CO_2 Storage Trapping Mechanisms Quantification

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Introduction

The capture and storage of CO_2 in deep geological formations is one of the proposed solutions to reduce CO_2 emissions to the atmosphere. CO_2 is injected as a supercritical fluid deep below a confining geological formation that prevents its return to the atmosphere. In general, the next four trapping mechanisms are expected, which are of increasing importance through time (1) structural, (2) residual saturation, (3) dissolution, and (4) mineral trapping. The prediction of the mass of CO_2 stored through time in storage systems is an essential parameter in the pre-injection assessment of a geological storage. For safety reasons, it is relevant to know the mass of CO_2 trapped under these different trapping mechanisms.

Mathematical description

mass species conservation

$$\partial_t(\phi s_\alpha \rho_\alpha m_\alpha^\kappa M^\kappa) = -\nabla(\boldsymbol{q_\alpha}\rho_\alpha m_\alpha^\kappa M^\kappa - \phi s_\alpha \rho_\alpha \boldsymbol{D_\alpha}\nabla(m_\alpha^\kappa M^\kappa)) + Q_\alpha^\kappa + T_\alpha^\kappa$$

$$\alpha = l, g \qquad \kappa = CO_2, w$$

energy conservation

$$\partial_t\left(\phi S_l \rho_l u_l + \phi S_g \rho_g u_g\right) + (1-\phi)\rho_s c_s T = -\nabla \cdot \left(\boldsymbol{q}_l \rho_l h_l + \boldsymbol{q}_g \rho_g h_g - \lambda_{pm}\nabla T\right) + Q_e$$

Darcy's law

$$\boldsymbol{q_\alpha} = -\frac{\boldsymbol{k} k_{r,\alpha}}{\mu_\alpha}(\nabla p_\alpha - \rho_\alpha \boldsymbol{g})$$

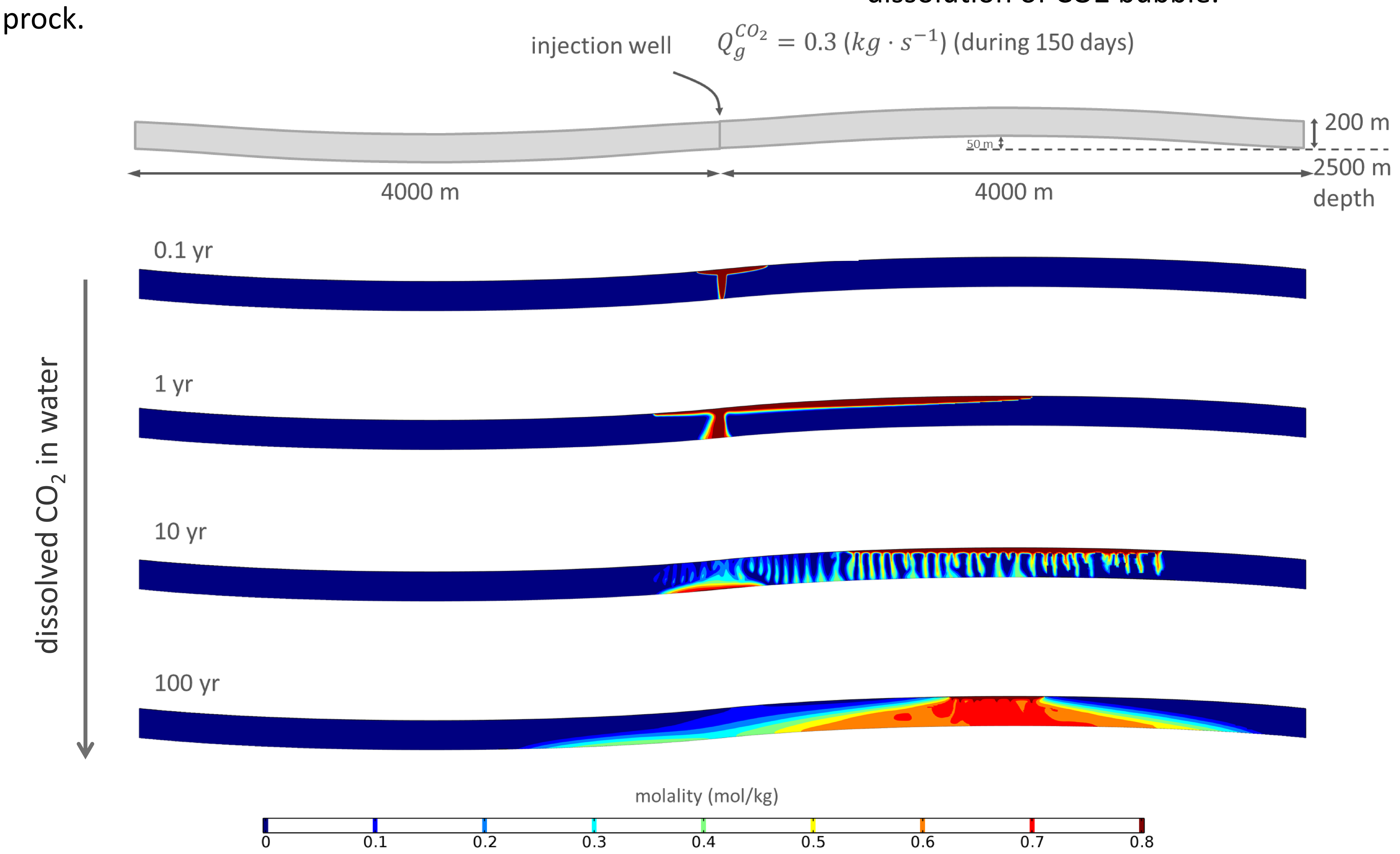
See references [1]-[9] for the complete formulation

2D model of a synthetic dome

In this work, storage quantification in a synthetic 2D dome under different injection conditions has been performed by using multiphase transport simulations.

