The Formation of Fe/Mg Smectite Under Mildly Acidic Conditions on Early Mars

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INTRODUCTION
The detection of Fe/Mg smectites and carbonate in Noachian and early Hesperian terrain of Mars suggests that neutral to mildly alkaline conditions prevailed during the early history of Mars. Early Mars surface geologic conditions were neutral to moderately alkaline with a denser CO2 atmosphere than today; thus, large carbonate deposits should be more widely detected in Noachian terrain.

PROBLEM
Why have so few carbonate deposits been detected compared to Fe/Mg smectites?

Fe/Mg smectites on early Mars formed under mildly acidic conditions, which would preclude the extensive formation of carbonate deposits.

OBJECTIVES

GOAL

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1. Examine sources of mild acidity on Mars.
2. Evaluate terrestrial examples of smectite formation under mildly acidic conditions.
3. Propose experiments to test the hypothesis that alteration of basaltic glass parent under mildly acidic conditions (pH 3-5) can yield Fe/Mg smectites.

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MATERIALS AND METHODS

Basalt glass synthesized to have Adirondack bulk chemistry
1-g glass exposed to 200°C solutions (Table 1) for 15 days in 45 ml Teflon lined reactors.

Reducing solutions N2 purged with 0.1 wt% hydraziniumchloride.

Glas and solutions loaded in a N2 purged glove box to ensure reducing conditions.

Task 1: Determine the Fe and Mg solution concentrations required for the formation Mg2+-saponite and Fe2+-saponite in reducing and pH 8 conditions.

Task 2: Determine the Fe and Mg solution concentrations required for the formation Mg2+-saponite and Fe2+-saponite at pH 3, 4, and 5.

Task 3: Determine the conditions for Fe3+-nontronite formation at low and high pH from alteration of basaltic glass.

Table 1: Tasks 1, 2 and 3: Experimental pH, redox and Mg (MgCl2) and Fe (FeCl2) concentration treatments.

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<th>Experiment</th>
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Solution analyses

Scanning Transmission Electron Microscopy (STEM)

Infrared Analysis

X-ray diffraction

Selected area diffraction (SAD) electron micrographs

Selected area electron diffraction (SAED) patterns

Micrographs of micromorphology

Characterization of micromorphology

Perceived Impact

Fe and Mg solution concentrations on an early mildly acidic Mars may be higher than currently modeled (e.g., Catling, 1999).

Potential microbiological activity would not be eliminated under a mildly acidic Mars; however, there could be tighter constraints as to the type and species of microbiology that could exist.

REFERENCES


Proposed Experiments

- Objective 1: Determine the Fe and Mg solution concentrations required for Mg2+-saponite and Fe2+-saponite formation from alteration of basaltic glass at low pH and high pH.

- Objective 2: Determine the conditions required for nontronite formation from alteration of basaltic glass at low and high pH.

- Objective 3: Determine the conditions for Fe3+-nontronite formation at low and high pH from alteration of basaltic glass.

Background image color coded to reflect phyllosilicates (green) in the Nili Fossae region. Photo credit NASA/JPL/JHUAPL/Brown University.