A THEMIS SPECTRAL INDEX FOR DETECTION OF PHYLLOSILICATES ON MARS. C. E. Viviano\(^1\), J. E. Moersch\(^1\), and J. L. Piattek\(^2\), \(^1\)Department of Earth & Planetary Sciences, University of Tennessee, Knoxville, TN 37996; \(<\text{cviviano@utk.edu}>, \)\(^2\)Physics & Earth Sciences Department, Central Connecticut State University.

Introduction: The Mars Express OMEGA and Mars Reconnaissance Orbiter CRISM experiments have discovered and mapped mineralogically diverse phyllosilicate deposits on Mars through hyperspectral detection in the near-infrared, e.g., [1], [2], [3], [4], [5]. Examples of these deposits have been reported in the Mawrth Vallis region (~24°N, 340°E), the Nili Fossae region (~22°N, 77°E), a Noachian-aged outcrop in Syrtis Major (~19.5°N, 73°E), and a dark deposit in Ismenius Lacus (~34°N, 17°E) [1], [2], [3], [4], [5]. OMEGA and CRISM spectra of these phyllosilicates are most similar to laboratory spectra of Fe/Mg and Al-rich varieties, e.g., [1], [3], [5], [6].

THEMIS, aboard the Mars Odyssey spacecraft, has acquired multispectral thermal infrared images of Mars at 100m/pixel spatial resolution with nearly global coverage. Observation of the primary silicate absorption feature in the thermal infrared may be used to constrain clay mineralogical identification [7]. Although it is recognized that THEMIS may detect spectral uniqueness in clay-rich areas [8], little has been done to utilize this feature, due to the lack of a definitive clay signal deconvolved from corresponding TES data.

Here, we have used THEMIS and OMEGA coverage of the Mawrth Vallis, Nili Fossae, Syrtis Major, and Ismenius Lacus to find a clay spectral signature in the thermal infrared. This signature was used to develop a spectral index that is sensitive to the spectral shape of clays. Application of this index to other THEMIS images will be used to identify clay-rich regions in areas of Mars not yet observed by OMEGA or CRISM.

Methods: THEMIS daytime infrared images of OMEGA-identified clay-rich regions were corrected for drift, rectified, “deplaided”, radiance corrected, and map projected using the THEMIS image processing web interface (http://thmproc.mars.asu.edu). Initially, images with the highest average temperatures (a minimum of 240 K) were chosen to maximize signal-to-noise ratios in the scene. The ENVI 4.2 remote sensing software suite was used to run a custom TES-derived multiplicative atmospheric correction using techniques described in [9]. Mean spectra were extracted from regions of interest (ROIs) corresponding to the locations of OMEGA-identified phyllosilicate-rich deposits.

A spectral index was developed based on manual inspection of THEMIS spectral shapes within and outside the phyllosilicate areas mapped by OMEGA. This index was then refined through application to multiple THEMIS scenes of example areas on Mars where OMEGA has detected phyllosilicates.

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\text{THEMIS Phyllosilicate Index} = 3\times(b6/b7)+(b7/b5)+(b8/b9)+2\times(b8/b5)+2\times(b3/b4)+(b6/b5)
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(Outputted values >11.2 correspond to OMEGA-identified clays)

Note that the spectral index above is refined from a preliminary version we have previously published [10], and will probably be further refined as we examine more clay-rich targets.

Results and Discussion: The results of applying our phyllosilicate spectral index to THEMIS data are shown in the left-hand panels of Figure 1 (below) for Mawrth Vallis, Syrtis Major, and Ismenius Lacus. THEMIS pixels with a phyllosilicate index greater than 11.2 correspond to OMEGA-identified, clay-rich regions (right-hand panels in Figure 1), though there are some slight discrepancies, particularly in a region NE of the clay deposit in Syrtis Major. We were unable to map clays in the Nili Fossae region using the same spectral index that worked in the other three locations. This lack of detection in Nili Fossae could be due to the physical nature of the clays in this region. It has been hypothesized that the region is comprised of >100µm olivine grains [11] within a possible matrix of clays produced by alteration [6]. If the clay grains in this matrix are sufficiently small (<~30µm), they would be more difficult to observe in the longer-wavelength thermal infrared wavelengths [12], [13], used by THEMIS than at the near-infrared wavelengths used by OMEGA. In contrast, the phyllosilicates observed in Mawrth Vallis are associated with layered rocks [1] part of a >100m thick geologic unit [3], which perhaps would be less affected by loss of spectral contrast associated with particle size effects. The output of the index also relies on the quality of the atmospheric correction of a region, which is dependent upon TES data quality, as well as signal-to-noise and atmospheric dust content in the THEMIS scene. THEMIS scenes with poor atmospheric corrections tend to give false-positive detections (index greater than 11.2) over the majority of the image. It was also determined that the THEMIS phyllosilicate index produces ambiguous results when used on clay-rich areas with brightness temperatures of greater than 255 K.
Conclusions: Our results suggest that the phyllosilicate-bearing outcrops in Mawrth Vallis, Syrtis Major, and Ismenius Lacus detected by OMEGA also have consistent THEMIS thermal infrared spectral properties that are distinct from surrounding terrain. These spectral properties can be quantified in a THEMIS spectral index. A reliable THEMIS spectral index for phyllosilicates would have tremendous utility in mapping the full distribution of these minerals because of the near-global coverage of the THEMIS dataset. THEMIS-based detections of new areas of phyllosilicates could be used to target future OMEGA and CRISM observations for confirmation.


Figure 1. A, left: Mawrth Vallis phyllosilicate index image (see text) derived from THEMIS image I01199005. Red pixels correspond to index values greater than 11.2, which we consider a positive THEMIS detection of phyllosilicates. A, right: Subset of OMEGA-detected spectral indices of the 1.93µm, 2.20µm, and 2.3µm bands (blue, green, red, respectively) [3] for the same area as A, left. Both right and left centered at (~24°41’N, 340°48’E). B, left: Ismenius Lacus phyllosilicate index image derived from THEMIS image I03220002. B, right: Subset of OMEGA coverage of Ismenius Lacus (phyllosilicate in blue, pyroxene in green) [1]. Both right and left centered at (~34°10’N, 16°57’E). C, left: Syrtis Major phyllosilicate index image derived from THEMIS image I02469002. C, right: OMEGA coverage of Syrtis Major (phyllosilicate in blue) [1]. Both right and left centered at (~19°35’N, 73°1’E). All OMEGA image panels are adapted from figures in [3] and [1].