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Development of a measurement concept for monitoring brine migration processes in saline aquifers

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CO2 is considered to be one cause of climate changing. Therefore, the preferential objective is to reduce the greenhouse gas, produced by industrial production. The long term storage in underground reservoirs represents one possible way to this aim.
The safe storage of CO2 in subsurface reservoirs is an important research focus of a multidisciplinary integrated project. That means an adequate monitoring of possible brine migration into freshwater aquifers from lower saline aquifers, by gas displacement. Being part of a complex monitoring system, the electrical resistivity tomography (ERT) should be responsible for the near subsurface region and the surrounding area of the boreholes.
On the one hand a depth of the storage horizon at about 1000 m makes it difficult to deploy ERT. The volume of investigation depends strongly on the electrodes distance, which should be practicable in field surveys. Otherwise we expect only a small contrast in resistivity changing, due to a shallow transition between freshwater and saltwater. Therefore, the main objective is to find an optimal combination of several electrode arrays like surface, surface-downhole and cross-borehole configurations to detect time-lapse effects of the resistivity distribution in the subsurface.
At first a large scale geological model was installed with the correct depth and thickness of the layers. The temporal process of brine migration was simulated by changing the resistivity values. The limit of resolution could be appointed by different separations of electrodes and boreholes. In addition, an appropriate sandbox model has been realised in order to control and to adjust the numerical simulations. Material of several grain sizes represents the underground layers and pressure connections on the sides of the sandbox control the brine flow for different salinisation scenarios. Boundary effects on laboratory models are a well-known problem that has to be considered. Generally there is no current flow through the boundary layers. Test measurements under predefined conditions have been performed in order to quantify undesirable effects and errors.
Furthermore, the measurement concept under development includes also temperature, salinisation and saturation sensors in different depths of the sandbox, for calibration and completion of the geoelectrical measurements. These small-sized sensors are based on optical fibres, which cannot disturb the electrical measurements due to their electromagnetic inertness. First tests with the salinisation sensor show high temporal resolution and a high accuracy of the investigated synthetic brines.