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3D modeling of density and substratum topography effects in a heterogeneous aquifer: the case of the hundred year saline pollution in the Upper Rhine valley

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Knowing the distribution of fresh and saline groundwater is an important issue of the sustainable management of water resources. Here we deal with groundwater plume pollution coming from brines of salted waste heaps in the Upper Rhine aquifer, one of the most important groundwater resources for Western Europe. It has been contaminated in its upstream part by mining brine infiltration coming from potash extraction which started at the beginning of the twentieth century. The salty residues were stored in waste heaps near the mine shafts, and, due to rainwater percolation through the heaps, saline aqueous solutions mixed with groundwater and then progressed in the flow direction, forming high salinity plumes. In the present case, it is proved that density effects are all the more necessary to be considered in a modeling approach that brines density can reach high values just below waste heaps. For this purpose a 3D model is developed using the SEAWAT option of Modflow in a 30 layers model. Simulations are performed on about one hundred years, where chlorine concentration data on the last thirty years are used to constrain the model. In our case, conjugated to a heckled substratum topography, heterogeneous hydrodynamical conditions and the fact that pollution history alternates high pollution phases with relatively low pollution phases, density driven flows lead salted water into original directions downstream waste heaps. From a numerical point of view, it is also shown that discretization degree plays a major role in the density effect modeling.