Clay Formation and Metal Repartitioning during Isochemical Hydrothermal Basalt Alteration

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Background

Widespread detections of minerals produced through aqueous alteration demonstrate substantial water-rock interaction during the earliest period of Mars history [1,2]. Many of these secondary minerals are Fe-Mg smectites that likely formed via isochemical alteration in hydrothermal systems [3,4]. However, the smectites detected to date have been largely ferric iron bearing, unexpected for subsurface clay formation [5] and difficult to reconcile with the expected oxidation state of Fe on early Mars [6]. This suggests that clays observed today are oxidized remnants of the original phases formed. This study investigates clay formation and trace element repartitioning during experimental hydrothermal alteration of basalt to investigate possible initial phyllosilicate formation during the Noachian period of Mars.

Results

Two USGS mafic rock standards (DNC-1a, North Carolina dolerite; BIR-1a, Iceland basalt) were heated to 200ºC for 21 days in an anoxic nitrogen atmosphere. Both rock standards produced a trioctahedral Fe(II)-Mg saponite, with greater amounts generated by DNC-1a. Notably, this material displays XRD features similar to the phyllosilicates detected in the John Klein and Cumberland targets by Curiosity, suggesting that clay formation at those sites may have occurred under anoxic conditions. X-ray absorption spectroscopy shows that Mn and Ni repartition from olivine, which is also the primary Fe host in the rocks, into neoformed smectites.

Analysis of alteration fluids shows only trace amounts of dissolved metals, indicating high retention of these elements. These chemical patterns of alteration may aid in identifying alteration conditions during future rover operations.

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