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Geochemical reactivity of hydrogen with Buntsandstein sandstones under reservoir conditions: implications for underground hydrogen storage

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Underground hydrogen storage is a promising method for large-scale energy storage to balance the fluctuation of renewable power supply. However, results for the geochemical reactivity of hydrogen with reservoir rocks are still rare, particularly for their potential effects on reservoir performance. Some minerals such as hematite, pyrite, and calcite can react with hydrogen under certain temperatures to for other minerals (i.e., magnetite/iron, pyrrhotite, and CaO/Ca(OH)2, respectively) and consume hydrogen. These mineralogical transformations due to the presence of hydrogen may change the pore structure and affect the storage properties. In this study, we investigated the geochemical reactivity of hydrogen with Buntsandstein reservoir sandstones, collected from hydrocarbon wells at a depth of about 2.5 km. The experiments were performed at 100 °C under a constant hydrogen pressure of 150 bar for one month. Four different scenarios including dry hydrogen, dry air, synthetic saline fluid-saturated rocks with pure hydrogen and with pure helium were compared to systematically understand the reaction attributed to hydrogen instead of fluid-rock interactions or temperature effects. Permeability, porosity, magnetic susceptibility and fluid element concentration were measured before and after hydrogen experiments to shed light on the potential reaction. The results indicate that no fundamental and substantial changes in the minerals were induced by hydrogen reaction under the simulated conditions. Magnetic susceptibility reveals that no magnetic minerals (e.g., magnetite) were formed. The slight variation of permeability and porosity is mainly due to fluid-rock interaction indicated by the changes in the fluid element concentration. Our overall results reveal that there is no risk of hydrogen loss and reservoir performance reduction due to geochemical reactions between Buntsandstein sandstone and pure hydrogen under temperatures up to 100 °C. However, we are continuously investigating more extreme pressure and temperature conditions with samples containing sufficient amounts of Fe2O3 and FeS2, which is not very well known.