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Upconing of deep saline waters via Quaternary erosion windows considering varying hydrogeological boundary conditions

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Intrusion of deep saline waters into freshwater aquifers does not only endanger the regional drinking water supply, but also rivers and stagnant waters as well as their fauna and flora are threatened by salinisation. The upconing of highly mineralised saline waters in large parts of the North German Basin is favoured by the presence of Elsterian glacial erosion windows in the Lower Oligocene Rupelian Clay, the most important confining unit in this region. Lower precipitation rates and decreasing groundwater levels as a consequence of global climate change, but also anthropogenic interventions, such as increasing extraction rates or the utilisation of the geological subsurface, decrease the pressure potential in the freshwater column and may possibly accelerate primarily geogenic salinisation processes in the coming years [1, 2].

In this study, density-driven flow and transport modelling [3] was performed to investigate the upconing mechanisms of deep saline waters across Quaternary window sediments in the Rupelian. First, the main variables influencing the dynamics of the freshwater/saltwater boundary were determined using generic 2D models. For a site-specific analysis along a 20 km long transect in the Federal State of Brandenburg, Germany, the geological/hydrogeological conditions were then integrated into the 2D models, starting from the Mesozoic strata in the bedrock of the Rupelian sequence as the model basis, up to the Quaternary unconsolidated rock series at the ground surface. At site, the Rupelian Clay has been partially eroded and salinisation in the hanging freshwater column is already detectable.

Simulation results show that the interactions between influencing variables, e.g., the regional groundwater flow and seasonal dynamics of the groundwater recharge rate, as well as anthropogenic interventions such as extraction rates of drinking water wells, have a significant influence on the groundwater pressure potential in the freshwater aquifer and associated saltwater upconing. The temporal development of saltwater intrusion shows up quite differently, depending on boundary conditions and also strongly depends on flow rates and cross-section of the Rupelian windows. Depending on the topography, the fluid density gradient and its effect on flow conditions and pressure potential, creates a dynamic between deep saline and shallow freshwater aquifers, with ascending flow occurring locally in larger discharge areas. The next steps will comprise a 3D extension of the model as well as consideration of chemical rock-water interactions.

Literature

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