Fe(II)-bearing brucite reactivity during low-temperature serpentinization in Oman

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The partitioning of Fe among secondary mineral phases is a primary control on the production of H_2 during serpentinization, which can support hydrogenotrophic metabolisms. Low-temperature serpentinization typically leads to the formation of Fe(II)-bearing brucite, which diverts substantial Fe(II) from participation in H_2-producing reactions. This brucite can be lost in subsequent stages of water-rock reaction, potentially fueling later Fe-oxidation coupled to H_2 production. However, the reactivity of brucite under changing conditions (e.g. increasing aSiO$_2$, decreasing pH) has not been thoroughly assessed.

Through bulk and microscale mineralogical characterization with X-ray diffraction, Raman spectroscopy, electron microprobe analysis, and X-ray absorbtion spectroscopy of core samples recovered by Phase II of the Oman Drilling Project, we have begun to assess the reactions that control the distribution of Fe(II)-bearing brucite in rocks undergoing modern low-temperature serpentinization. Brucite is detected in all three “active alteration” cores, and it is most abundant in samples with dunite lithology and below 100 m depth, reaching 5-7 wt% as determined by quantitative XRD. Brucite is most frequently localized in mesh cores after olivine, and is Fe-rich ($X_{Fe} \approx 0.15$). However, above 100 m depth brucite becomes less abundant and mesh cores are instead replaced by lizardite that is similarly Fe-rich ($X_{Fe} \approx 0.15$), while magnetite is qualitatively more abundant. Coupled aqueous geochemical measurements from nearby wells show elevated aSiO$_2$ out of equilibrium with brucite.

We suggest that brucite becomes destabilized in the shallow subsurface during interaction with Si-rich groundwater. Fe released from brucite may be oxidized and incorporated into later generations of serpentine and/or magnetite. We will present microscale X-ray spectroscopy results characterizing redox states of Fe-bearing phases, and consider the Fe tranformations occuring during the later stage of reaction. Finally, we will discuss the drivers and consequences of brucite reactivity during low-temperature serpentinization, including the potential for these reactions to fuel low-temperature H_2 production.