

SUPPORTING EVIDENCE FOR AN ULTRAMAFIC COMPONENT OF THE MARTIAN CRUST. Douglas A. Howard and Harry Y. McSween, Planetary Geoscience Institute and Department of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996, dhowar16@utk.edu.

Introduction: Recent Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) visible, near-infrared, and short-wave infrared spectral analysis suggests that the Nili Fossae region contains ultramafic rocks composed of olivine, serpentine, and magnesite [1, 2]. Here we show that the ultramafic mineralogy indicated by CRISM qualitative spectral mixing studies is generally supported by Thermal Emission Imaging System (THEMIS) IR quantitative spectral deconvolution, although the previously proposed mineral assemblage is not unique and the spectra can be matched without Mg-carbonate.

CRISM and THEMIS spectral analysis: Nili Fossae has been the focus of intense VNIR/SWIR (1–4 μm) spectral assessment in part due to outcrops reported to contain carbonate [1, 2]. Spectral analyses coupled with observations of ultramafic analogs on Earth indicate that serpentine and magnesium carbonate are reasonable aqueous alteration products from ultramafic rocks [3, 4]. Due to the non-linearity of VNIR/SWIR spectral deconvolution, it is difficult to accurately assess the quantitative proportion of each identified mineral in the spectrum. Therefore, proportions are estimated by synthesizing “best fit” spectral combinations of the minerals identified, as was done by [2].

THEMIS is an emissive imaging spectrometer (0.425 – 14.88 μm) which allows linear deconvolution to assess proportions of the minerals identified. Although the spatial resolution of the THEMIS instrument is 2.5 – 5.5 times less than CRISM, it is invaluable for large scale mineral mapping and analysis (Fig. 1). Figure 1 demonstrates that although CRISM is higher spatial resolution than THEMIS there are only four general spectrally homogeneous groups in this area of Nili Fossae. Here we use THEMIS to estimate the general mineralogical character of the areas assessed by CRISM as having ultramafic lithologies.

Results: Mineral compositions reported by [2] suggest 80 wt% magnesite, 15 wt% medium-grained olivine (fayalite) sand, and 5 wt% nontronite to match the CRISM spectra in Nili Fossae (CRISM image FRT00003E12). Although the modeled spectra could not be exactly replicated using Mg carbonates and olivine from the RELAB spectral database (adding any of the nontronite spectra do not significantly affect the result), the spectral solution of [2] does provide a reasonable match to the image extracted spectra.

THEMIS IR deconvolution also resulted in a non-unique solution with 59 wt% olivine (forsterite), 31 wt% low-Ca pyroxene (hypersthene) and 9 wt% talc/serpentine. (Vol% in the deconvolution was converted to wt% to facilitate comparison.) The



Figure 1. Images of Nili Fossae ultramafic mineral assemblage region; a. CRISM VNIR/SWIR image FRT0000E12, b. THEMIS IR radiance image I02007009, c. THEMIS decorrelation stretch of image I02007009 showing 4 homogeneous spectral groups (zoomed out slightly from a. and b. For scale, the green “carbonate” feature in the center of a. is about 400 m long.

deconvolution is non-unique in that serpentine is interchangeable with talc when available in the spectral mixing library.

The association of olivine and orthopyroxene with serpentine and their alteration products (talc and various phyllosilicates) may lead to spectral ambiguity and confusion. In fact, plotting the THEMIS deconvolution spectra in reflectance wavelengths shows a very good correlation to CRISM spectra in Nili Fossae (Fig. 2). Thus THEMIS spectra confirm the ultramafic composition of this region, but suggest that a mineral assemblage without carbonate is possible. Given that magnesite is a common mineral in altered ultramafic rocks on Earth, is there any reason to suppose that it might not also be on Mars?

