

## **Dry abiotic oxidation of H<sub>2</sub> by hematite, pyrite, and other redox-active minerals at subsurface conditions (120°C, 200 bar)**

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Despite widespread H<sub>2</sub>-generating processes in the subsurface like serpentinization or radiolysis of water, molecular hydrogen in the subsurface rarely occurs in higher concentrations [1]. Hence, significant amounts of H<sub>2</sub> are lost in a variety of processes that encompass microbial activity as well as abiotic oxidation. The knowledge of reaction rates of abiotic oxidation of H<sub>2</sub> at reactive mineral surfaces or by dissolved oxidizing species are not only useful for a quantitative description of natural H<sub>2</sub> flows but also for underground hydrogen storage (UHS). UHS is a promising technology for buffering fluctuations in electricity production by renewable sources [2]. The extent of abiotic oxidation of H<sub>2</sub> under UHS conditions is one crucial parameter for the assessment of a potential storage formation. However, there is a lack of kinetic data for low-temperature abiotic H<sub>2</sub> oxidation processes.

To fill the gap we conducted a series of initially dry experiments with H<sub>2</sub> at potential UHS conditions. H<sub>2</sub> was reacted with several redox-active minerals (hematite, pyrite, magnetite, goethite, anhydrite and chlorite) typically occurring in porous sandstone formations or shale cap rocks to (1) identify H<sub>2</sub>-oxidizing mineral surfaces and (2) to derive kinetic data of abiotic H<sub>2</sub> oxidation for minerals with significant reactivity. The experiments used sealed gold capsules as reaction cells in high-pressure reactors at 120°C, 200 bar for 2-14 days. The reaction progress was monitored by quantifying the amount of consumed H<sub>2</sub> and, in addition, the amount of generated reaction products as H<sub>2</sub>O or H<sub>2</sub>S by means of gas chromatography and mass spectrometry.

In experiments with initially dry conditions, only hematite and pyrite along with the less reactive goethite and smectite exhibited a detectable H<sub>2</sub>-consumption. Thus, kinetic data of H<sub>2</sub> oxidation by hematite and pyrite in the dry system were obtained in follow-up experiments at different temperatures. Current investigations focus on hydrothermal experiments of redox-active minerals with an initial liquid water phase and H<sub>2</sub>.

[1] - Sherwood-Lollar *et al.* (2014) *Nature* **516**, 379-382.

[2] Liebscher *et al.* (2016) in *Hydrogen Science and Engineered Materials*, 629-658.