EXPLORING TERRA SABAEA VOLCANIC TERRAIN USING CRISM MAPPING-MODE DATA.

A. B Peña[1], C. E. Viviano[2], D. L. Buczkowski[2], and K. D. Seelos[2]. [1]The Johns Hopkins University <apena7@jh.edu>, [2]Johns Hopkins University Applied Physics Laboratory.

Introduction: Constraining the composition of the earliest volcanic materials on Mars can be difficult, as much Noachian crust is heavily degraded. The Terra Sabaea region, to the northwest of Hellas Basin, exposes spatially concentrated rocky units [1] associated with the Hellas ring structures which may be suggestive of their basin-induced origin [2]. The Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [3] is sensitive to many primary minerals that make up ancient volcanic lithologies, providing insight into the planet's crustal evolution. The purpose of this study is to use CRISM 180-m/pixel mapping-mode data to validate and map the compositions present in the Terra Sabaea region and characterize its mineralogic transitions. While initial investigations have utilized the 18-m/pixel CRISM data [2], this work is novel as the more complete coverage of CRISM mapping data can confirm and expand upon past findings related to the origin of these volcanic materials.

Methodology: CRISM's 180-m/pixel multispectral mapping mode was used exclusively for this effort. The data are mosaiced into 5°x5° "tiles", and the initial area of study spans three of these tiles. Absorption bands from mineral signatures were parametrized [4] to create red-green-blue false color composites of each tile that highlighted the presence and concentration of different minerals.

Elevated parameter values identified in these composite tiles that were not obviously affected by lighting conditions (e.g., steep slopes), were marked as regions

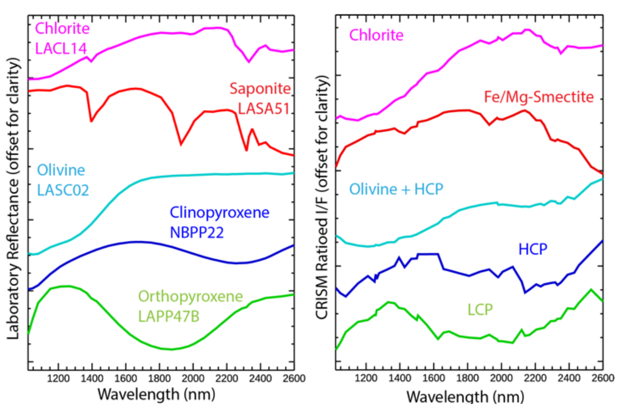


Figure 1. Laboratory spectra from RELAB library (left) and example CRISM spectra units from mapped Terra Sabaea units (right). Chlorite and Fe/Mg-smectite spectra have Fe/Mg-OH band centers at ~2.35 μm and ~2/30 μm, respectively.

of interest. Using ENVI, spectral data from these regions were extracted and compared to spectral signatures from the MICA library [4], a compilation of the best CRISM end members from published literature, and laboratory spectra resampled to the CRISM MSP (multispectral) bandpasses [5] (see Fig. 1).

To map spectral units, similar spectral signatures across CRISM data gaps were interpolated where morphology was identical but spectral data were missing (e.g., crater floor fill material). These mapped units were transposed over a THEMIS map of the region to create an interpreted spectral unit map using JMARS. Figure 2 displays the area of study under a mafic (MAF) composite[4], which was one of three main composites used for mapping. Parameter composites were chosen based on a previous understanding of which mineral groups were expected to be found and through trial error. The MAF composite was most useful for identification of olivine, and low- and high-Ca pyroxenes (LCP and HCP, respectively) signatures since it displays olivine and HCP in red hues and LCP in cyan hues. Under this composite, phyllosilicates appeared in a darker red that was difficult to distinguish from the olivine and HCP, so a different composite (PFM) was used to better identify phyllosilicate mineralogy and distribution [4].

Findings/Trends: The majority of the spectrally distinct units in the Terra Sabaea region were located within the topographic lows (craters or graben), or along the crater rims. Spectral signature consistent with HCP and olivine in variable amounts were the most predominant compositions identified, and were detected in flat-floored craters and within the lows of the graben (blue units, Fig. 2). Smaller exposures of LCP and Fe/Mg-phyllosilicates were identified mostly related to crater rims and ejecta, suggesting excavation from underlying material. Several crater floors also had a LCP signature. Spectral signatures consistent with pure HCP were rarer, with most of the HCP spectral units bearing a strong olivine signature (see cyan spectra unit in Fig. 1).

Using MOLA elevation data [6], chlorite and olivine + HCP were identified to be found on the highest elevations, though both were within one standard deviation of the average elevation. Four different geological units were represented within the area of study: Early Noachian highland (eNh), Middle Noachian highland (mNh), Late Noachian highland (lNh), and Amazonian and Hesperian impact units (AHi) [7]. 47% of the spectral units fell within both eNh and mNh, and 3% fell within both lNh and AHi. The olivine + HCP mixture was the most prevalent in all of the geological units. The mapped LCP and Fe/Mg-smectite were only identified in the eNh and mNh units.

Average TES thermal inertia [8] was also extracted for each spectral unit for direct comparison with work by [2]. LCP had the highest average thermal inertia (~277 tiu), followed by the olivine + HCP mixture, while chlorite had the average lowest (~256 tiu). All averages were within one standard deviation of each other. For a more robust comparison with work by [2], identifying sub-regions within our mapped units that are debris-free will likely result in more distinct thermal inertia values for each unit.

