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Low-temperature reactivity of Fe-brucite in serpentinites: Experiments and natural sample characterization

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The low-T alteration (< 150 °C) of serpentinites is of primary importance for natural CO_2 storage and H_2 generation under conditions where life may exist. Reactions happening in this temperature range are difficult to study in the laboratory for kinetic reasons.

While missing in most hand-collected or dredged oceanic samples, (Fe-bearing) brucite is abundant in cores of oceanic serpentinites retrieved from depths > 200 m [1]. This ferroan brucite, $(Mg,Fe)(OH)_{2,}$ is one of the most reactive phases in changing redox and temperature conditions, owing also to its small grain size often ranging between 20-100 nm. For example, rapid oxidation of ferroan brucite into ferrian (Fe^{3+}) brucite has been observed at T < 150°C in the laboratory. An isostructural Fe^{2+} - Fe^{3+} oxidation was inferred, involving charge-balance by deprotonation [2].

In this study, reactivity of synthetic ferroan brucite was investigated through time-resolved oxidation experiments on synthetic and lab air at ambient temperature. Based on XRD and the UV–Vis spectrophotometric analytical technique, the Fe^{2+}/Fe_{tot} was analyzed both in initial and reacted brucite. Synthetic ferroan brucite oxidation reached a close-to-maximum reaction progress already after 5 days in lab experiments. Progressive oxidation was also observed in experiments using natural sample powders as starting material.

Additionally, in-situ synchrotron XAS experiments in a diamond-anvil cell showed a decreasing Fe-O bond length during the isostructural oxidation, consistent with the hypothesized charge-balance mechanism.

Further, phase relationships between brucite and serpentine in a natural sample studied by TEM, coupled to EDX chemical analysis, indicate that ferroan brucite often occurs together with lizardite, in reaction zones where Mg-brucite is abundant.

[1] Klein et al. (2020). Brucite formation and dissolution in oceanic serpentinite. *Geochemical Perspectives Letters*, *16*, 1-5.

[2] Carlin et al. (2023). Fe(III)-substituted brucite: Hydrothermal synthesis from $(Mg_{0.8}Fe^{2+}{}_{0.2})$-brucite, crystal chemistry and relevance to the alteration of ultramafic rocks. *Applied Clay Science*, *234*, 106845.