Fast Modeling of Fault Leakage during CO2 Storage

Ramachandran, Hariharan; Doster, Florian; Geiger, Sebastian

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Hariharan Ramachandran (Institute of GeoEnergy Engineering, Heriot-Watt University, Edinburgh, UK),
Florian Doster (Heriot-Watt University),
Sebastian Geiger (Delft University of Technology)
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Storing carbon dioxide (CO2) in geological formations is a crucial method for mitigating climate change. However, CO2 leakage during injection and storage poses a significant risk, and faults represent a particular concern as they can act as major structural traps or connect pathways to shallower geological layers. Therefore, it is vital to understand the behavior of faults and related structures such as micro-cracks, joints, fracture networks, deformation bands, and fault cores to assess the risk of CO2 leakage and ensure safe and effective storage.

Accurately simulating fault-related properties at different scales is crucial to predict the consequences of CO2 injection and storage. However, this task can be challenging, particularly in the early stages of a storage project when knowledge of the storage reservoir is limited, and the cost of obtaining high-quality well logs, cores, and seismic data is high. To address this issue, this study proposes a workflow for ultra-fast screening of fault leakage risk during injection and storage at the concept selection stage. The workflow employs a vertically integrated reservoir model coupled with an upscaled fault leakage function.

Simulation results of various CO2 injection scenarios in a storage reservoir with potential for fault leakage demonstrate that the workflow can produce reliable saturation profiles with substantially reduced computation time compared to fine-scale models. Matching CO2 saturation profiles obtained from fine-scale and vertically integrated models adds confidence to the proposed workflow. The fast workflow presented in this study provides a useful tool for identifying the uncertainties associated with key fault parameters, reservoir architecture, and other constitutive relations that affect the behavior of the storage reservoir and potential fault leakage outcomes. By incorporating this workflow at the concept selection stage, stakeholders can quickly assess the risk of CO2 leakage and evaluate the feasibility of the storage site. Overall, the proposed workflow provides a cost-effective and efficient method for screening fault leakage risk during CO2 injection and storage, helping to ensure safe and effective carbon storage.