Constraining apparent groundwater age in the Samail ophiolite

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The Samail ophiolite in Oman is a site of naturally occurring CO2 mineralization and serpentinization and acts as a natural analog for an engineered CO2 storage project. Mineralization rates depend on water-rock interaction, so apparent groundwater ages could help constrain natural reaction rates and predict the potential for rate acceleration.

A suite of environmental tracers was used to constrain apparent groundwater age in the Samail ophiolite. Shallow peridotite groundwater and samples from boreholes near the mantle transition zone have a pH < 9.3, are 4-40 years old, have little to no non-atmospheric He accumulation, NGTs (noble gas temperatures) equivalent to the modern mean annual ground temperature, and stable isotopes within the range of current local precipitation. In contrast, hyperalkaline springs and deeper samples from peridotite boreholes appear to be considerably older as they have a pH > 10, are pre-H-bomb (older than 1952), have significant non-atmospheric helium accumulation (30-70% of dissolved helium), often are isotopically heavier (enriched in δ18O), and can have NGTs 6-7°C lower than the modern ground temperature.

Because pH increases during the serpentinization process, it can be considered a proxy for the extent of water-rock reaction (and perhaps groundwater age). Recent field work with a packer system within two boreholes located ~20 m from each other in the peridotite revealed disparate patterns of pH with depth. Borehole BA1D contained water with a pH of 11 at depths of 45-75m and 102-132m. In contrast, borehole BA1A contained water with a pH of 8 at depths < 30m and 45-65 m, and only reached a pH of 10 at depths of 108-132m. Both boreholes had very low permeability (too low to allow sampling) below a depth of 140 m. This suggests that the groundwater flow path within the peridotite aquifer does not follow a uniform progression from modern pH 8 water near the surface to older pH > 11 water at depth and that there may be very little groundwater flow at depths > 140 m.