Contribution ID: **412** Type: **Poster Presentation**

About approaches to large-scale simulation of CO2 plume characteristics at realistic conditions

Thursday, 22 May 2025 10:35 (1h 30m)

The fundamental importance of CO2 trapping mechanisms during geological storage in deep saline aquifers (DSA) remains indisputable and requires adequate means for adequate description and successful application. During last decades tremendous efforts have been made in many research areas to provide experimental, theoretical, simulation and pilot tests data at diverse conditions and multiple description scales [1,2], see also the references in [1]. One of the essential lessons learned during this period was the recognition of many issues where the huge power inherited from the conventional reservoir simulation is insufficient from the viewpoint of geological storage applications. It's enough to mention that this is true, for instance, for completely different characteristic time and space scales of typical storage cases, especially in view of upcoming stage of the storage sites clustering [3]. Since the beginning of pioneering CO2 storage pilot, the reservoir-scale simulation has contributed much to general understanding of the process dynamics and to assessment of the storage data. Nevertheless, up to now the dedicated reservoir simulators seem hampered, especially in direct realistic simulation of storage cases which comprises evaluation of several principal trapping mechanisms, cf. eg. [4]. Our current work is aimed at development and testing of approaches to modelling capable to provide simulation results for realistic storage cases on the base of enhanced computational performance [5]. The indispensable elements of this work include the definition of relevant description for and quantification of CO2-in-brine dissolution dynamics. Recently convective dissolution and its dynamics were found to be influential factors in the CO2-plume evolution during injection and post-injection periods of the storage. Moreover, they can impact the key indicators of geological storage like its efficiency and spatial limits of the CO2 plume.
Taking advantage of our recent experience involving the studies of dissolution for typical conditions of Utsira and also for one of typical sites called in literature "natural analogues for CO2 storage"[6], the extension of numerical analysis towards generalization of dissolution dynamics for anisotropic and heterogeneous DSA has been carried out. Currently, the dynamic dissolution process in heterogeneous porous media represent a paramount challenge of density-driven flow dynamics [7]. The methodological aspects of (1) enhanced performance models and their development and (2) theoretical approach to quantification of convective dissolution in a heterogeneous aquifer, are discussed in some details. Also, the discussion together with corresponding illustrations are provided on the feasibility of reported approach to simulation of CO2 plume dynamics and possible directions of the work extension in nearest future.
Analysis of conditions when dynamic CO2 dissolution in an aquifer brine may impact the plume parameters and shape during post-injection can play a role in the adaptation of design and monitoring strategy for geological carbon storage sites.

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Session Classification: Poster

Track Classification: (MS08) Mixing, dispersion and reaction processes across scales in heterogeneous and fractured media