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Unified multiphysics framework for assessment of CO2 storage in heterogeneous saline aquifers

Friday, 4 June 2021 14:00 (15 minutes)

CO2 injection into deep saline aquifers has shown to be a feasible option in many locations in the world, as for their large storage capacity under safe operational conditions. Previous studies have revealed that CO2 can be trapped in the subsurface by several mechanisms, including hydrodynamical, residual, dissolution, and mineral trapping. Despite the major advances in studying these trapping mechanisms, their dynamic interactions have been widely ignored; i.e., they are studied independently at their so-called 'separated time scale of importance'. These mechanisms, however, are dynamically interconnected and influence each other even outside of their main time scale of importance. Specially in presence of heterogeneous rock properties and complex CO2-brine thermo-hydraulic interactions, it is not trivial to assume these trapping processes have separation of scales in the time domain. Of great importance is to quantify the interactions between different trapping mechanisms, and allow for a fully-coupled multiphysics strategy in estimations of the trapped mass.
To this end, we present a full-cycle coupled multiphysics workflow, in which the CO2 injection, migration and post-migration processes are all considered in a unified multiscale-in-time framework. Our framework specially represents hysteresis characteristics of the constitutive Kr and Pc relations. Moreover, a compositional formulation representing a two-component, two-phase system is employed to capture dissolution trapping at all time. Note that dissolution is often times studied much longer after injection. However, as a significant step forward, we include all of these physics, including dissolution, at all times. As for a convenient implementation strategy, we utilized the well-developed black-oil-type formulation, where only the lighter component (CO2) exists in both phases. In particular, the CO2-brine ratio (similar to the solution gas-oil ratio) is calculated based on a thermodynamic model which are verified against experimental measurements. The overall-composition variable set is used and the coupled system is solved using a fully implicit scheme; allowing for a robust coupling treatment.
Through several test cases, we quantify the impact of different trapping mechanisms and uncertain reservoir and fluids parameters on the injection, migration and post-migration of CO2. We demonstrate that the time scale associated with each trapping mechanism indeed varies significantly, yet their dynamic interplay needs to be considered for accurate and reliable simulations. Our studies shed new lights on the impact of the coupled reservoir and fluid time-dependent interactions in estimation of the securely trapped CO2 in the reservoir.

Time Block Preference

Time Block B (14:00-17:00 CET)

References

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Student Poster Award

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