



Experimental investigations and geochemical modelling of site-specific fluid-fluid and fluid-rock interactions in underground storage of CO₂/H₂/CH₄ mixtures: the H2STORE project

Marco De Lucia and Peter Pilz

GFZ, Potsdam, Germany (delucia@gfz-potsdam.de)

Underground gas storage is increasingly regarded as a technically viable option for meeting the energy demand and environmental targets of many industrialized countries. Besides the long-term CO₂ sequestration, energy can be chemically stored in form of CO₂/CH₄/H₂ mixtures, for example resulting from excess wind energy. A precise estimation of the impact of such gas mixtures on the mineralogical, geochemical and petrophysical properties of specific reservoirs and caprocks is crucial for site selection and optimization of storage depth.

Underground gas storage is increasingly regarded as a technically viable option for meeting environmental targets and the energy demand through storage in form of H₂ or CH₄, i.e. resulting from excess wind energy. Gas storage in salt caverns is nowadays a mature technology; in regions where favorable geologic structures such as salt diapires are not available, however, gas storage can only be implemented in porous media such as depleted gas and oil reservoirs or suitable saline aquifers. In such settings, a significant amount of in-situ gas components such as CO₂, CH₄ (and N₂) will always be present, making the CO₂/CH₄/H₂ system of particular interest. A precise estimation of the impact of their gas mixtures on the mineralogical, geochemical and petrophysical properties of specific reservoirs and caprocks is therefore crucial for site selection and optimization of storage depth.

In the framework of the collaborative research project H2STORE, the feasibility of industrial-scale gas storage in porous media in several potential siliciclastic depleted gas and oil reservoirs or suitable saline aquifers is being investigated by means of experiments and modelling on actual core materials from the evaluated sites. Among them are the Altmark depleted gas reservoir in Saxony-Anhalt and the Ketzin pilot site for CO₂ storage in Brandenburg (Germany). Further sites are located in the Molasse basin in South Germany and Austria. In particular, two work packages hosted at the German Research Centre for Geosciences (GFZ) focus on the fluid-fluid and fluid-rock interactions triggered by CO₂, H₂ and their mixtures. Laboratory experiments expose core samples to hydrogen and CO₂/hydrogen mixtures under site-specific conditions (temperatures up to 200 °C and pressure up to 300 bar). The resulting qualitative and, whereas possible, quantitative data are expected to ameliorate the precision of predictive geochemical and reactive transport modelling, which is also performed within the project.

The combination of experiments, chemical and mineralogical analyses and models is needed to improve the knowledge about: (1) solubility model and mixing rule for multicomponent gas mixtures in high saline formation fluids: no data are namely available in literature for H₂-charged gas mixtures in the conditions expected in the potential sites; (2) chemical reactivity of different mineral assemblages and formation fluids in a broad spectrum of P-T conditions and composition of the stored gas mixtures; (3) thermodynamics and kinetics of relevant reactions involving mineral dissolution or precipitation. The resulting amelioration of site characterization and the overall enhancement in understanding the potential processes will benefit the operational reliability, the ecological tolerance, and the economic efficiency of future energy storing plants, crucial aspects for public acceptance and for industrial investors.