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Modelling of thermohaline circulation in sedimentary basins

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In several areas of the Thuringian basin saline water comes close to or even reaches the surface. However, it is not obvious, why denser brine overlays lighter fresh water in this region. The hydrogeological processes which cause the rising of saltwater plumes from deeper geological layers to the surface are not yet fully understood. The goal of this modelling project is to investigate the mechanism of brine transport within the aquifers of sedimentary basins in general and of the basin of Thuringia in particular. So in this research we ask, how does the fluiddynamic look like and how does the fluid convection of the deep horizons interact with groundwater flow near the surface? The coupling of different flow processes could explain salty groundwater near the surface and within springs in the Thuringian basin.

We focus on convection caused by density differences due to varying salinity and temperature. This process, known as thermohaline flow, is nowadays theoretically well understood. Further there exists a range of laboratory experiments as well as benchmarks for numerical solutions of simulation software. The challenge for us is to include density driven flow as a numerically very sensitive process to a model that represents a large scale geologically realistic setting.

Our model is a cross section of the Thuringian basin of approximatly 150 km length and 600 m height. The hydrogeological model is based on the major stratigraphical units from upper Perm (Zechstein) to upper Triassic (Keuper) with the lower Triassic (Bundsandstein) formations representing the main aquifer. The structural model as well as aquifer parameters are provided by geological partner groups at the University of Jena, Germany. To investigate hydrogeological scenarios we use the groundwater simulation program OpenGeoSys, which allows us to calculate thermally, hydrologically and chemically coupled processes.

The first cornerstone is the setup of a converging groundwater model with realistic boundary conditions and geological stratificaton. The next step is to include thermal and chemical processes for brine transport. The numerical simulation of these processes is very sensitive to the quality of the grid. Therefore substantial analysis of the mesh quality is necessary. This poster presents work in progress. Further improvement of the model will focus on including geological faults and the impact of heterogeneity.

With this work we contribute to the understanding of the interaction between diffusive solute transport and thermally and head-driven flow in the sedimentary basin of Thuringia.