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Impacts of Mineralogy, Rock Fabric, Architecture in the Selection of a Site for CCS

François Bouchet[1]

[1]SLB – Asset Consulting Services

Abstract

Carbon sequestration in siliciclastic reservoirs involves complex interactions among mineralogy, rock fabric, and reservoir architecture that affect CO_2 storage efficiency, containment, and risk management. Understanding these factors is essential for optimizing injection strategies and ensuring long-term security.
Mineralogical impact on CO_2 reactions: Mineral composition influences sequestration efficiency, with quartz-rich sandstones being stable and feldspathic or clay-rich rocks undergoing geochemical changes such as mineral dissolution and precipitation that affect porosity and permeability. These reactions can immobilize CO_2 as stable carbonates over time.

Rock fabric effects on injection and containment: Grain size, sorting, cementation, and natural fractures impact fluid flow, injectivity, and mechanical integrity. Heterogeneous fabrics can create flow barriers, while fracturation risks must be managed to prevent CO_2 leakage.

Reservoir architecture and storage capacity: The spatial arrangement of facies and connectivity between reservoir and caprock units determine storage volume and containment robustness. Layered sealing units enhance vertical containment, but heterogeneities may cause preferential flow and leakage risks.

Injection rate and fracturation limits: Injection must consider reservoir permeability and mechanical strength to avoid fracturing. Field cases like In Salah and Frio Brine Pilot illustrate the balance between enhancing injectivity and preventing leakage through controlled injection rates.

Mineralogical and geomechanical changes: CO_2-induced acidification triggers mineral dissolution and secondary precipitation, altering rock strength and potentially causing compaction or subsidence. Mineral trapping is a slow but important long-term immobilization mechanism.

Field examples and reservoir modeling: Projects like Sleipner and the Frio Brine Pilot demonstrate successful CO_2 injection guided by reservoir characterization, dynamic modeling, and monitoring to ensure safe and effective storage.