Martian analogs: Synthesis, characterization, and oxidation of ferrous Iron phyllosilicates

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Data collected by the Mars Express OMEGA spectrometer and confirmed by the MRO CRISM instrument indicate the widespread presence of iron-bearing phyllosilicates on Mars' surface. The species identified include nontronite, kaolinite, and montmorillonite [1]; notable is the occurrence of ferric phyllosilicates. These units were primarily deposited during the Noachian, the earliest period of Mars' history, which is thought to have been marked by moist, reducing, and alkaline conditions. Such conditions favor the initial formation of ferrous iron-bearing phyllosilicates. Subsequent surface alteration events could then have oxidized these units. A thorough understanding of the formation and oxidation of ferrous phyllosilicates can offer insight into the environment of early Mars [1, 2].

Our research explores different formation pathways for these phyllosilicates. To date, our work has focused on synthesizing a ferrous phyllosilicate through a hydrothermal sol-gel procedure [3] and subsequently oxidizing it. The goal is to characterize the chemical and structural changes that occur upon oxidation of a ferrous phyllosilite. The initial product was characterized by X-ray diffraction (XRD), transmission electron microscopy (TEM), and X-ray absorption spectroscopy (XAS). The phyllosilicate was then oxidized with hydrogen peroxide and characterized using these three methods again. H_2O_2 was used it is likely the dominant oxidant currently present on Mars [4].

Our analyses indicate that the initial product is a nanocrystalline 2:1 phyllosilicate containing Fe (II) in the octahedral sheet. Oxidation of this ferrous phyllosilicate by H_2O_2 is complete but does not disrupt the overall structure. The oxidation product contains Fe (III) distributed between the octahedral and tetrahedral sheet, a feature common to many nontronites [5]. This indicates that oxidation of a precursor ferrous phyllosilicate by H_2O_2 can produce a nontronite-like phase, as is currently observed on Mars.

[1] McKeown *et al*. (2009) *JGR* **114**, E00D10. [2] Bibring *et al*. (2006) *Science* **312**, 400-404. [3] Decarreau & Bonnin (1986) *Clay Miner*. **21**, 861-877. [4] Atreya *et al*. (2006) *Astrobiology* **6**, 439-450. [5] Komadel *et al*. (1995) *Clays Clay Miner*. **43**, 105-110.

Co-evolution of land plants and mycorrhizal fungi as biotic feedbacks on the long-term carbon cycle

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The rise vascular land plants is widely hypothesized from theory and field experiments to have driven a 90% drop in atmospheric CO_2 during the Palaeozoic (480-350 million years ago) by enhancing the chemical weathering of continental Ca-Mg silicate rocks. However, this long-standing paradigm overlooks the co-evolution of roots with the major groups of symbiotic fungal partners that have dominated terrestrial ecosystems throughout Earth history. In this presentation, I will outline emerging evidence from field experiments, and rigorous controlled-environment microcosm and mesocosm-scale experiments, that increasingly supports the view that the symbiotic fungal partners of vascular land plants play an active role in driving biotic weathering processes. Moreover, these effects appear to be enhanced along the evolutionary progression from ferns to gymnosperm trees, and from the ancestral arbuscular mycorrhiza (AM) to the more advanced ectomycorrhiza (EM). Our findings point to the requirement for developing process-based geochemical models that capture these effects to better understand biotic controls on Earth's atmospheric CO_2 history.