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Quantification of CO_2 masses trapped through free convection process in isothermal brine saturated reservoir

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Abstract

Dissolution trapping of supercritical CO_2 into formation brine has been investigated as a potential mechanism for reducing buoyancy force in carbon storage formations. This study attempts to quantify how much CO_2 can be stored through dissolution trapping assuming the free-phase CO_2 will be dissolved continuously on the top of perturbed brine phase. Most former investigations focused on physical explanations of density-driven free convection instability. Our aim is to compute the amount of CO_2 (by mass) captured by dissolution trapping until the model reservoir reaches steady state. The numerical experimentation is done using dimensionless mass and momentum conservation laws. The major problem parameter here is the Rayleigh number, for which we carry out an extensive survey to find out its low and high ends based on field and observed data from the literature and in-house database. Because density difference is the main driving force, we also investigate the effects of impurities retained in CO_2 stream on density contrast. We study both homogeneous and heterogeneous reservoirs. Also, different boundary conditions (Neumann, Dirichlet, and periodic) are compared to understand their effects. The simulations are run until nearly complete saturation (~99%) is reached. For a test case (T = 40 °C, P = 50 bar) of geologic and thermophysical conditions, we have found that on average 0.33–15 g CO_2 will dissolve per year until a heterogeneous unit reservoir volume of 1 m3 reaches complete saturations. For the case of homogeneous reservoir this amount is 0.28–6 g.