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Paper**



**Assessment of Possible Geochemical Reactions During
Hydrogen Storage in Salt Caverns-A Lotsberg Case Study**

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Abstract

Hydrogen can play a crucial role in the transition from fossil fuels to clean energy. Salt caverns are considered one of the most promising underground options for safe and efficient H₂ storage due to their high sealing potential and impermeability. To improve upon the underground hydrogen storage (UHS) process, it is necessary to investigate underground interactions of hydrogen with brine and salt rocks. However, these storage sites can be impacted by subsurface geochemical reactions. Specifically, reactions between H₂ and rock minerals may lead to the consumption of stored H₂, and result in its contamination with by-products. This research aims to conduct a geochemical modelling study to achieve the following objectives: 1) assess H₂ consumption associated with H₂ dissolution in brine and H₂-related geochemical reactions; 2) evaluate the effects of pressure, temperature, mineralogy, and brine composition on geochemical reactions. The subject of this study is the Lotsberg Salt Formation located in central Alberta.

We conduct thermodynamic equilibrium and kinetic modelling to investigate the potential geochemical reactions in salt caverns. The analysis revealed that silicate and clay minerals exposed in H₂-saturated brine maintain geochemical stability, having a negligible effect on H₂ consumption, thereby fostering a pH-neutral environment. However, the presence of carbonates (calcite and dolomite) and anhydrite can induce the dissociation process of H₂ in brine and result in the potential production of methane and H₂S through H₂-related redox reactions, consequently elevating the pH of the system. For Lotsberg Salt composed of more than 90% halite and a small fraction of carbonate impurities, H₂ consumption is just 0.1% after 30 years. For Lotsberg marlstone with 50% halite and 50% carbonate matrix, H₂ consumption is approximately 1% (without anhydrite) and 3% (with anhydrite) over a 30-year period. The potential CH₄ generation for marlstone is around 270 ppm. However, the kinetic modelling in this study considers only mineral dissolution rate while excluding the kinetic rate of H₂ related redox reactions, representing a theoretical upper limit of H₂ consumption.

Key words: Underground Hydrogen Storage, Salt Caverns, Geochemical Modelling