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Reservoir-scale simulation of CO2 solutal convection: approaches and limitations

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The CO2 dissolution in the reservoir brine (eg. within an aquifer) is one of the primary trapping mechanisms during CO2 geological storage (CGS). Significant amounts of injected CO2 can be trapped in this way with the overall dissolution rate controlled by density-driven convective mixing (CM). As such, the CO2 solutal convection results from the gravitational instability: under the action of buoyancy the injected CO2 displaces reservoir brine from the reservoir top so that denser CO2-saturated brine is found above a less dense original brine [1,2]. As a result, the typical dynamic CM pattern includes descending fingers of CO2-saturated brine surrounded by ascending volumes of original reservoir brine and accompanied by the progressive CM of CO2 [3].

After nearly 30 years of compehensive research efforts where significant part of results on the CO2 convective mixing was obtained via numerical analysis (cf. [4]), the reservoir-scale simulation remains surprisingly scarce while dedicated reservoir simulators are generally poor in adequate description of more or less realistic CGS scenarios comprising the long-term dynamics of CO2 dissolution [5].

The main objectives of our current work were (1) to summarize the successful approaches to realistic large-scale modelling of the CM during CGS (cf. [6]); (2) to understand the origin of principal restrictions which make inefficient the dedicated simulators, and (3) to specify possible ways to enhance existing simulation models in order to estimate, for instance, the impact of CO2 dissolution on the dynamics of the plume size and/or the CO2 storage. The essential result of the steps (1) and (2) was the development of 3D computationally efficient model of the CM; in particular, besides the study of dynamic dissolution regimes occurring after the solutal convection onset (eg. under the typical Utsira conditions), the model has been applied for the realistic size and physical properties distribution cases, cf. [7]. The direct comparison to dedicated simulators has demonstrated the limits in their accuracy and computational performance. At the same time, it was found that a study of such a kind may indicate the direction of possible model improvements. The necessary methodological elements to be taken into account or to be developed and incorporated to the general workflow are discussed in some detail together with examples demonstrating their application.

Participation

In-Person

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