THE NILI FOSSAE CARBONATE PLAINS AS VIEWED BY TES, THEMIS, AND CRISM: ALTERATION OF ULTRAMAFIC ROCKS AND CLAY-CARBONATE STATRIGRAPHY C. S. Edwards[1] and B. L. Ehlmann [1], [1]California Institute of Technology, Division of Geological and Planetary Sciences, Pasadena, CA, cedwards@caltech.edu.

Introduction: The regional and local scale geology of the Nili Fossae region has been characterized in detail by a variety of investigators [e.g. 1, 2-6]. Several distinctive stratigraphic units record a number of unique environments and varied history of aqueous alteration, from the early Noachian to early Hesperian, including: 1) Fe/Mg smectite clay bearing units commonly found in ancient Martian terrain, 2) a rocky carbonate/olivine bearing unit, 3) an Al clay [e.g. 1, 4], 4) a mafic cap unit of basaltic composition, and 5) olivine bearing sands.

We have examined several locations of interest, with an emphasis on constraining the nature and geologic conditions responsible for the areally extensive Carbonate Plains. In order to accomplish this, we need to establish the differentiability of the five units above in a variety of datasets including High Resolution Imaging Science Experiment (HiRISE), Compact Reconnaissance Imaging Spectrometer (CRISM), Thermal Emission Imaging System (THEMIS) and Thermal Emission Spectrometer Data (TES). This is a challenging undertaking given the disparate spatial resolutions (0.3m to ~3x6km), spectral sampling (4 to 438 spectral bands) and spectral ranges (VIS/NIR to TIR) of the orbital instruments.

Larger goals for characterizing the geology of the region include: 1) constraining the mineral abundances associated with the carbonate unit and other distinguishable geologic units, 2) establishing the nature of the olivine-bearing unit (e.g. ultramafic, picritic, etc.), 3) examining the geologic character of the layered carbonate plains (e.g. strike, dip, bedding), and 4) examining the relationship between the clay-bearing terrains and the other geologically significant units in the region. Moderate spatial resolution (but spectrally limited datasets) such as THEMIS in combination with TES (low spatial but high spectral resolution) have the potential to allow for the mapping and examination of the regional distribution of differentiable geologic units while the high-spatial and high spectral resolution CRISM dataset can aid in the fine-scale differentiability and interrelatedness of the geologic units in question. In this work we provide a linked view (Fig. 1) of several geologically significant surfaces using all the datasets available at each location and for each geologic unit.

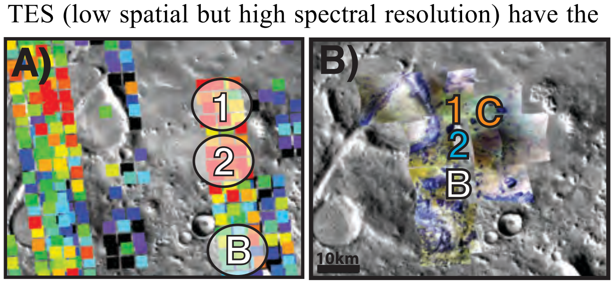

Figure 1. Overview site A) TES index developed by [7] and shows the location of TES spectra in Figure 3. B) CRISM color mosaic (green=carbonate, purple=mafic cap unit, yellow-brown=olivine bearing), with the locations of a CRISM spectrum (C) and THEMIS/HiRISE observations (1, 2, B).

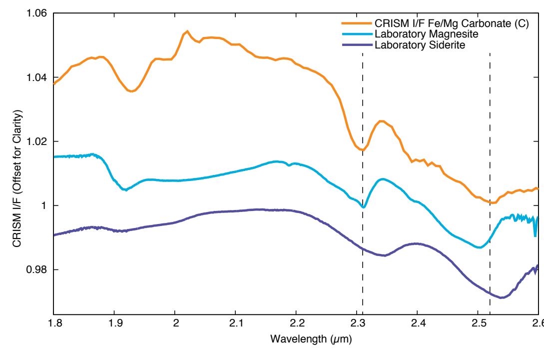

Figure 2. CRISM Ratioed I/F of location C (Fig. 1B) compared to endmembers of the Magnesite-Siderite solid solution [8].

CRISM: In this work, we did not focus solely on CRISM observations as most work to date in the area has been conducted using the VIS/NIR wavelength ranges to identify clays and carbonates [e.g. 1, 2-4]. Fig. 2 shows a sample spectrum from location C (Fig. 1B). The CRISM spectrum (at 2.3 and 2.5μm) is not a perfect match for either the Fe- (siderite) or Mg- (magnesite) endmember and may indicate the true composition lies on the Fe-Mg carbonate solid solution and that the geologic unit includes some Fe/Mg smectite clay [e.g. 4].

