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 geochronological conditions were neutral to moderately alkaline with a denser CO₂ atmosphere than today, thus "lager carbonates 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.

GOAL

- The goal of the proposed work is to evaluate the formation of Fe/Mg smectites under mildly acidic conditions.

OBJECTIVES

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

Noachian Mild Acidity on Mars

- Early CO₂-dominated atmosphere (~1-4 bar) could have contributed to mild acidity caused by carbonate equilibration in water
- \[ \text{H}_2\text{O} + \text{CO}_2 \rightarrow \text{H}_2\text{CO}_3 \]
- \[ \text{H}_2\text{CO}_3 \rightarrow \text{H}^+ + \text{HCO}_3^- \]
- The added Mg in solution appears to have enhanced the crystallization of phyllosilicate despite the presence of low pH solutions.

Smectite Formation from Glass

- Flow-Through Dissolution Studies pH 2-11 basaltic glass (Berger et al., 1994; Gisleron and Oelkers, 2003)
- After 15 d, 1 mM NaClO₄ will be added for two days.

Batch Dissolution Studies

- Batch dissolution studies of basaltic glass in pH 4 synthetic seawater solutions at 260-320°C solutions (Table 1) for 15 days in 45 ml Teflon lined reactors.
- Results from Task 1 will be used to determine what Fe and Mg solution concentrations are required to produce saponite at pH 3, 4, and 5.

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

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

- Oxidizing only experiments will mix 1 mM NaClO₄ with the basalt glass and Fe solution concentrations at the beginning.

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

- Fe³⁺-nontronite form initially reducing conditions that then become oxidizing.
- Alter 15 d, 1 mM NaClO₄ will be added for two days.

- Oxidizing only experiments will mix 1 mM NaClO₄ with the basalt glass and Fe solution concentrations at the beginning.

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

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

Fig. 1. Model of the formation of Mg²⁺- saponite derived from basaltic glass. Arrows indicate direction of cation movement into and out of the glass and altered layered zones (from Berger et al., 1987).