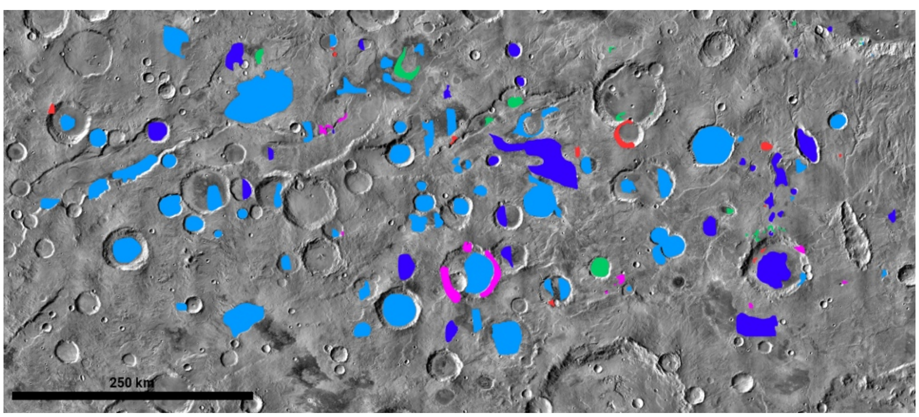
Conclusion: The goal of this project was to regionally characterize the mineralogic transitions of Terra Sabaea that are recorded in geologic units of differing ages. This heavily-cratered region is mostly composed of primary crust with Noachian-aged material. Based on the mapped compositional units found, Terra Sabaea displays the chemical evolution of pyroxene in Mars's primary crust from LCP to HCP through the early and middle Noachian period and the abrupt decrease of either into the late Noachian.

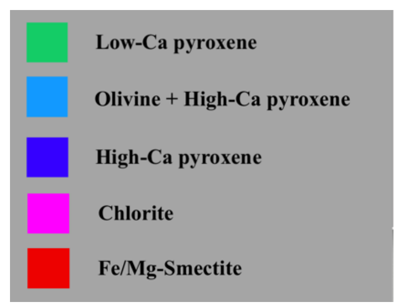
A strong relationship between thermal inertia and the CRISM compositional mapping remains to be determined, although previous efforts [2] have identified this relationship for an overlapping region of our map.

As this study continues, the goal will be to further identify trends between the morphology and the composition of the units identified in order to facilitate mapping, improve future identification in new areas, and help to constrain the origin of each compositional unit to better determine the regional geologic history.

Acknowledgments: Thanks to Will Gray-Roncal and Martha Cervantes from CIRCUIT, a program for undergraduate research at Johns Hopkins Applied Physics Laboratory (APL) in Laurel, MD. Special thanks to my mentors from APL: Debra Buczkowski, Kim Seelos, and Christina Viviano. This work was funded by grant #80NSSC17K0451 through the NASA Mars Data Analysis Program, and by the CRISM investigation on the Mars Reconnaissance Orbiter through JPL subcontract 1277793 to the Johns Hopkins Applied Physics Laboratory.

References: [1] Rogers et al. (2009). [2] Rogers et al. (2013), JGR, 118, 1094-1113. [3] Murchie, S.L. et al. (2007), JGR, 112, E05, S03. [4] Viviano-Beck et al. (2014), JGR, 119(6), 1403-1431. [5] RELAB Spectral Database: http://www.planetary.brown.edu/relab/ [6] Fergason et al. (2018), Astrogeo, PDS Annex, USGS. [7] Tanaka et al. (2014), Geol. Map of Mars, USGS Map SIM 3292. [8] Christensen and Moore (1992), ed Kieffer, 686-729.





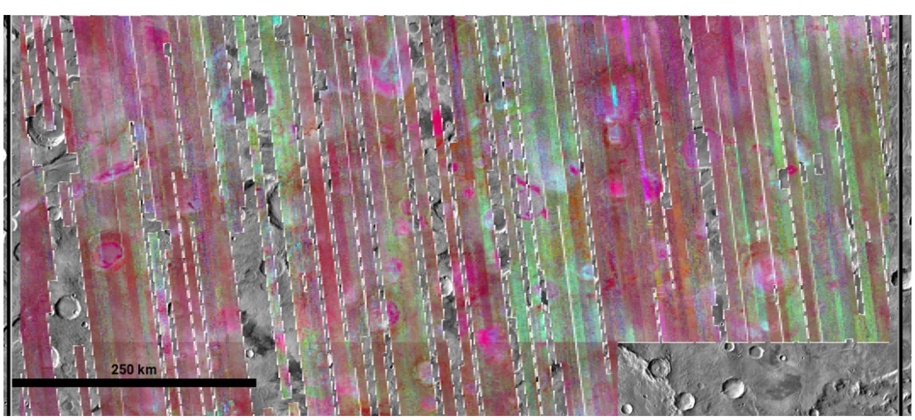


Figure 2. CRISM Tiles 0667, 0678, 0669 (area of study). (Top) Mapped compositional units in Terra Sabaea with key. (Bottom) MAF CRISM mapping data overlain on THEMIS daytime infrared mosaic.

MAF composite:
R: OLINDEX, G: LCPINDEX2, B: HCPINDEX2.

PFM channels (not depicted):
R: BD2355, G: D2300, B: BD2290.