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Investigating controls on H_2 availability in groundwaters during active serpentinization in the Samail ophiolite

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Hydrogen is of great interest as an energy source in industrial, geological and biological systems. Geological hydrogen is commonly produced and stored in terrestrial ultramafic rock-hosted systems reacting with meteoric waters. For example, hyperalkaline, Ca-OH groundwaters and spring fluids containing high concentrations of dissolved and free hydrogen have been detected at numerous localities in the Samail ophiolite in Oman (Nothaft et al. 2021; Vacquand et al. 2018; Neal and Stanger 1983). Some hydrogen is being produced by modern water/rock reactions occurring between dunites and harzburgites and low salinity fluids under closed-system, low-temperature conditions ($\leq 50^{o}$C) (Miller et al., 2017; Ellison et al. 2021; Leong et al. 2021, Kelemen et al. 2021). However, it is challenging to estimate the net rates of hydrogen production, due to slow serpentinization and H_2 degassing rates, coupled with uncertainties associated with how much H_2-loss might occur due to in-situ consumption.

We will discuss new insights into active continental serpentinization been derived from recent downhole investigations within the "Multiborehole Observatory", in collaboration with Peter Kelemen, Juerg Matter and the Oman Drilling Project Science Party (Kelemen et al. 2021). A combination of mineralogical, hydrological and geochemical data is being used assess the reactivity of Fe(II)-bearing minerals, controls on secondary mineral formation, and the residence times of the fluids, in order to infer the processes controlling in-situ H_2 activity. We will also address many open questions about the scale of subsurface microbial activity and the prevalence of H_2-dependent metabolisms. There is sufficient chemical dis-equilibrum to stimulate biological activity and extensive H_2-oxidation. Using a combination of cell counts, metagenomic data and microbial rate activity assays in groundwater fluids and rock cores, we will show where abundant microbial communities consume hydrogen through metabolisms such as methanogensis, acetogenesis, and sulfate reduction. Ultimately, geophysical, geochemical, geochronological and microbiological data need to be integrated together to generate quantitative estimates of hydrogen availability in peridotite aquifers. Given the growing interest in geological hydrogen, we will also speculate upon the potential for stimulated hydrogen production within the mantle rocks in the Samail ophiolite, as well as the potential microbial response to increased hydrogen flux.