Constraining apparent groundwater age in the Samail ophiolite

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The Samail ophiolite in Oman is a site of naturally occurring CO_2 mineralization and serpentinization and acts as a natural analog for an engineered CO_2 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.[a] 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 $\delta^{18}O$), and can have NGTs 6-7°C lower than the modern ground temperature.[a]

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.

[a]Paukert Vankeuren et al., *Earth Planet. Sci. Lett.* (2019)