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CO2 Breakthrough Pressure in Resedimented Caprock Seals

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Structural trapping is the ultimate barrier for reducing the risk of leaks at CO2 storage sites. Small pores in high specific surface clay-rich caprocks give rise to high capillary entry pressures and high viscous drag that hinder the migration of buoyant carbon dioxide CO2.
In this work we show measurements of the CO2 breakthrough pressure and ensuing CO2 permeability through sediment plugs prepared with sand, silt, kaolinite and smectite. Our experiments and data from the literature demonstrate that the breakthrough pressure can reach ~6.2 MPa in argillaceous formations, and 11.2 MPa in evaporites. The CO2 relative permeability after breakthrough increases up to a maximum of ~0.2. Our parametric study highlights the inverse relationship between breakthrough pressure and pore size, as anticipated by Laplace's equation. In terms of macro-scale parameters, the breakthrough pressure increases as the sediment specific surface increases and the porosity decreases.
In addition, we introduce two dimensionless numbers that help pre-asses the safety of storativity condtions in-situ. The "sealing number"and the "stability number"combine the initial fluid pressure, the buoyant pressure caused by the CO2 plume, the capillary breakthrough pressure of the caprock, and the stress conditions at the reservoir depth; these two numbers provide a rapid assessment of potential storage sites.

References

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