**COMBINED VISIBLE/NEAR INFRARED AND THERMAL INFRARED ANALYSES OF THE NILI FOSSAE REGION, MARS.**
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**Introduction and background:** Phyllosilicates discovered in the Nili Fossae region of Mars using near infrared reflectance data from the Observatoire pour la Minéralogie, L'Eau, Les Glaces, et L'Activité (OMEGA) and the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) [1-2] provide a window into ancient aqueous processes on Mars. In this work, we compare data from the Thermal Emission Spectrometer (TES) with OMEGA data to constrain the mineralogy and thermophysical properties of this region. The different wavelength regions measured by these two instruments provide complimentary information about surface composition.

Clay mineral deposits at Nili Fossae correspond to a variety of geomorphic surfaces, including locally layered terrain, massive deposits, and surfaces seemingly cut by dikes and fractures [3]. In these surfaces, OMEGA data show smectite clay minerals along with pyroxene and, in some cases, olivine. Based on near infrared data, the phyllosilicates are largely classified Fe/Mg-bearing smectite clays because of the occurrence of spectral absorptions related to H-O-H (interpreted as interlayer water in expandable clays) at ($\lambda$=) 1.9 μm, octahedral (Fe/Mg)-OH near 2.3 μm, and the overall spectral shape of the phyllosilicate-bearing surfaces. CRISM analyses have shown local exposures of other clay minerals such as kaolinite, chlorite, illite or muscovite, and other unidentified alteration phases scattered in patchy deposits throughout the region [4].

TES data are used here as another method to map phyllosilicates in the Nili Fossae region. We developed spectral indices tailored to identify spectral absorptions in thermal emission spectra of phyllosilicate minerals in the 470-540 $cm^{-1}$ region; these features are related to Si-O-M (M=$Al^{3+}$, $Fe^{3+}$, $Fe^{2+}$, and $Mg^{2+}$) bonds between the tetrahedral and octahedral sheets. In addition, thermal infared data are sensitive to some minerals not detectable in the near infared, such as feldspars and anhydrous silica phases. We present qualitative and quantitative approaches to constrain the surface mineralogy.

**Methods:** OMEGA data were processed to I/F using standard procedures to correct for instrument effects, solar influx, and atmospheric path discussed in previous work [1]. OMEGA mineral maps were produced using the same band indices described by [5] to identify pyroxene and olivine from $Fe^{2+}$ electronic absorptions, and hydration from the 1.9 μm water absorption (Figure 1).

TES data were used in three tasks: 1) to map surface mineralogy from spectral indices, 2) to produce simple spectral ratios of altered terrain to adjacent, unaltered surfaces (to determine if there are unique spectral features of the altered surfaces), and 3) to extract atmospherically corrected surface emissivity of the clay-bearing surfaces.

For spectral mapping, data from orbits up to 20,000 were selected for the highest quality using constraints for low water ice opacity (<0.15), low dust extinction (<0.3), and high surface temperature (T >260 K). We focus on long wavelength features to identify specific minerals because in this region (300-565 $cm^{-1}$) the martian atmosphere is more transparent. TES spectral index maps have been used by [6] to search for phyllosilicates on Mars from long wavelength spectral features before and here, we use a similar approach with modifications to the specific spectral indices. Our 466-476 index is defined as the ratio of 561 $cm^{-1}$ band divided by the sum of bands at 466 and 476 $cm^{-1}$, and is used to search for absorptions related to high-silica phases or trioctahedral clay minerals (*e.g.* saponite). The 508-518 indes is defined as the ratio of the band at 561 $cm^{-1}$ divided by the sum of bands at 508 and 518 $cm^{-1}$, and is used to search for $Fe^{3+}$-bearing dioctahedral clay minerals such as nontronite. In addition, we also adopt spectral indices used in previous work to map olivine [7].

For tasks 2 and 3, we use the same constraints, but limit TES data to lower orbits (ock < 7000). Data were processed to calibrated, un-atmospherically corrected emissivity data for task 2. We then take the ratio of a group of detectors on the clay-bearing deposit to a group of detectors off the deposit in a nearby area, measured during the same orbit. For task 3, we take an additional step and correct for atmorpheric contribtions using a linear unmixing of atmospheric components described by [8].

**Results:** TES spectral index mapping shows several correlations with OMEGA spectral maps (Figure 1). The TES olivine index shows a detection in the northeast part of the map area, where the strongest OMEGA olivine detections occur. The TES 508-518 spectral index shows patchy occurrences of nontronite-like materials throughout the ancient cratered terrain. Where it occurs, it is usually correlated with the 1.9

μm hydration feature detected by OMEGA. The 466-476 index also shows positive detections throughout many parts of the ancient cratered terrain to the north and east, and within small exposures of ancient terrain totally embayed by lava in the central map area. Where it occurs, the 466-476 spectral index is usually correlated with OMEGA hydration, suggesting it is detecting either a trioctahedral clay mineral phase, a silica-rich phase associated with the OMEGA phyllosilicates, or both. In the southwest map area, where OMEGA data show a hydration feature associated with the central peak of the ~30 km diameter crater (spot 2), the 466-476 index shows a positive detection.

