Global bedrock composition mapping on Mars using THEMIS and TES Data. D. Rogers[1], J. L. Bandfield[1], and P. R. Christensen[1]. [1]Dept. of Geological Sciences, Arizona State University, Campus Box 6305, Tempe, AZ, 85287-6305, deanne.rogers@asu.edu.

Introduction: The Mars Global Surveyor Thermal Emission Spectrometer (TES) has a spatial resolution of ~ 3 x 6 km/pixel, with 143 spectral bands between 50-6 µm (~200-1600 cm^{-1}). Previous compositional studies using TES data have been conducted at the multi-pixel (tens to thousands) level [1-6]. At these spatial scales (>30 km), outcrops of bedrock cannot be resolved, therefore surface composition determined previously with TES data was detected from sand-sized particles or a mixture of rocks and fines [e.g., 2]. Infrared images from the Thermal Emission Imaging System (THEMIS) aboard the 2001 Mars Odyssey spacecraft have a spatial resolution of ~100 m/pixel, with 10 spectral bands between 14.9-6.8 µm (~672-1474 cm^{-1}). The higher spatial resolution of THEMIS allows for areally-small regions of bedrock to be resolved. In this work, nighttime temperatures measured with THEMIS are used to locate bedrock surfaces on Mars (see example, Figure 1). Where available, corresponding daytime THEMIS images are converted to emissivity, and are then used to determine the general composition of these bedrock surfaces. Finally, TES data, used together with THEMIS data, can be used to extract a more precise mineralogy.

Approach: In this work, "bedrock" is defined as any surface with a thermal inertia >2200 $J/m^2Ks^{1/2}$, and is taken to be representative of materials that cannot be moved by saltation. This thermal inertia value is a conservative representation of immobile materials. The geological origin of these surfaces cannot be constrained from the thermal inertia. For example, they could be igneous, consisting of crust-forming materials or lava flows, or sedimentary, consisting of sandstones or densely-cemented dust.

Nighttime surface temperatures measured from orbit are controlled by the thermal inertia of the surface, as well as latitude, solar longitude, and time of day. Other important factors include surface albedo, elevation (atmospheric pressure), and atmospheric dust opacity [7,8]. Here, a thermal model (provided by H. H. Kieffer) is used to determine the expected nighttime (2-5am local time) temperature of a surface with a thermal inertia of 2200 $J/m^2Ks^{1/2}$, as a function of latitude and solar longitude. For this work, the model input parameters of albedo, visible dust opacity, and elevation are held constant at 0.10, 0.55, and 0 m, respectively. The THEMIS database is then searched for images that contain areas with these minimum nighttime temperatures, while constraining on latitude and solar longitude.

For each nighttime THEMIS image that covers a bedrock surface (using the above criteria), corresponding daytime radiance images (where available) are converted to emissivity by finding the highest brightness temperature between bands 3 and 9, and dividing by a Planck curve that corresponds to that brightness temperature. At present, atmospheric absorptions are separated from surface emissivity by ratioing the average emissivity spectrum from the bedrock surface with the average emissivity spectrum from a dusty surface within the same image. This method is based on the fact that dusty surfaces have little spectral character at wavelengths >~8 µm [5,9], therefore any absorption features in emissivity spectra taken from these areas are due solely to atmospheric dust and (occasionally) ice. Atmosphere-removed emissivity spectra from the bedrock surface are then used to determine a general lithologic composition of that surface. In addition, if the bedrock surface is large enough (>3 km in diameter), TES data acquired under optimum atmospheric conditions are also used to determine the mineralogy of that surface, using the linear deconvolution and atmospheric separation methods of [10-12].

Results: To date, the first 1283 orbits (about 970 nighttime images) from the first THEMIS mapping phase have been searched for images that contain bedrock. Of these, over 80 THEMIS nighttime images have been found to cover surfaces with temperatures characteristic of bedrock, between orbits 816 and 2099. These bedrock surfaces range from a few hundred meters to tens of kilometers in the longest diameter. Bedrock is exposed in a range of geologic settings, such as crater and valley floors, chaotic terrain, and relatively featureless plains. In general, the spectral character of these surfaces is consistent with the Type 1 and Type 2 surfaces of [2]. Several of the andesitic surfaces are found within the southern highlands.

It is worth noting that for the majority of these surfaces, the spectral contrast is lower than would be expected for bedrock (1000 cm^{-1} emissivity is ~0.95, versus ~0.88 for non-particulate surfaces). This may be due to a number of reasons. A thin layer of dust would not affect the nighttime surface temperature, but may slightly reduce the spectral contrast of the underlying bedrock surface. A vessicular surface texture could also have the effect of reducing spectral contrast [13].

Conclusion: This study is currently in progress, with the goal of producing a global map of exposed bedrock locations and their corresponding mineralogic compositions. Global bedrock composition mapping will contribute towards our understanding of the origin and distribution of TES Type 1 (interpreted as basaltic [2,14,15]) and Type 2 (interpreted as andesitic [2,14] or weathered basaltic [15]) surfaces on Mars. For example, *Ruff and Christensen* (2002) [16] have identified a younger, Type 2 bedrock surface superposed on an older, Type 1 bedrock surface in Nili Patera, which supports an andesitic composition for Type 2 in this region. A global study of martian bedrock surfaces may find more areas similar to this example, where geological relationships between surfaces of different compositions can be determined. In addition, relating global bedrock composition to surface unit age will contribute a compositional view to the resurfacing history of the martian crust and possible evolution of martian lavas. A thorough investigation of bedrock compositions may also reveal mineralogic assemblages that are distinct from those of the Type 1 and Type 2 surfaces of Bandfield et al. (2000) [2] or SNC-like lithologies of Hamilton et al. (2002) [6]. Finally, linking bedrock composition to sand composition maps may assist studies of sand transport on Mars.

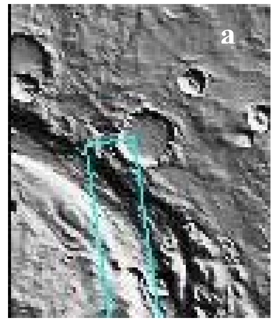

Figure 1. Example of a bedrock surface located with THEMIS nighttime data. a) Context for nighttime THEMIS IR image I01967002, over Ares Vallis. b) Portion of THEMIS band 9 brightness temperature image (I01967002). The temperature ranges from 182 K (dark tones) to 216 K (bright tones). The arrow points to Ares Vallis, which has nighttime surface temperatures characteristic of bedrock. The width of this image is 32 km.

References

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