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Cross-hole ERT monitoring of freshwater injection in a hyper-saline aquifer

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In November 2011 we performed a freshwater injection experiment in the hyper-saline aquifer underlying the Molentargius-Saline Regional Park located near Cagliari in southern Sardinia, very close to the coastline. The subsurface water reaches salinity levels as high as three times the NaCl content of seawater, most likely as a consequence of salt release from the nearby salt works, active from Roman times to the mid-twentieth century. Five ERT boreholes were drilled with 4 inches inner diameter to a depth of 20 m and positioned in the shape of a square with an 8-m long side, with one borehole at the centre. All boreholes are equipped with a fully screened PVC pipe bearing externally twenty-four stainless steel cylindrical electrodes from 0.6 m to 19 m depth with 0.8 m separation. The water table is stable around -5.2 m from the ground surface. The sediments are mostly composed of sands with thin layers of silty sand, clayey sand and silty clay. Electric fluid logs recorded in the boreholes allowed to discriminate two zones, with a transitional layer in between: (a) from the water table to 7.5 m the water electrical conductivity is about 2 S/m; (b) below 12 m depth the water electrical conductivity reaches 18.5 S/m. In November 2011 we injected 19.4 m3 of freshwater in about 4 hours using a double packer system positioned in the central borehole, with an injection chamber located between 13.5 and 14.5 m below ground surface. Time-lapse ERT monitoring was achieved by measuring along two 2D ERT planes corresponding to the two square diagonals, thus involving three boreholes at a time for a total of 72 electrodes. A mixture of skip 0 dipole-dipole and bipole-bipole configurations was used in each acquisition, that required about 1 hour using an IRIS Syscal Pro resistivity meter. The resulting ERT time-lapse images show clearly the development and motion of the injected freshwater bulb, that undergoes a fast vertical migration and a quick disappearance probably caused by intense mixing with the hyper-saline aquifer water. Modeling of the injection experiment using a gravity-driven flow simulator is aimed at defining the quantitative parameters controlling the plume behavior as observed in the ERT tomography, with the final aim of building a joint hydro-geophysical inversion procedure.