Description of doctoral project and research results achieved to date

Global climate change, shortage of resources and the growing usage of renewable energy sources have led to an increased demand for the utilization of subsurface systems. Meanwhile, this leads to a situation where the demands of certain types of the subsurface compete with each other. Among such technologies are, for example, Carbon Capture and Storage (CCS), geothermal energy, nuclear waste disposal, “renewable” methane or hydrogen storage as well as the ongoing production of fossil resources like oil, gas and coal.

One of the key issues is finding suitable sites, considering that the a priori database is usually small: relevant hydrogeological reservoir properties such as permeabilities and porosities are unknown beforehand and estimations may vary over orders of magnitude due to the large spatial variability of these parameters. Therefore, a screening step taking into account all reliable data of the reservoir has to be followed by more detailed investigations on a smaller scale until a number of qualified sites has been found. Each step requires the definition of different criteria. The criteria can be manifold and may include technical, economical, legislative and social aspects. For CCS, storage efficiency is an important criterion (Bachu 2003 and Kopp et al. 2009).

This thesis investigates CCS storage efficiency. The chosen approach is based on the gravitational number as a simple qualitative indicator which comes at a negligible computational cost. The developed indicator is applied to the Middle Buntsandstein subgroup in Northern Germany. It is calculated based on data for depth, temperature and salinity which can be used to determine fluid properties of brine and CO$_2$. The results (Kissinger et al. 2014) show that variations of depth, temperature and salinity as found in the North German Basin have a noticeable influence on the CO$_2$ and brine densities and viscosities, and thus on storage efficiency.

Various technologies may create conflicts with essential public interests such as water supply. For example, the injection of CO$_2$ into the subsurface causes an increase in pressure. This increased pressure reaches far beyond the actual radius of influence of the CO$_2$ plume, potentially displacing large amounts of salt water that could contaminate drinking water aquifers. For estimating the impact of different uses, it is necessary to consider not only the reservoir itself but also the regional-scale hydrogeology. This is especially important for the vertical migration of displaced formation fluids or contaminants. Structures such as fault zones or salt domes are considered as potential pathways or barriers for displaced fluids into shallow systems and their influence has to be taken into account. Salinity and temperature gradients in a multi-layered system in combination with potential conduits such as a fault zone create complex flow patterns which may influence the movement of displaced fluids. Since far field data availability for the deep subsurface is usually sparse, the uncertainty of the model output is high and the use of simple and fast models becomes more attractive. It is the aim of this work to test different levels of model complexity and show (i) where simplified calculation methods may still lead to reasonably accurate results on the basis of a sparse data base, and (ii) which situations and problems require more complex/less simplified approaches. A realistic CO$_2$ storage site with typical geological features found in the North German Basin is used to test different levels of model complexity.
References