TES: In order to quantitatively assess the bulk mineralogy of the carbonate plains, we modeled at-

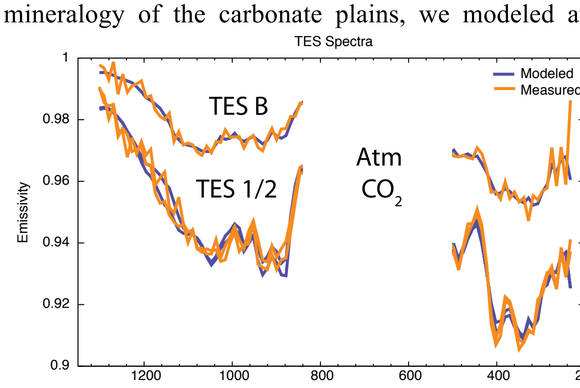

Figure 3. TES spectra of high and low index values from [7], Fig. 1A.

Table 1. TES model mineral abundances from Figure 3

Mineral	B	1/2
Pyroxene	24 (8)	23 (4)
Olivine	10 (6)	23 (3)
High-Si Phases	23 (8)	22 (5)
Carbonate	10 (5)	16 (4)
Feldspar	22 (10)	10 (6)
Other	10 (3)	5 (2)

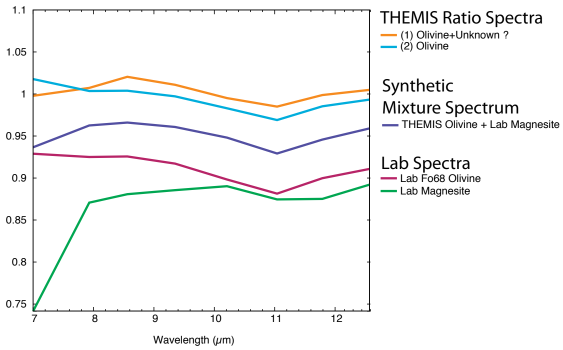

Figure 4. THEMIS ratio and lab spectra of the Fe/Mg carbonate solid solution. The locations of the spectra are shown in Figure 1B. A synthetic mixture has been made of THEMIS olivine ratio and laboratory carbonate, which is a reasonable match for the location 1 spectrum, while the spectral ratio location 2 is an excellent match for olivine.

mospherically corrected [9-13] TES data for geologic units with CRISM carbonate and non-carbonate signatures and the spectral library of Rogers and Fergason [14] plus additional carbonates from [7]. Spectra from TES locations 1/2 are nearly identical and have enhanced olivine and carbonate and decreased feldspar abundances relative to location B (Fig. 3, Table 1).

THEIMS: When the olivine and carbonate bearing materials are examined using THEMIS data, they appear to be differentiable at small scales, but due to the low number of spectral bands the separation of significantly significant spectral features becomes more challenging. However, ratioing geologic units of interest against the mafic cap unit has proven to be a powerful tool to identify minor spectral differences between geologic units that have few varying components. In region 1, THEMIS bands 1/2/3 slope downward in the ratio spectrum and may be indicative of an enhancement in carbonate as compared to a spectrum more similar to olivine from region 2 (Fig. 4). HiRISE observations of the same sites as the THEMIS spectra (Figs. 1 & 5) show distinctive morphologies that can be directly related to unit composition throughout the region.

We have not yet conducted the full THEMS atmospheric correction [15] as the modeled mineral abundances for the carbonate plains show carbonate at ~15% which may be too low to detect with THEMIS

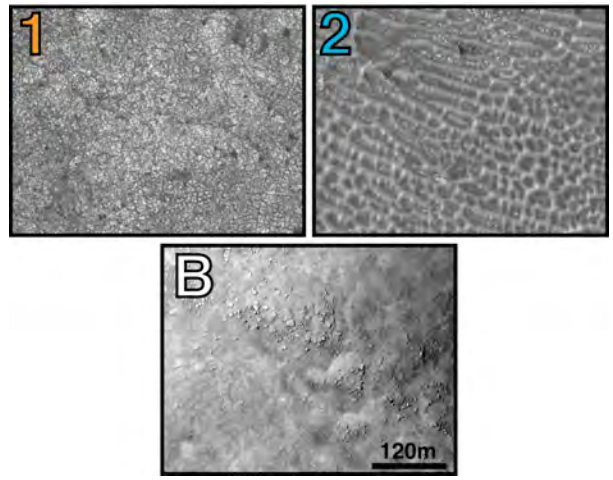

Figure 5. HiRISE images that correspond to the same locations as the THEMIS spectra in Figs. 1 & 4.

with standard spectral unmixing techniques. However, using scene endmembers to map unit distribution may be a satisfying alternative for mineral library unmixing procedures [e.g. 16], especially when combined with a spectral sensitivity study and with information from other datasets.

Discussion/Future Work:

In this work we have shown that TES and THEMIS compositional data can be directly related to CRISM units of interest where outcrops are large enough or geologic units are of significantly different composition. The best geologic understanding of the region will be made when these datasets are used in combination to map, characterize, and quantify the variably in geologic setting. A comprehensive morphologic, thermophysical, and spectroscopic map of the west Nili Fossae region is being constructed to robustly assess the variety of past geologic environments observable at this location, allowing for better quantification of mineralogy, the extent and nature of aqueous environments represented in the diverse units, and the scientific potential for future landed missions.

References:

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