Simple ratios of TES emissivity data show some spectral difference between phyllosilicate-bearing deposits and adjacent surfaces off the deposits. In general however, the differences are small. This suggests that either, at the scale of TES spatial resolution, the surface spectral signature is usually dominated by a mobile sandy surface component of basaltic composition, or that the phyllosilicate-bearing deposits are in fact dominantly basaltic composition by nature.

Atmospherically corrected surface emissivity spectra of the phyllosilicates are broadly similar to typical basaltic terrains on Mars but with some important differences. The phyllosilicate-bearing terrains exhibit broad absorptions in the 800-1200 $cm^{-1}$ region typical of basaltic surfaces. By comparison to other dark terrain spectra, this implies mineralogy dominated by plagioclase feldspar and pyroxene. However, strong absorptions present from 300-400 $cm^{-1}$ in typical dark terrain spectra are weaker in the Nili phyllosilicate surfaces, indicating slightly less olivine and pyroxene than present in typical dark terrains. Spectral unmimxing results suggest 15-30% clay minerals, depending on the particle size distribution of the surface.

**Conclusion:** The Nili Fossae phyllosilicate deposits are dominantly basaltic in composition, suggesting the alteration in this region was widespread, but not pervasive. TES results support the presence of at least two classes of alteration phases throughout the region: one that is nontronite-like and one that is saponite-like. It is possible that the nontronite-like phases is an oxidative weathering product of an Fe-rich saponite like phase [9]. The abundance of clay minerals within these surfaces is estimated in this work at 15-30%, depending on the particle size distribution of the surface.

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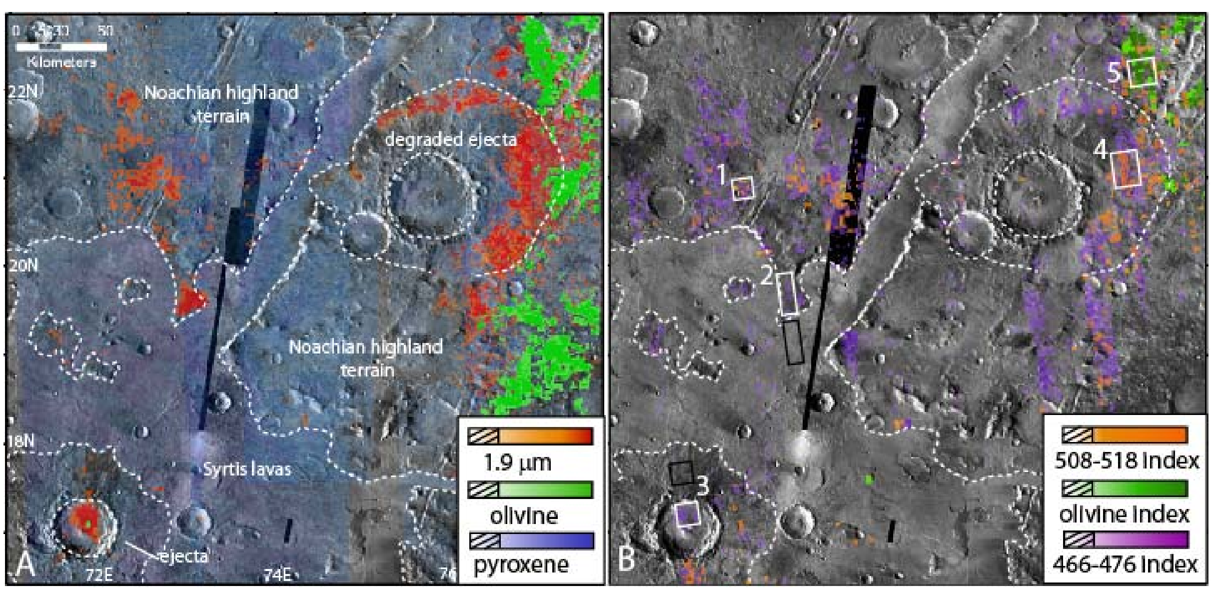


**Figure 1:** OMEGA spectral index maps (A) are shown at the left. Basic geomorphic/geologic mapping is shown in with dashed lines based on the work of [3]. TES spectral index maps are shown in (B). The 466-476 index shows the occurrence of saponite-like clays associated with OMEGA phyllosilicates in the ancient terrain. The 508-518 index identifies nontronite-like clays, often associated with the saponite-like clays. These materials are mapped in the ancient, eroded surfaces to the north and east,, discussed in detail by [3].