Contribution ID: **147** Type: **Oral Presentation**

Three-Dimensional Imaging of Density-Driven Convection in Porous Media Using X-ray CT Scanning

Monday, 31 May 2021 18:00 (15 minutes)

In the context of subsurface CO_2 storage, the mixing process is triggered by the local density increase in the ambient brine following the dissolution of CO_2. As a result, gravitational instabilities occur and characteristic, perpendicular elongated finger-like patterns form that are enhancing the mixing between CO_2 and water compared to a purely diffusive process. This density-driven mixing process is considered as a key trapping mechanism for subsurface CO_2 storage, because it accelerates the dissolution of CO_2 into brine and could eventually form a stable stratification in the aquifer, thereby reducing the chances of leakage.
Owing to the difficulty of imaging the time-dependent convective process, experiments so far have largely focused on two-dimensional systems (e.g., Hele-Shaw cells). However, the convective fingers are propagating into all three spatial directions and neglecting the third spatial dimension imposes a strong restriction on the lateral spreading of the plumes. To explore the dynamic flow pattern within a three-dimensional medium, we developed an experimental procedure by applying X-ray CT imaging and 3D reconstructions that allow visualisation of the evolution of the plumes non-invasively at a high spatial and temporal resolution. To imitate the dissolution process of CO_2 in brine under laboratory conditions, we use salt with a high X-ray attenuation coefficient that dissolves in water and creates a heavier solution than pure water. We perform dissolution experiments for a range of Rayleigh numbers and infer several global quantities including the average mass fraction, dissolution flux and dilution index. We show that the three-dimensional mixing evolves successively through three regimes, starting with a simple one-dimensional diffusional profile, transit into a convection-dominated regime and continues to attain the maximum dissolution capacity of the system with the shutdown.
Results provide more representative information towards the investigation of convective mixing in the context of Carbon Capture and Storage. Insights into the complex three-dimensional mixing structures will additionally support the elucidation if two-dimensional scaling laws can successfully predict three-dimensional behaviour.

Time Block Preference

Time Block A (09:00-12:00 CET)

References

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Session Classification: MS8

Track Classification: (MS8) Mixing, dispersion and reaction processes across scales in heterogeneous and fractured media