Numerical Simulation Study for the Evaluation of the UHS Pilot Test HySTORAGE

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With the scope of a carbon-free energy economy, the importance of Underground Hydrogen Storage (UHS) is unquestionable. First pilot tests on smaller scale have been conducted to assess the technical feasibility of hydrogen storage in porous reservoirs. Particular interest is located on the mixing behavior of the stored hydrogen with the initial gas and potential losses due to microbial process.

To improve the understanding of these hydrogen-related processes, the ongoing field test HySTORAGE initiated by Uniper Energy Storage GmbH is accompanied by a numerical simulation study. For this purpose, a previously developed bio-reactive transport model realized in the open source simulator DuMu^x is employed to predict and reproduce the observations from the field test. A compartment of the complex geological model was selected, the grid was modified, and recent field history was reproduced to validate the developed simulation model. For considering the contribution of mechanical dispersion to the gas-gas mixing, the approach encompassed modifications regarding the discretization scheme, gridding, and well modeling. First simulation runs of the first phase of the field test were performed to provide a prediction for the operation and estimate potential hydrogen losses. According to the simulations, for the base case, neglecting microbial reactions and mechanical dispersivity, approximately 98 % of the injected hydrogen was reproduced after the first phase. With increasing dispersivities and microbial activity, this hydrogen recovery decreased.

After completing the first phase of the field test, the measured data are compared with the modeled prediction to identify dominating processes during the field test. In particular, the reproduced gas compositions indicate the contributions of microbiology and gas-gas-mixing to the permanent and temporary losses of hydrogen.