Structural and diagenetic controls on CO$_2$ leakage in a natural long-term carbon sequestration analogue, Little Grand Wash fault, Utah

Scientific Achievement

Determined footprint of fault-controlled CO$_2$ leakage in a natural long-term analogue of a carbon sequestration sandstone reservoir.

Significance and Impact

Highly focused flow and limited lateral extent of CO$_2$ footprint around fault leakage conduits requires dense monitoring networks in sequestration applications.

Research Details

- CO$_2$-related alteration as a proxy for paleo-leakage of CO$_2$ along exhumed fault leakage conduits.
- Distribution of CO$_2$ alteration indicates that flow is focused along narrow (10-50 m wide) structural conduits within the reservoir sandstone units.
- CO$_2$-related calcite cement precipitation significantly reduces porosity & permeability of sandstones, restricting flow through the conduit.
- Presence of multiple paleo-leakage conduits indicative of shift of active conduits along fault zone over time.'

Urquhart, A., & Eichhubl, P., Structural and diagenetic controls on CO$_2$ leakage in a natural long-term carbon sequestration analogue, Little Grand Wash fault, Utah. In prep.
Porosity & permeability trends

- CO₂ related cement spatially limited to vicinity of fault relay zone.
- Decrease in porosity from ~20% to ~0%.
- Decrease in permeability ~3 orders of magnitude toward leakage conduit.
Carbonate cementation around CO₂ flow conduit

- Sandstone pores occluded with calcite cement
- $^{16}$O depletion of carbonate pore cement adjacent to flow conduits due to CO₂ phase separation
- Width of CO₂ conduit \(\sim\) 10-50 m

Petrographic thin section of reservoir sandstone with pore space occluded by calcite mineral cement.
CO₂ leakage footprint in shale caprock (Mancos Shale)

XRD bulk sample mineralogy

Bulk sample (matrix) stable isotopes

- wt% vs. Distance from fault (m)
- ℓlụb stable isotopes vs. Distance from fault (m)
Mudrock topseal failure by chemically assisted fracture

Calcite lined fracture

0.5 mm