Effective formation of Al-rich surface clays through highly acidic water activity on early Mars

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Introduction

Remote sencing observations have revealed a widespread occurrence of weathering profiles in the low-latitude regions of Mars [1]. The weathering profiles consist of Al-rich clays and sulfate minerals in the upper part and Mg/Fe-rich clay minerals in the lower part [2]. These secondary minerals would have been formed through water-rock reactions between basement rocks and infused surface water in early Hesperian [3]. Here, we perform laboratory experiments of chemical weathering using a flow-through type reactor to constrain the chemistry of surface water and duration of water-rock reactions on early Mars. To simulate chemical weathering on early Mars, we used two types of solution: One is pure water in dissolution equilibrium with 1 bar of CO_2 (pH 4) and the other is sulfuric acid solution in dissolution equilibrium with 1 bar CO_2 (pH 1).

Results and Discussion

Our experimental results show that sulfuric acid surface water could effectively generate the weatheing profiles observed on Mars. Our results show that pH at the top of the reaction vessel is controlled as pH 2–3 owing to the formation of sulfate mineral, where dissolution of plagioclase proceeds effectively to provide dissolved Al and Si in the porewater. In the lower part of the vessel, pH of the infused porewater increases to 5–6. Upon the downward transport of Al- and Si-containing porewater, Al-rich clay mineral precipitates. After consumption of Al and Si in the porewater, Mg-rich clay mineral forms in the lower part of the vessel. The produced clay mineals are consistent with Martian weathering profile.

Based on the measured Al contents in the porewater and results of rain/snow precipitation from a climate model for early Mars [4], we suggest that the observed Al-rich clay deposits on Mars can be generated in a short-term (~10^3 years) through infusion of sulfric acid surface water. The weathering profiles may have formed upon transient warming at locations where sulfuric acids accumulated.

[1] Murchie et al. (2009) *J. Geophys. Res.* **114**, E00D06. [2] Bishop et al. (2008) *Science* **321**, 830-833. [3] Zolotov and Mironenko (2016) *Icarus* **275**, 203-220. [4] Wordsworth et al. (2015) *J. Geophys. Res. Planets* **120**, 1201-1219.