Chlorine-rich, water-poor Martian magmas

JUSTIN FILIBERTO* AND ALLAN TREIMAN

Lunar and Planetary Institute, 3600 Bay Area Blvd, Houston, TX 77058 (*correspondence: Filiberto@lpi.usra.edu)

Among the crucial unknowns about Mars are the pre-eruptive H_2O, Cl, and F abundances of martian basalts. While martian meteorite basalts contain only ~100ppm H_2O [1], some studies have suggested that the parental magmas contained up to 2 wt% H_2O [2-4]. These studies have suggested that in order to produce the mineral compositions and crystallization temperatures of the martian meteorites the parental magma needed to be hydrous. Here we integrate experimental, mineral-chemical, and cosmochemical constraints to show that the parental magmas to the martian meteorites were Cl-rich (~0.3 wt% Cl) and H_2O-poor (<< 0.3 wt% H_2O).

Our recent results have shown that chlorine has similar effects as water on mineral compositions and crystallization temperatures [5]. Therefore, experimental results seeming to require abundant water in Martian magmas are equally well explained by abundant Cl. The compositions of minerals in martian meteorites also suggest H_2O-poor and Cl-rich parental magmas. Apatites and amphiboles in martian meteorites are Cl-rich and OH-poor - not OH-rich as would be expected from a hydrous parental magma [6, 7]. In fact, the bulk chemistry of the martian meteorites [8] and surface rocks (analyzed by the Mars Exploration Rovers [9] and Mars Odyssey [10]) is consistent with Mars' overall enrichment in chlorine.

Eruption and degassing of such chlorine-rich, water-poor martian basalts would have increased the acidity of the martian surface and would not have contributed significant water, limiting the availability of water for life as we know it.

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Lu(III) coprecipitation with hectorite: A P-EXAFS approach

N. FINCK[1,4], M.L. SCHLEGEL[2] AND D. BOSBACH[3,4]

[1]Institute for Nuclear Waste Disposal, Karlsruhe Research Centre, P.O. Box 3640, D-76021 Karlsruhe, Germany (*correspondence: nicolas.finck@ine.fzk.de)
[2]CEA Saclay, DEN/DPC/SCP/LRSI, F-91191 Gif-sur-Yvette, France (michel.schlegel@cea.fr)
[3]Institute for Energy Research 6, Jülich Research Centre, D-52425 Jülich, German (d.bosbach@fz-juelich.de)
[4]Helmholtz Virtual Institute "Advanced Solid Aqueous Radiogeochemistry" Germany

Various secondary phases may form upon alteration of the High Level nuclear Waste (HLW) glass over geological time scales, including hectorite [1] (a magnesian smectite). Such secondary phases represent a significant retention potential for radionuclides (RNs), including actinides. In addition to (surface) adsorption reactions, effective RN incorporation into the bulk structure may occur by coprecipitation. Recently, hectorite was coprecipitated in the presence of the trivalent lanthanide Eu(III) [2], as non-radioactive chemical homologue for trivalent actinides. Time-resolved laser fluorescence spectroscopy data suggested that Eu(III) substitutes for cations at octahedral position.

Polarized EXAFS (P-EXAFS) experiments [3] were performed on Lu(III)-containing samples associated with the hectorite multi-step synthesis protocol [4]. P-EXAFS spectra were collected for the (Mg/Lu) hydroxide precursor and the Lu(III)-coprecipitated hectorite at different angles α between the electric field vector of the X-ray beam and the mineral layer plane. The modeling results for the oxygen shell (d(Lu-O) = 2.27 Å) strongly suggest that Lu(III) is located in an octahedral brucite-like environment in the precursor. For this sample, an additional Mg shell is detected at 3.30 Å. The apparent coordination numbers for the O and Mg shells decrease with increasing α, supporting the Lu(III) incorporation in flattened brucite layers. In hectorite, the short Lu-O distance (2.19 Å) and the detection of Mg (3.12 Å) and Si (3.37 Å) shells strongly suggest that Lu(III) is located in a strained octahedral clay-like environment. Finally, no surface complex was detected, as evident by comparison with the Lu(III) sorbed smectite.

[1 Zwicky *et al.* (1989) *Mater. Res. Soc. Symp. Proc.* **127**, 129-136. [2] Finck *et al*. (2008) *J. Contam. Hydrol.* **152**, 253-262. [3] Manceau *et al.* (1988) *Phys. Chem. Miner.* **16**, 180-185. [4] Carrado *et al*. (1997) *Clay Miner.* **32**, 29-40.