Hydrogen solubility in brine at reservoir temperature and pressure and induced mineral-fluid reactions

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Hydrogen gas storage in the subsurface is considered as a potential option for temporarily storing large amounts of power and thereby to dampen the fluctuating production by wind or solar power plants, which is required for the transition to renewable energy sources ("Energiewende"). Subsurface energy storage, however, requires an adequate process and system understanding in order to assess the feasibility of and effects induced by the storage operation [1]. When injecting hydrogen into porous formations for storage, hydrogen dissolves in the resident formation fluid and may trigger geochemical reactions with the reservoir host rock. For the quantitative description of induced effects, the hydrogen solubility is a key factor, as it determines the amount of hydrogen in the formation water and thus the extent of possible reactions.

In this work, a new thermodynamic model of hydrogen dissolution under reservoir conditions is established, which accurately determines solubility and brine density. It accounts for pressure, temperature, the fugacity coefficient, gas composition, Henry's constant, the Poynting Factor and activity coefficients in the formation brine (i.e. at high salinity conditions). Appropriate ranges of application are 273-373 K, 0.1-50 MPa and 0-5 mol/l NaCl. The model is verified against experimental data and can reproduce the measurements to within measurement error (< 5%) [2].

The model was included in the open source scientific numerical simulator OpenGeoSys [3] and subsequently used for simulating the induced geochemical effects of a hypothetical hydrogen gas storage into a typical storage formation in North Germany. Generally it is found that abiotic reactions are not fast and strong for typical temperature conditions, however may become stronger at elevated temperatures at increased depth.

[1] Bauer *et al*. (2013) *Environ Earth Sci* **70**:3935–3943. [2] Young. (1981) IUPAC Solubility Data Series, v5/6 Hydrogen and Deuterium. [3] Kolditz et al. (2012) *Environ Earth Sci* **67**:589–599.