Contribution ID: **56** Type: **Oral Presentation**

Hydro-Geomechanical Reservoir Modelling of Underground Hydrogen Storage in a Saline Aquifer of the North German Basin

Wednesday, 21 May 2025 14:05 (15 minutes)

To balance the seasonal fluctuations of supply and demand in renewable energy, hydrogen can be produced using excess electricity and temporarily stored in geological formations. Due to their large storage capacities and widespread distribution in sedimentary basins, saline aquifers have great potential for underground hydrogen storage (UHS). However, the practical feasibility of UHS in porous formations remains to be demonstrated. This study focuses on the Triassic Stuttgart Formation near the city of Ketzin, a site located in the North German Basin previously used for a carbon dioxide (CO_2) storage pilot project. The formation is lithologically heterogeneous and its anticlinal structure offers potential as a structural trap for hydrogen storage. However, the presence of a fault zone at the top of the reservoir raises concerns about potential gas migration, which could be intensified by the geomechanical effects induced by cyclic hydrogen injection, thereby compromising the integrity of both the reservoir and the caprock.

Previous UHS modelling efforts on the reservoir scale have predominantly focused only on hydrodynamic aspects, while the geomechanical effects in geological porous media remain underexplored. However, their understanding is critical for ensuring safe, long-term hydrogen storage. To address this gap, this study presents a coupled hydro-geomechanical reservoir model to evaluate key geomechanical phenomena such as reservoir fracturing and the reactivation of faults. Numerical reservoir simulations are conducted using site-specific field data and performed using the computational simulator software CMG GEM. The output is assessed under varying operational scenarios (e.g., change of injection and production pressure).

The results provide critical insights into the flow and geomechanical behaviour of UHS operations in a saline aquifer of the North German Basin. Even though this analysis is site-specific, it strongly enhances understanding of the mechanical integrity of the reservoir and caprock, contributing to the broader development of hydrogen storage technologies in saline aquifers. Ultimately, the findings will advance the study of the feasibility of UHS and additionally support the design and evaluation of a prospective hydrogen storage demonstrator.

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References

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Session Classification: MS01

Track Classification: (MS01) Porous Media for a Green World: Energy & Climate