Contribution ID: **304** Type: **Oral Presentation**

Modeling and Simulation of Long-term Wettability Alteration on CO_2 Storage Efficiency and Containment

Wednesday, 1 June 2022 11:15 (15 minutes)

Geological CO_2 storage can be successfully implemented in deep saline aquifers that have sufficient storage efficiency and are overlain by a competent sealing caprock. Constitutive functions that govern macroscale capillary pressure and relative permeability are central in constraining both storage efficiency of the formation and sealing properties of the caprock. Capillary pressure and relative permeability functions for porous systems are in part determined by wettability, which is a pore-scale phenomenon that has direct influence on macroscale displacement processes. While wettability of saline aquifers and caprocks are assumed to be remain water-wet when CO_2 is injected, there is recent intriguing evidence of contact angle change due to long-term exposure to CO_2. This phenomenon weakens the strength of capillary forces which subsequently alters capillary pressure and relative permeability functions dynamically over time.

Recently, new dynamic models have been developed for both capillary pressure and relative permeability functions that captures the impact of wettability alteration (WA) due to long-term CO_2 exposure. These dynamic macroscale saturation functions are driven by CO_2 exposure time that is calculated from the saturation history. In this paper, the dynamic functions are implemented into a two-phase two-component simulator to study the impact of long-term WA dynamics on field-scale CO_2 storage systems. We simulate horizontal migration patterns for CO_2 injection affected by WA dynamics for different flow regimes. Our results show that the impact of WA dynamics leads to a complex CO_2 migration behavior that is not captured by static saturation functions. Also, we find that storage efficiency can be described effectively by the capillary number. In addition, we simulate buoyancy-driven migration in the caprock caused by loss of containment due to dynamics WA. We develop scaling models for CO_2 migration into the caprock caused by dynamic wettability that show that long-term WA poses little risk to CO_2 containment over relevant timescales.

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References

Time Block Preference

Time Block A (09:00-12:00 CET)

Participation

Online

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Session Classification: MS01

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