
Introduction: We use Thermal Emission Spectrometer (TES) data to examine the composition of geologic units in Valles Marineris (VM), Mars. The goal of these analyses is to explore the utility of techniques for removing atmospheric effects from TES data to allow mapping of unit compositions [1-3]. Another goal is to determine the origin of VM interior deposits.

Data: We use TES data from the Aerobraking and Science Phasing Orbits. We first focus on data from Orbit 98: IFOV=10-13 km, L=258.7, T1=highest T in a 70 cm\(^{-1}\) band between 800 cm\(^{-1}\) and 1360 cm\(^{-1}\). These data were retrieved from the PDS archive [4] and processed to emissivity [5].

Background: The Valles Marineris offer unique 3-D views into the upper Martian crust to depths of 8 to 10 km (e.g., [6-9]). The VM are thought to expose the record of geologic history of Mars from late-stage heavy bombardment (i.e., early evolution of the crust and possible formation of a megagregolith), through modification by volcanism and possible lacustrine and other hydrologic activity, to tectonic processes that formed and modified the chasmata [10]. A major question is the origin of VM interior layered deposits; they may be of mass-wasting, lacustrine, sedimentary (e.g., eolian, diagenetic, pedogenic), and/or volcanic origin [8-14]. Layered deposits may contain evidence of a wide variety of geologic processes, including volcanic flows [8] [9] [11] that may indicate that revisions in volcanic flux rates are necessary [15] and may show evidence of magmatic differentiation, and sedimentary deposits that help to constrain the presence and distribution of water on Mars. Determination of the origin of these deposits offers insight into the geologic history and past climates on Mars.

Another major reason for studying the layered deposits in areas such as VM is the recent recognition that eolian and other mantling deposits are very common on the surface of Mars [16-18]. These sedimentary deposits may often serve to obscure evidence of early geologic processes and thus Mars’ climate history. Layered deposits in canyon, channel, and crater walls may provide the best exposures of subsurface geologic units on Mars and thus the best means of characterizing geologic processes that have operated in the past. Clarifying the processes forming layered deposits on Mars will help us evaluate current paradigms, including the roles of surface versus subsurface water and its effects on channel and valley formation [19], the volcanic flux rate [15], and the effects of volcanic gases released into the atmosphere.

Current Work: VM geologic units are diverse (e.g., [10], [20]) and they are likely to contain a variety of major rock-forming minerals (e.g., pyroxenes, plagioclase, olivine, quartz, calcite, etc.) and weathering products (mostly clay minerals) that have diagnostic spectral signatures in the TES 6- to 40-micron wavelength range. Our analysis of surface compositions in VM focuses on distinguishing volcanic units such as basalt, andesite, dacite, komatiite, and rhyolite, which have major emissivity features in the 8 to 12 micron (1300 to 800 cm\(^{-1}\) wave number) region. Other rocks, such as sandstone, siltstone, and granite, also have emissivity absorptions in this spectral range. Spectral signatures of mafic units have been observed in Hebes Chasma [21], where initial TES observations are consistent with the presence of Ca-rich clinopyroxene. A basaltic component (largely plagioclase feldspar and clinopyroxene) has also been identified on the martian surface at Cimmeria Terra [3], following successful removal of an atmospheric dust component.

We are using the TES data to distinguish compositional differences among geologic units in VM with absorptions in the 8 to 12 micron range. Orbit 98 passes through the center of VM, covering portions of Ophir, Candor, and Melas Chasmata. We use principal component analyses (PCA) to characterize an atmospheric dust component in the ~10 micron region, and we examine the transformed data for emissivity features attributable to compositional variations in geologic units in VM. The interior region of VM was selected for PCA calculation, and the resulting transformation was applied to the full orbit. For compositional interpretation, emphasis is placed on units interior to the VM and in the near-rim region. Eigenvector 1 (EV1; Figure 1, top) shows the major atmospheric dust component, which varies substantially with local elevation as expected. Eigenvector 2 (EV2; Figure 1, middle) contains surface compositional information. These data show spatial variation corresponding well to the location and inferred lithologies of geologic units mapped at 1:15M scale [22]. Units such as the (basaltic) plains unit to the NW and SW of Ophir (light gray mottled) have low EV2 values (EV2 -0.06 to -0.10, black/purple/blue). Interior wall units (layered basalts? [7-12]) just below this plateau unit and between Candor and Melas have intermediate EV2 values (-0.02, green). Slump/flow and floor deposits in Ophir and Candor (0.04, cyan) are distinct from slump/alluvium and floor deposits in Melas (0.03-0.05, orange/red). The surface-texture varia-
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...ions used in mapping these units are not a major component in the TES spectral signatures. Thus, this variation may be due to intrinsic compositional differences, mantling by loose materials at the surface, and/or lower elevations in Melas. Emissivity spectra (Figure 1, bottom) show prominent atmospheric absorption features in the TES data, and they reveal probable elevation-related effects: deeper atmospheric absorption features are observed as elevation decreases from top (orange) to bottom (cyan) in VM [23]. Although we have not yet accounted for these effects, we are successfully distinguishing among many of the major basaltic components of VM geologic units. This technique for examining the atmospheric component in the TES data and retrieving surface compositional information has promise for continued geologic analysis of the VM and for identification of the origins of the interior layered deposits. This work serves as an independent validation of ongoing work by the TES team [1-3]. We will continue to explore the utility of these techniques with higher spatial-resolution (~3 km/pixel) TES data from the Mapping Phase. A major emphasis of our future work will be the spectral deconvolution of the atmospheric and surface signatures in the TES data, and ultimately the mapping of surface compositions.


Figure 1: TES Orbit 98, central Valles Marineris: (top) Eigenvector 1 over MOLA topography data [23]. Arrows mark sites of spectra at bottom (orange is off-screen). (middle) Eigenvector 2 over geologic map [22]. Units (~band depth) are magnitudes of EV2 about the PC origin. (bottom) Emissivity spectra (averages) from sites at top.