Aqueous alteration of the martian crust during magma ocean cooling

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Mars' basaltic crust has been chemically altered by fluids to form secondary minerals, particularly phyllosilicates, that are distributed all over the surface and to great depth [1,2]. The reactions that drove this alteration required a source of heat and water; while it is generally agreed this occurred mostly >3 Ga, it has been difficult to constrain exactly when and where these reactions originally took place. Once formed, phyllosilicates are thermodynamically robust against being transformed further at near-surface conditions, so they could be inherited from very early in Mars' history and simply shuffled around by impact gardening and fluvio-lacustrine activity since then. A cooling magma ocean probably represents the largest source of heat and volatiles Mars ever had, and here we explore the possibility that some of the observed crustal alteration happened during this time.

We synthesized basaltic rocks with a composition similar to the estimated bulk martian crust. The samples consist of plagioclase > pyroxene ($Wo_{46}En_{30}Fs_{24}$) > olivine (zoned from $Fo_{31\text{-}63}$), with accessory oxides and glass. We are reacting coarsely ground particles (0.5-1 mm) of this material with water in a hydrothermal cell at 4 conditions within and adjacent to the supercritical field; these conditions are predicted to be relevant to the martian surface and subsurface at the time of primordial crust formation [3]. Altered samples are being analyzed by visible/near-infrared spectroscopy, scanning electron microsopy, X-ray diffraction, and electron probe microanalysis to determine the extent of alteration and compare the alteration products with those identified on Mars through remote sensing. Preliminary results show noticeable Fe/Mg phyllosilicate formation in the supercritical region (425°C, 300 bar) after just 2 weeks; we will present full data on all samples, comparing near-supercritical conditions with more typical crustal environments considered for ancient Mars.

[1] Carter *et al*. (2013) *J. Geophys. Res*. **118,** 1-28. [2] Sun and Milliken (2015) *J. Geophys. Res*. **120,** 2293-2332. [3] Elkins-Tanton (2008) *Earth Planet. Sci. Lett*. **271,** 181-191.