

ALTERATION OF BASALTIC GLASS TO Mg/Fe-SMECTITE UNDER ACIDIC CONDITIONS: A POTENTIAL SMECTITE FORMATION MECHANISM ON MARS

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Phyllosilicates of the smectite group including Mg- and Fe-saponite and Fe(III)-rich nontronite have been identified on Mars. Smectites are believed to be formed under neutral to alkaline conditions that prevailed on early Mars. This hypothesis is supported by the observation of smectite and carbonate deposits in Noachian terrain on Mars. However, smectite may have formed under mildly acidic conditions. Abundant smectite formations have been detected as layered deposits hundreds of meters thick in intracrater depositional fans and plains sediments, while no large deposits of carbonates are found. Development of mildly acidic conditions at early Mars might allow formation of smectite but inhibit widespread carbonate precipitation. Little is known regarding the mechanisms of smectite formation from basaltic glass under acidic conditions. The objective of this study was to test a hypothesis that Mars-analogue basaltic glass alters to smectite minerals under acidic conditions (pH 4). The effects of Mg and Fe concentrations and temperature on smectite formation from basaltic glass were evaluated.

Phyllosilicate synthesis was performed in batch reactors (Parr acid digestion vessel) under reducing hydrothermal conditions at 200°C and 100°C. Synthetic basaltic glass with a composition similar to that of the Gusev crater rock Adirondack (Ground surface APXS measurement) was used in these experiments. Basaltic glass was prepared by melting and quenching procedures. X-ray diffraction (XRD) analysis indicated that the synthesized glass was composed of olivine, magnetite and X-ray amorphous phase. Samples were prepared by mixing 250 mg Adirondack with 0.1 M acetic acid (final pH 4). In order to study influence of Mg concentration on smectite formation, experiments were performed with addition of 0, 1 and 10 mM MgCl₂. After 1, 7 and 14 day incubations the solution composition was analyzed by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) and the altered glass and formed phyllosilicates were examined by XRD analysis. Mineralogical changes were significant in Adirondack incubated with 10 mM MgCl₂ at pH 4 and heated at 200°C. X-ray diffraction analysis revealed formation of phyllosilicate during 14 day incubation (Figure 1). Smectite was confirmed as the phyllosilicate after treatments with glycerol and KCl and heating to 550°C. The position of 02l (4.60 Å) and 060 (1.54 Å) diffraction bands were indicative of trioctahedral smectite such as saponite. Analysis of solution composition demonstrated that aqueous concentration of Mg decreased from 10 mM to ~4 mM after 7 day incubation likely due to saponite formation. Smectite also formed in Adirondack incubated with 0 mM MgCl₂ at pH 4 and heated at 200°C. However, diffraction peak positions of 02l (4.52 Å) and 060 (1.51 Å) suggested formation of dioctahedral nontronite. The 100°C Mg and Fe(II) treated basaltic glass experiments are ongoing and results will be presented.

We demonstrate here the first reported synthesis of saponite from a basaltic precursor under mildly acidic conditions. Saponite and smectite minerals in general have thought to have formed under neutral to alkaline conditions during the Noachian era followed by acid sulfate alteration. Our results provided a new plausible mechanism of smectite formation under acidic conditions on early Mars. The lack of the carbonate detection in Noachian materials also supports a non-alkaline environment during this era.

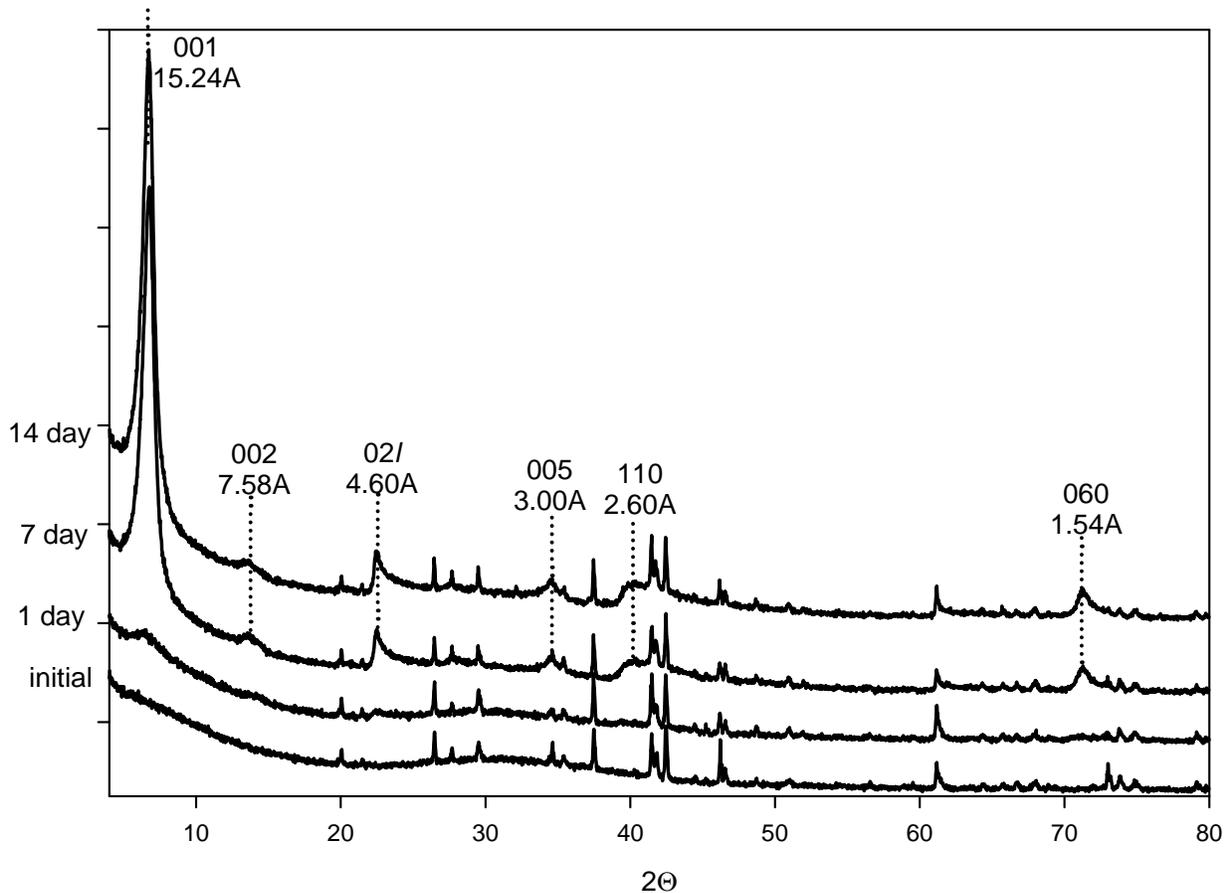


Figure 1. X-ray powder diffraction patterns of synthetic Adirondack basaltic glass treated with 10 mM MgCl₂, at pH 4 heated at 200°C for varying times. Olivine and magnetite are present in initial non-altered basaltic glass while saponite forms during basaltic glass alteration. Identified peaks indicate saponite while all other peaks are associated with magnetite and olivine. The broad hump from 20 to 40° 2θ indicates X-ray amorphous basaltic glass.