electromagnetic method (TEM) applied from helicopter; it is a transient electromagnetic method (TEM) applied from helicopter; it is transient electromagnetic method (TEM) applied from helicopter. The airborne electromagnetic SkyTEM survey area is marked in red.


Fig. 1: SkyTEM survey Lower Saxony, resistivity map (depth: 0–200 m) and cross-section (left side). Background map shows elevation (max. 837 m) and rivers.

Interpretation models

GOCAD® Modeling of stratigraphic units and identification of stratigraphic units in the SkyTEM models

GOCAD® Combined geological-geophysical 3D-model

INTERPRETATION OF BOREHOLES AND ELECTRIC LOGS

420 boreholes from data base of Geological Survey LBEG are included in the GOCAD® 3D-model. In preparation of the 3D-model several 2D cross-sections were constructed.

To guarantee a reliable interpretation of the SkyTEM resistivity data 164 borehole resistivity logs were analyzed leading to a resistivity-grainize distribution for 24 petrographical classes (Fig. 4).

RESULTS

- The resistivity-grainize 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 (Fig. 4).
- Most of the described stratigraphic units can be identified in SkyTEM data and can be modeled with a high resolution. The combined model shows that Eemian sediments (U4, aquifer) occur in the whole western and central part of the basin (Figs. 5-7).
- With the SkyTEM information it is possible to define the area with salinized water in the lower aquifer. The resistivity cross-section (Fig. 6) shows areas where the Saalian meltwater sand (U5) does not show the characteristic resistivities of about 100 – 200 Ωm. This fact is used to define the distribution of this salinized zone (Figs. 5-7).
- The groundwater salinization can clearly be identified and distinguished from non-salinized regions in the basin due to the low resistivities of about 10 Ωm.
- As the salinization is limited to the lower aquifer, we assume that it is caused by the Permian salt-rich fluids and that faults in the anticline below the basin acted as pathways.