

THEMIS OBSERVATIONS OF COMPOSITIONAL VARIATION IN ELYSIUM PLANITIA. B. B. Wilcox^{1,2} and V. E. Hamilton¹, ¹Hawaii Institute of Geophysics and Planetology, University of Hawaii, 2525 Correa Road, Honolulu HI 96822, ²email: bbwilcox@higp.hawaii.edu.

Introduction: Although the abundance of thermal infrared (TIR) data now available has allowed great strides to be made in the understanding of the composition of much of the surface of Mars, the composition of about half the planet has remained elusive due to a pervasive cover of dust. Just tens to hundreds of μm of dust completely obscure any underlying TIR signal, rendering instruments like the Thermal Emission Spectrometer (TES) and the Thermal Emission Imaging System (THEMIS) ineffective. In addition, any compositional information that can be learned about the dust itself is likely irrelevant to the composition of the surface below, due to the global nature of dust storms and transport [1]. This study attempts to determine whether or not it is possible to find local areas in THEMIS IR images (100 m/pixel) that have low enough dust cover at certain times of the Martian year to detect surface composition. We focus on the Elysium Planitia region because its composition is of particular interest. The area contains some of the youngest flows on Mars, possibly as young as 10 Myr [2], and has been suggested as a possible source region of the Martian meteorites [3, e.g. 4].

Approach: The area chosen for study is to the east of Elysium Mons (20-30°N, 150-160°E). This area has been mapped as “rolling plains” material, interpreted as mostly lava flows thinly covered by aeolian deposits, with some of the flows originating from Elysium Mons and Albor Tholus [5].

Thermophysical Properties: This region has moderate thermal inertia (220-330 $\text{J m}^{-2}\text{K}^{-1}\text{s}^{1/2}$) and an intermediate albedo (0.22-0.29) compared to Elysium Mons itself. These values correspond to unit C as mapped by [6], interpreted as either a thin dust cover over an initially darker, high thermal inertia surface or a thicker deposit of cemented dust (their preferred interpretation). A dust cover index (DCI) based on particle size effects observed in TES spectra shows this area to be dust covered, with the same DCI as Elysium Mons to the west [7]. The fact that the eastern Elysium area has a similar DCI, but a lower albedo and higher thermal inertia than Elysium Mons is interpreted to be the result of a mantle of dust thick enough (several tens of μm to a few mm) to dominate the emissivity spectrum, but not so thick as to dominate the thermal inertia [7]. Thus this region is an ideal place to search for local areas where dust cover might be thin enough to determine the composition. A THEMIS nighttime brightness temperature mosaic was created of the $10^\circ \times 10^\circ$ study area. The mosaic revealed flows that are

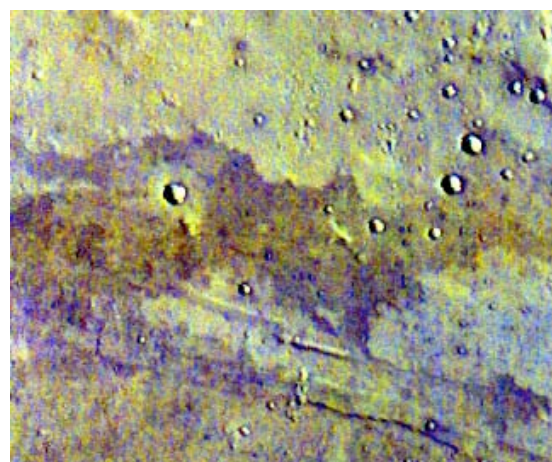


Fig. 1. DCS (bands 7, 4, 2) image of a portion of THEMIS IR image I02129003.

significantly warmer (5-7 K) than their surroundings in the eastern half of the mosaic, and especially prominent in an area centered around 22°N, 158°E.

Spectral Properties: We produced decorrelation stretch (DCS) images using THEMIS daytime IR radiance of the eastern region with warm flows. The DCS images highlight spectral variations and allow for a preliminary spectral analysis [8]. We assigned bands 7, 4, and 2 to red, green, and blue, respectively in the DCS. We chose bands 7 and 4 (11.04 and 8.56 μm) because silicate minerals like pyroxene and feldspar (the primary constituents of basalt) have fundamental absorption features at these wavelengths. We selected band 2 (6.78 μm) because emissivity at this wavelength decreases with particle size [9], thus the strength of this band is used here as a proxy for dust cover. Next, we studied the emissivity spectra of units discriminated in the DCS images. We processed spectral radiance images of the area using the constant radiance offset correction method of [10] and then converted the images to apparent emissivity. To reduce the atmospheric contribution to the data, we ratioed spectra from units identified in the DCS, allowing for a first-order estimate of surface spectral variation [7, 11].

