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Natural CO_2 movement through seal and overburden as an analogue for engineered geological storage

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One of the significant but poorly constrained potential problems associated with deep geological storage of CO_2 is the mechanism and rate of leakage through seal and overburden rocks above the target reservoir. It is important to understand these as completely as possible in order to assure public confidence, to assess leakage volumes for emission credits, and to design robust engineered site performance. Research and demonstration projects worldwide can only operate for a few years or decades, leaving a need for substantial extrapolation of leakage rates and processes into the future. We have used naturally occurring CO_2 accumulations to provide insights to geological processes that occur over timescales of years to tens of thousands of years. These sites enable us to understand processes which could occur decades or millennia after CO_2 injection. We present data from two suites of natural springs in the western USA that emit cold CO_2-rich brines. The first site has no known CO_2 reservoir at depth, and lies about 15km south of Green River, Utah. The second site occurs above a known CO_2 accumulation in NW Arizona at St Johns Dome, Springerville, Arizona. At the surface, these springs have deposited clusters of travertines that are localised along mapped fault surface traces, and/or located above structural dome.

At the Green River locations, U-Th dating shows travertines located along a fault damage zone to be up to 70 kyr old. Stable isotopes, and salinity of porewaters, suggest that 10% of the surface water is from a deep aquifer source whilst 90% is of shallow meteoric origin. CO_2 content of the water at the surface is high relative to the quantity

of water, suggesting that vertical transport has been as a discrete gas phase within the fault damage zone, as well as in solution. Noble gases are contained within this CO_2 and can be used as natural tracers and show that $<10\%$ of CO_2 originates directly from a mantle source, whereas $>90\%$ CO_2 is of crustal origin.

At St Johns, the travertines lie above a steeply dipping reverse fault tip and above the structurally highest part of the trapping structure. This implies both sub-vertical migration of CO_2 leakage from the top of the reservoir and CO_2 migration through the fault damage zone. Noble gas and C stable isotope data from the deep reservoir exist and indicate a mantle origin for the CO_2. This data will be compared to measurements taken from several shallow groundwater wells and surface seeps in order to test the ability of these natural tracers.

These studies show that: 1) Subsurface CO_2 migration can be tracked with confidence to the surface, 2) baseline geochemical characterisation of a site will greatly improve resolution of leakage detection, 3) CO_2 migration in overburden shallower than 700m can occur vertically as a discrete gas phase.