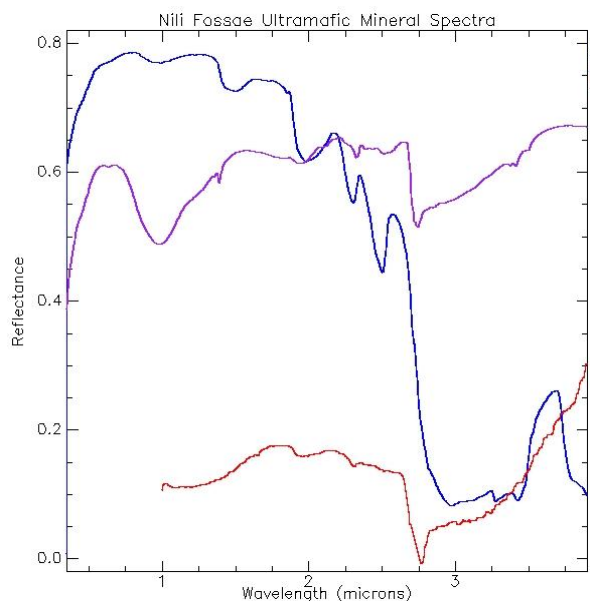


Figure 2. Nili Fossae ultramafic mineral assemblages. Red line is averaged CRISM spectra extracted from CRISM image FRT000E12, blue line is the CRISM qualitative spectral mixture [2], and purple line is THEMIS IR deconvolution spectra (olivine + orthopyroxene + serpentine/talc) in reflectance wavelengths.

Geochemical model: Using an ultramafic rock precursor in a Mars geochemical model produces varied results depending on atmospheric and hydrologic condition assumptions. Many geochemical models focus on P_{O_2} and P_{CO_2} that reflect the current cold dry atmospheric conditions [5-7], resulting in evaporite deposits rich in chloride and sulfate salts. However, under hypothesized ancient, warmer, wetter, and high P_{CO_2} , an ultramafic composition can alter to produce

siderite, as a precursor to Fe oxide and hydroxide dominant mineral species (Fig. 3). Under these possible early Martian conditions the model shows that Mg carbonate dissolves and is thus unstable.

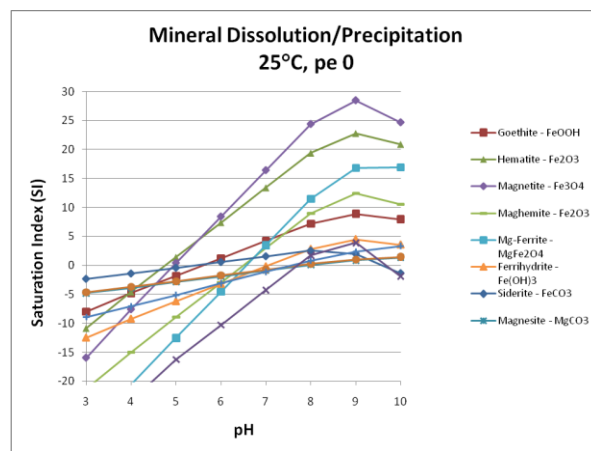


Figure 3. Mineral dissolution (SI < 0) and precipitation (SI > 0), from ultramafic regolith composition at 25C and high P_{CO_2} .

Conclusions: Although the spectral character of the Nili Fossae region is different for each imaging instrument, the resultant mineral assemblages do support an ultramafic crustal component. However, the mineralogy as determined from spectra appears to be non-unique, and alteration assemblages without carbonate may be possible. The mineral assemblage deconvolved from THEMIS spectra corresponds to harzburgite (olivine + orthopyroxene) that is less altered than that suggested from CRISM spectra.

References: [1] Ehlmann, B.L., Mustard, J.F., Murchie, S.L. (2009), *LPS XXXX*, Abstract #1787. [2] Ehlmann, B.L. et al. (2008), *Science*, 322, 1828-1832. [3] Möller, P., ed. (1989) *Magnesite*, Monograph Series on Mineral Deposits, 28, Berlin-Stuttgart. [4] Brown, A.J., Walter M.R., and Cudahy, T. (2004), *LPS XXXV*, Abstract #1420. [5] Gaidos, E. and Marion, G. (2003), *JGR*, 108, doi:10.1029/2002JE002000. [6] Tosca, N.J. et al. (2005), *Earth & Planetary Letters*, 240, 122-148. [7] King, P.L., Lescinsky, D.T., and Nesbitt, H.W. (2004), *Geochimica et Cosmochimica Acta*, 68, 4993-5008.