Preliminary Results: The albedo of the area centered on 22°N, 158°E changes with heliocentric longitude (L_s), peaking at 0.25 around $L_s=230^\circ$, and having a minimum of 0.22 around $L_s=0^\circ$. THEMIS IR images of the area acquired during periods of high albedo show little spectral contrast. Only three of the ten DCS images produced show any significant spectral variation. These three images were acquired

at L_s with especially low albedo. One DCS image in particular, I02129003, shows significant spectral variation, and was acquired at $L_s=24.1^\circ$ (Fig. 1).

Two distinct units can be observed in the DCS image of I02129003, one yellow and one blue. These units are also visible in nighttime THEMIS IR images; the yellow corresponds to areas of relatively low brightness temperature, and the blue to higher brightness temperatures. The contacts between the two units range from sharp to gradational, and many craters within the yellow unit have blue ejecta. The ejecta of the same craters show elevated brightness temperatures in the nighttime IR mosaic.

At this time no quantitative mineralogic determinations have been made from the emissivity spectra, but the constant radiance offset correction allows for qualitative comparisons of the spectral features of the units. The yellow unit has reduced emissivity in band 2 and increased emissivity at long wavelengths compared to the blue unit (Fig. 2a).

Discussion: The yellow and blue units are distinct in both their thermal and their short wavelength spectral character, and these differences point to a variation in particle size. The reduced band 2 emissivity and decreased nighttime brightness temperature of the yellow unit indicate that it is dominated by a fine particle size, likely dust. The blue unit, with its higher Band 2 emissivity and increased nighttime brightness temperature, is interpreted here as a relatively young lava flow, that in places has not been covered with enough dust to obscure its spectral features. A ratio of the blue/yellow unit spectra results in a spectrum resembling olivine (Fig. 2b) [12]. The ratio spectrum resembles neither Surface Type 1 or 2 [13].

The contacts between the two units range from sharp to gradational, and craters with blue ejecta are common within the yellow unit. Emissivity spectra of areas that are gradational between the yellow and blue units are intermediate between the two type unit spectra. These findings suggest that the yellow unit is

a surface veneer of variable thickness, but generally thin enough to be penetrated by craters as small as the limit of detectability of the THEMIS resolution (several hundred m). This supports the interpretation of Ruff and Christensen [7] that the dust cover in the region as a whole is generally (though not always) thick enough to dominate the emissivity spectrum, but not to dominate the thermal properties.

Conclusions: We have identified a region east of Elysium Mons centered around 22°N , 158°E , where dust coverage is thin enough in local areas for the surface below to contribute to the emissivity spectrum. Our preliminary identification of olivine-rich material will be evaluated with further study of THEMIS IR and TES data acquired during seasons of low albedo. Future work with these data has the potential to elucidate the composition of lava flows in this area that has been often dismissed as too dusty for much hope of learning quantitative mineralogy. This will shed new light on the composition of recent Martian volcanism, and help to evaluate the suggestion that the region might have been a source of the Martian meteorites.

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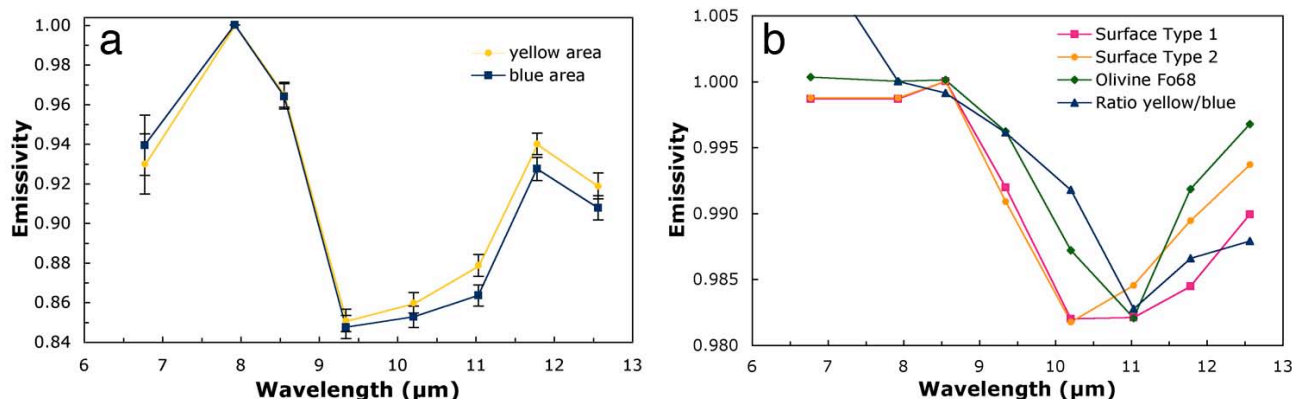


Fig. 2. a) Emissivity spectra of yellow and blue units, produced from constant radiance offset-corrected THEMIS IR data. Error bars are 1 standard deviation. b) Ratio of yellow/blue spectra shown with spectra of Surface Types 1 and 2, and Olivine (normalized to spectral contrast of ratio spectrum).