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Convective salt transport in the North East German Basin: results from 3D numerical simulations

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Solute and heat transport in aquifers are studied for their relevance in socio-ecological issues such as energy self-sufficiency and pollution of the environment. An example is the migration of dissolved halite released by salt structures which are commonly found in many geological formations. Subsurface dissolution of salt diapirs is usually invoked to account for the origin of saline groundwaters in sedimentary basins (Musgrove and Banner 1993). In different areas of the North East German Basin (NEGB) saline waters come close to or even reach the surface. Several mechanisms may be responsible for driving the heavier saline water up to the surface. The driving forces can be intrinsic to the basin like thermal variations or external (hydraulic head). However, because the topography is rather flat in the NEGB, local effects from a varying hydraulic head can not be the only reason for this processes while preliminary model approaches indicate a sufficiently strong interaction with the temperature field which can induce free convection (Clausnitzer et al. 2001). It is proved that temperature gradients can lead to transport dissolved salt over large spatial scales and significantly shorter migration time scales than compared with diffusion alone (Simms and Garven 2004). This flow regime is also referred to as thermohaline convection. Based on a extensive data collection, a hydrogeological model of the NEGB was developed which contains the major stratigraphic and hydrogeologic units from Quarternary to the Upper Permian. In contrast to normal groundwater models for freshwater, large scale simulation of coupled flow requires a proper fluid density model. Available data from wells indicate that brine stratification is under unstable conditions in the deeper underground. Therefore an appropriate fluid density model is incorporated in which brines are supposed to be pure NaCl solutions. In order to analyse the possible transport mechanisms within the basin 3D thermohaline simulations have been carried out on the whole basin extension (230x330 km). The results indicate that salt water oc-

curring close to the surface within the lowlands along the larger rivers may mainly be driven by hydrostatical forces from the surrounding highlands. The results also point out a situation where thermohaline convection occurs in a hypersaline geothermal system over a large spatial and temporal scale. Thermally induced convective flow play a dominant role in areas with minor topography. In summary, the complex pattern of near surface occurrences is probably due to the interaction of hydrostatic and thermal forces. Scenarios that allow for such mixed convection may be needed to understand the mechanism behind numerous previously unexplained field observations of deep-groundwater occurrences near the basin surface. The potential presence of large-scale convection cells has implications both for the fundamental understanding of basin processes as well as for socio-economic issues.

References

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