Evaluation of Coupled Flow and Geomechanics Simulations for CO2 and H2 Storage Projects

José-Antonio Torres, Sabine Delahaye

Geological Carbon Dioxide (CO2) and Hydrogen (H2) Storage are two technologies that have raised a lot of interest for their potential to enable new clean energy pathways. While injection of CO2 and H2 into the subsurface share many common traits, nowadays these two technologies are in different technology readiness levels. On one side, CO2 storage is a technology that has been demonstrated at the megaton scale. On the other hand, H2 storage is in an earlier development stage. The success of both technologies heavily relies on our ability to develop reliable and predictive physics-based simulations, which are needed for carrying out quantitative Risk assessments. The ability to perform predictive simulations is paramount to inform decision-making processes along each phase on industrial projects’ life, from pre-feasibility to post-closure phases.

Well integrity, caprock integrity, and triggered seismicity are three domains that require an accurate representation of the coupled fluid flow and mechanical deformation. There is a lot of concern about the mechanical deformations caused by the overpressure from fluid injections. Also, hydromechanical properties may be affected by geochemical reactions, which can impact the response of the reservoir-caprock system to H2/CO2 injection. For that reason, regulators and stakeholders demand new standards on integrated modeling and simulation approaches for the evaluation of the new generation of H2/CO2 projects.

In this work we perform an independent evaluation of commercial and research simulators to simulate coupled flow and geomechanics mechanisms occurring in CO2 and H2 projects. More specifically, we investigate if the results from a new generation of research codes are in agreement with existing industrial codes. When possible, we use analytical models as reference solutions. We investigated the new GEOS simulation platform that embraces advanced features such as handling unstructured grids, implements solvers supporting fully-coupled strategies, and is capable to exploit high performance computation resources of the next-gen architectures.

We present a brief summary on the 2023 R&D collaboration between CHLOE and TotalEnergies’ OneTech (OT). A realistic geological model has been developed by OT’s specialists, while CHLOE conducted numerical simulations using GEOS and another industrial code. Two types of model configurations have been tested, assuming that the geological structure is representative of a sedimentation process in a tectonically passive environment. We evaluated linear-elastic single material models, and Heterogeneous poro-elastic models. Comparison of GEOS simulation results were performed against the industrial software and against analytical solutions. In general, GEOS results have been found to be in good agreement with the other results. This work helped us gain confidence on the new GEOS simulation platform, and allowed us to develop new post-processing Workflows customized for H2/CO2 projects. Future work include testing newer GEOS developments, including but not limited to new solvers and constitutive equations, (e.g. visco-plastic models, non-linear temperature dependencies, etc.). We also plan to test a newer Thermo-poromechanics solver, which is a fundamental feature for the evaluation of thermal effects.

José-Antonio Torres
CHLOE

Sabine Delahaye
TotalEnergies