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Mineral reactivity under subsurface hydrogen storage conditions from the Carpathian-Pannonian region: an experimental and geochemical modeling study

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The concept of subsurface hydrogen storage was born in the middle of the 1970's in the shadow of the global oil crisis, however the high prices of commercial hydrogen limited the interest in it as an energy source. Today, hydrogen is considered to be a major energy carrier as well as potential alternative fuel in transportation.

Porous rocks receive a high attention for the future hydrogen storage as geologic structures can achieve greater void volume compared to surface storage options. Understanding the potential reactions of injected hydrogen with pre-existing minerals, gases, ions, and other substances (e.g., microorganisms) is critical as it is required for safety and keeping the quality of the withdrawn hydrogen. Abiotic processes are inorganic reactions between the reservoir rock, in-situ brine, and injected H_2 that could alter the petrophysical reservoir performance (porosity, permeability, pore structure, and composition) and the geo-mechanical stability of the rock.

The subject of this research is the Late Miocene sandstone of the Alföld Formation Group located in the Pannonian basin, Carpathian-Pannonian region. This succession can potentially play a significant role in hydrogen storage in the future, due to its favorable reservoir geological and petrophysical characteristics.

We studied the abiotic reactions that can occur in the reservoir by a combined experimental and geochemical modeling work. Among the rock forming minerals, two constituents are highlighted in this study. K-feldspar ($KAlSi_3O_8$) is one of the most pH sensitive silicate minerals and pyrite (FeS_2) is a redox sensitive accessory mineral of sedimentary rocks.

Static batch reactor experiments were conducted in the pressure and temperature range of

subsurface hydrogen storage to track the effect of hydrogen on K-feldspar and pyrite in a similar way as described in Gelencsér et al. (2023). Geochemical modeling was performed in PHREEQC modeling environment.

Results show that K-feldspar behaves similarly both under hydrogen and nitrogen “atmosphere”. Pyrite can react with hydrogen resulting in partial alteration of pyrite surface (thorough the precipitation of pyrrhotite [FeS]) and hydrogen sulfide (H_2S) production, whereas the reference experiments (with nitrogen) did not show any H_2S release or the appearance of pyrrhotite.

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Reference:

Gelencsér O., Árvai C., Mika L. T., Breitner D., LeClair D., Szabó C., Falus G. and Szabó-Krausz Z. (2023) Effect of hydrogen on calcite reactivity in sandstone reservoirs: Experimental results compared to geochemical modeling predictions. *J. Energy Storage* **61**, 1–6.