A-130

Experimental investigations and development of a correlation to characterize the diffusion process of hydrogen and methane during UHS

J. Michelsen, S. Hogeweg, B. Hagemann, N. Langanke, L. Ganzer
TU Clausthal, Institute of Subsurface Energy Systems, Clausthal-Zellerfeld, Germany

Renewable energy sources are becoming increasingly important during the current energy transition. The growing share of renewable energy sources problematically leads to fluctuations challenging the entire energy system. To keep the balance between energy demand and production in the future, and therefore to maintain energy availability, excess energy can be converted into hydrogen, stored and thereby acts as a buffer. Porous reservoirs, such as depleted natural gas fields, offer a good potential to store hydrogen in appropriate quantities. A reliable and effective storage operation requires a fundamental understanding of the mixing processes between the injected hydrogen and residual/cushion gas, supporting the deliverability of the storage. Besides the pressure-driven advective flux, mechanical dispersion and molecular diffusion influence the progressive mixing with the initial gas, typically natural gas. In the present study, experimental investigations are performed to determine gas-gas diffusion coefficients of the binary hydrogen-methane system. Here, diffusion experiments using a novel pseudo-stationary approach with dry reservoir rock samples at typical storage conditions (temperatures and pressures) are performed. Evaluations of the experiments showed effective diffusion coefficients for the system to lie within a range of $9.00 \cdot 10^{-8} - 2.00 \cdot 10^{-7}$ m^2/s.
A temperature and pressure dependent correlation is developed to predict effective diffusion coefficients for the porous rock samples. Furthermore, the experimental results are used to establish an additional correlation describing the interdependence between bulk and porous medium diffusion. This relationship depends on petrophysical properties such as porosity, permeability, and tortuosity. For the correlation, the polynomial regression approach is used; nevertheless, more general forms can be produced by measuring other binary gas constellations. The achieved correlation can be used in various models, such as the simulation of underground hydrogen storages on field scale.