The CO2 gas bubble moves upwards and accumulates under the anticline caprock.

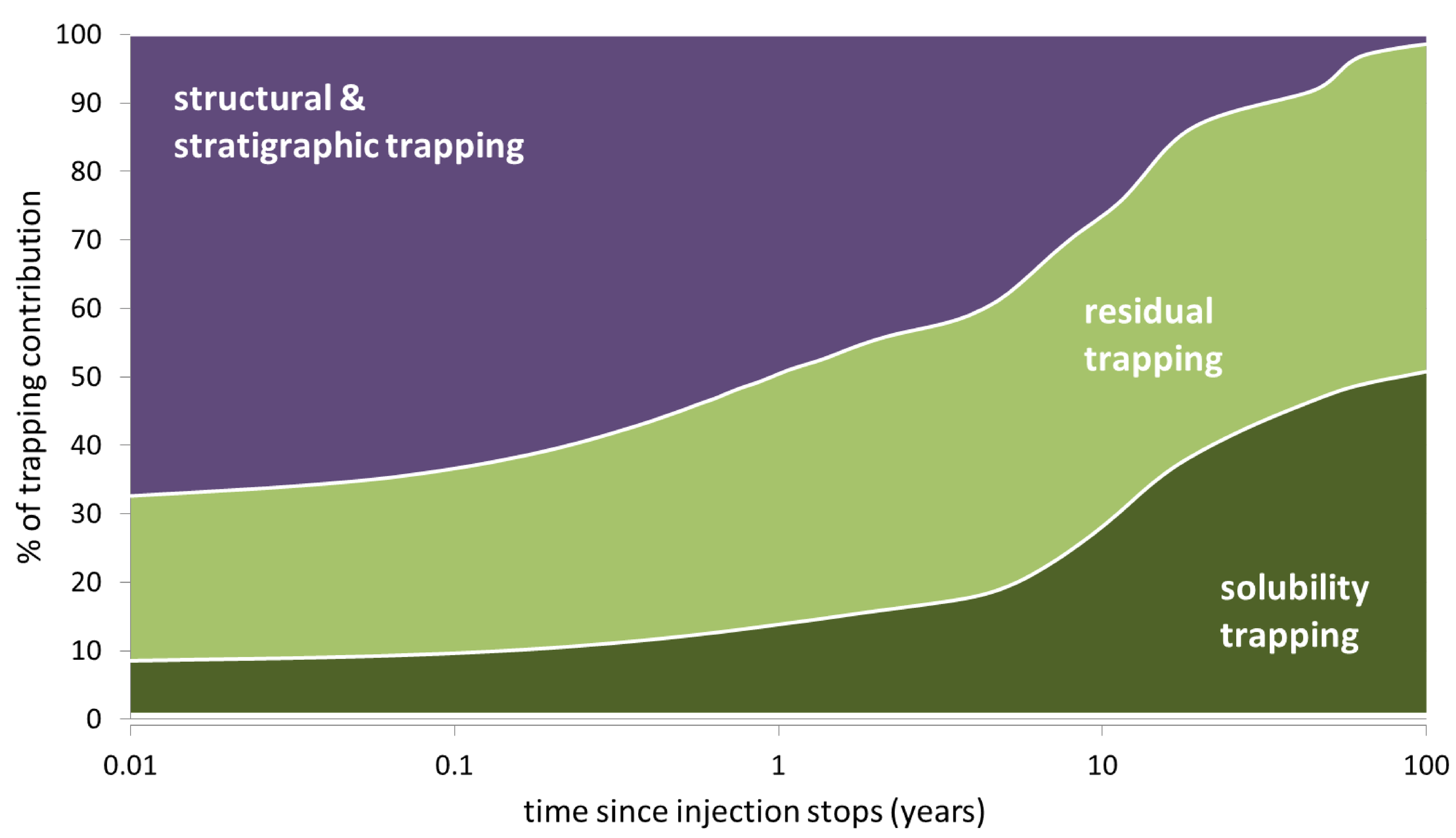
At the interface between the two fluids, CO_2 slowly dissolves into the resident brine. The CO_2-enriched brine is denser than the resident water and tends to sink leading to the formation of gravity fingers. The resulting convective flow facilitates a faster dissolution of CO2 bubble.



Conclusions

- Model calculates the amount of CO_2 trapped as residual phase and phase dissolved in the brine.
- The model simulates the onset of the formation of CO_2-rich brine fingers and their extent and evolution.
- The model is a valuable tool to assess the efficiency of different injection regime and well locations.
- The model is ready to be coupled to geochemical reactions.

Computed CO_2 trapping evolution



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