*Berichte Geol. B.-A.*, ***93***, *ISSN 1017-8880 – Applications in Contamination Monitoring*

# Monitoring the freshwater/saltwater transition zone on the North Sea Island Borkum using vertical electrode systems

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Resistivity is a key parameter in water sciences. In order to investigate the dynamics of the freshwater/saltwater boundary in the scope of climate change monitoring measurements are necessary. Besides repeated surface measurements using electromagnetic or electric methods in-situ measurements are required. Especially the long-lasting installation of electrodes in the target depth can provide continuous information.

In September 2009 the Leibniz Institute for Applied Geophysics (LIAG) Hannover installed two newly developed automated electrical resistivity tomography systems in the water catchment areas Waterdelle and Ostland at the North Sea island Borkum. The objective is the observation of changes in the thickness of the freshwater lens that can be caused by pumping of freshwater and upconing of saltwater. This work is part of the Interreg project CLIWAT (http://www.cliwat.eu).

The vertical electrodes were installed in the two boreholes CLIWAT 1 (Waterdelle) and CLIWAT II (Ostland) between 45 m and 65 m depth below the surface. In both boreholes this depth interval comprises the transition zone between the freshwater lens and the underlying saltwater. While in CLIWAT I sand was encountered at these depths, sand layers as well as silty / clayey layers were found in CLIWAT II.

Main part of the system is a vertical electrode chain of about 20 m length with 78 stainless steel ring electrodes mounted on a rigid PVC pipe. The distance between adjacent electrodes is 0.25 m. The measurements are carried out using a modified 4point light 10W (LGM Lippmann). The power is supplied by solar panels and the data are transmitted to an FTP server in Hannover. The time interval between subsequent measurements is 5 hours. Each data set comprises 975 single measurements using a Wenner-Alpha array with electrode distances between 0.25 m and 6.25 m. The correct geometry of the ring electrode is accounted for using the complete electrode model. The pseudosections can be inverted into real resistivities using a 1D-layered model.

Within the first months after installing the system the resistivity changes observed mainly in saltwater-dominated depths were caused by the readjustment of the disturbed conditions at the drilling locations to the normal situation. Afterwards the ongoing measurements in most depths show only small resistivity changes of less than five percent. This suggests a stable freshwater lens. But a more thorough analysis of the data shows that in some small depth intervals the change in resistivity may reach 20 %. Moreover, a different time-dependent behavior of resistivity is observed in different depths: In the freshwater and the saltwater layer the resistivity can be almost constant during a year, while resistivities change according to a sine wave in the transition zone. In the sandy and silty/clayey layers in CLIWAT II time behavior is different.

The ongoing in-situ measurements could be used to calculate TDS values. Moreover, they are necessary input parameters for the calibration of modeling studies that calculate future changes in this groundwater system caused by climate change.