Experimental insights into the formation of iron-rich clays on early Earth and Mars

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On Earth, Mars, and subsurface oceans on icy moons, ancient habitable environments likely occurred in anoxic water bodies in contact with igneous rocks containing silica, magnesium, and iron. Because the oxidation of iron using light or chemical oxidants can sustain microbial life, it is possible these environmental conditions hosted iron-oxidizing microbes. Intriguingly, environmental precipitates in Earth's early oceans and the ancient Martian (sub)surface include iron(III)-containing clays, with low levels of Fe(III) in the best-preserved particles from Earth's Archean oceans (Johnson et al, 2018) and higher concentrations of Fe(III) in ancient phyllosilicates on Mars (e.g., Michalski et al, 2015). Thus it is critical and timely that we assess the effects of iron oxidation, including microbially-mediated oxidation, on the precipitation and mineralogy of iron clays. Accordingly, we are performing experiments in ferruginous and silica-rich conditions to assess whether limited chemically-induced iron oxidation and/or the activity of iron-oxidizing phototrophic bacteria can catalyse the precipitation of Fe(II,III) silicate minerals. Preliminary results using a suite of spectroscopy- and diffraction-based techniques suggest that iron oxidation alters the amount and mineralogical characteristics of resultant mixed Fe(II,III) phases. As we develop a model of how mixed Fe(II,III) clay minerals can form under reducing conditions, our results will serve as a useful reference to compare against existing and future analyses of sediments from ancient Earth and other planetary bodies, leading to better-informed interpretations of paleo-(bio)geochemical conditions.