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Numerical simulation of CO_2 storage at Ketzin: Evaluation of model approaches

Ursula Lengler, Marco De Lucia, and Michael Kühn
GFZ German Research Centre For Geosciences, Centre for CO2 Storage, Potsdam, Germany (ulengler@gfz-potsdam.de)

Numerical modelling of multiphase flow is an essential tool to ensure the viability of long-term and safe CO_2 storage in geological formations. Uncertainties arising from the heterogeneity of the formation and lack of knowledge of spatially variable formation properties need to be assessed in order to create a model that can reproduce the data available from monitoring.

At the Ketzin test site (CO_2SINK) monitoring data used for history matching are injection pressure and CO_2 gas arrival times at two observation wells. The CO_2 breakthrough at the first observation well, 50 m from injection, was in good agreement with the predictions made by different modelling approaches, whereas the arrival of the CO_2 at the second observation well, 112 m from injection, occurred notably later than predicted. The reasons for this discrepancy between predicted and observed arrival times are under further investigation. The impact of spatial variability of the permeability within the fluviatile sandy channel-(string)-facies rocks of the Stuttgart Formation was studied with 2D vertical and horizontal models in a stochastic Monte-Carlo framework. The flow path in 2D vertical models is dominated by buoyancy and overlays the effects due to spatial heterogeneity, i.e. the second arrival time cannot be predicted by 2D vertical models. At the contrary, 2D horizontal, heterogeneous models are able to match the second arrival time with finite probability. To match the temporal injection pressure, the sandstone channel width of the 2D horizontal model was adjusted as well as the permeability.

The study concluded that the heterogeneity within a sandstone channel cannot be the only reason for the late CO_2 arrival. The decisive factor is possibly the heterogeneity of the geometry and location of the fluviatile sandy channel-(string)-facies rocks and the small scale heterogeneity emphasizes this effect.

The different model approaches (1D, 2D vertical, 2D horizontal, homogeneous, heterogeneous) are compared and evaluated regarding the assignments to cope with (i.e. storage capacity, max. CO_2 gas extent, injectivity).