

GEOLOGIC MAPPING OF THE MERIDIANI REGION OF MARS. G. Di Achille¹ and B. M. Hynek^{1,2},
¹Laboratory for Atmospheric and Space Physics, ²Department of Geological Sciences (392 UCB, Univ. of Colorado, Boulder, CO 80309).

Introduction: The Mars Exploration Rover Opportunity observed an upper layer of a more than 600-m-thick sequence of light toned outcrops that characterize the Meridiani region of Mars. Results from the rover analyses have shown that the bedrock contains mineral and textural characteristics that require at least the interaction of, and possibly an overall formation by, water-related mechanisms in order to be explained [1]. Additionally, remote sensing studies of the region have suggested that the rocks sampled in places by the MER rover consist of many distinct layers extending over an area of more than 3×10^5 km² spanning 20° of longitude [2].

Geologic Mapping: To address the origin and history of these unique materials, we are completing a PG&G funded detailed geologic, stratigraphic, and thermophysical properties study of this widespread terrain. Specifically, we are drafting a 1:2M-scale geological map covering the full extent of these water-related deposits. In tandem with the mapping, Hynek and Phillips [1] have conducted an initial stratigraphic analysis of the stack of materials, whereas Hynek and Singer [3] focused on the coupled analysis of remote sensing and lander observations in order to improve the understanding of the physical composition of the region, providing also the requisite ground truth observations for the calibration of spacecraft data. The latter study is particularly helpful to enable the characterization of the surface composition after mapping based on the thermophysical datasets (TES and THEMIS) is complete. All of these tasks serve several purposes including gaining an understanding of the complex nature of these materials, their potential source region(s), and their timing of emplacement, as well as to place the observations by the Opportunity Rover in a broader context.

PI Hynek and Collaborators Gaetano Di Achille (CU/LASP), Roger Phillips (SwRI), Ken Tanaka (USGS) and Bruce Jakosky (CU/LASP) are currently funded to complete detailed geologic mapping at 1:2,000,000-scale in the Meridiani region. The study area is defined here as 5°S-15°N, 15°W eastward across the prime meridian to 15°E. This covers portions of the quadrangles MC-11 (Oxia Palus), MC-12 (Arabia), MC-19 (Margaritifer Sinus), and MC-20 (Sinus Sabaeus). In places of particular interest with sufficient data coverage, we are also mapping the terrain at a larger scale to truly detail the local geology. The numerous units in the study area will be refined from recent works [4-8]. Formal geological mapping has recently begun using a 100-m-resolution THEMIS

base map produced by the USGS Flagstaff combined with MOLA gridded data. Additional data for mapping includes MOC WA images, THEMIS daytime and nighttime IR data, some THEMIS visible data, HRSC mosaics and stereo-derived high-resolution topography, MOLA topography, TES and THEMIS thermal inertia, some MOC NA images, CTX and HiRISE images, and mineral abundance maps from TES and OMEGA. We have completed mapping of regional valley networks to understand their potential link to the layers. Additionally, we have identified and characterized all craters in the region down to 1.5 km diameter. Our first thematic map was a thermophysical properties map to characterize the surficial units and assess their correlation (or lack thereof) with bedrock units. These results are discussed below. Formal mapping is now underway and we anticipate a near-final geologic/geomorphic map by fall 2009.

Stratigraphic and Thermophysical Analyses: We are currently focusing on the combined analysis of visible and thermophysical properties of the varied layers to derive possible compositional information of the materials in conjunction with their detailed stratigraphic analysis. Specifically, PI Hynek and Collaborator Roger Phillips recently mapped out the largest stratigraphic markers across the Meridiani region. Individual MOLA elevation data points along layer exposures show that most of these benchmark horizons: (1) are planar and coherent over at least a 100-km scale, and (2) have dip azimuth and magnitudes that are similar to the underlying regional slope, which was emplaced by 3.7 Ga. Mapping relations with nearby ancient river valleys suggest that these deposits also formed near this time and without significant contributions from precipitation-fed surface runoff.

We have also completed an analysis of the region based on the thermophysical properties from TES and THEMIS thermal inertia data (Fig. 1). The latter datasets were used to produce a thematic map of the entire region and to investigate the correlation between the thermophysical surface properties and the main geological units preliminarily outlined from textural, geomorphological, and mineralogical characteristics (Fig. 1a-b). The overall area is characterized by significant physical and compositional differences (Fig. 1b), possibly reflecting a changing paleodepositional environment and/or chemical alteration history. Several units could be mapped from the thermal inertia maps. However, we carefully evaluate each of the identified thermophysical regions in order to discriminate between

the bedrock/geological and/or secondary/physical significance of the thermophysical units. The latter, in fact, could not necessarily inform on the bedrock and geologic properties of the corresponding terrains but rather about their surface conditions (e.g. consolidated vs. unconsolidated; coarse- vs. fine-grained; dust-covered vs. deflated). Nonetheless, the main geological units identified based on textural, mineralogical, and morphological properties (e.g. etched terrains and hematite-rich deposits, Fig. 1a) show a strong correlation with the main provinces inferred from the thermal inertia maps. Particularly, units characterized by the exposures of etched terrains in the visible correlate well with high thermal inertia regions, whereas the hematite-rich terrains appear as low thermal inertia regions (Fig. 1a-b). Figure 1c shows a close-up from a contact region between the etched and hematite units. The geological contact is well evidenced by the sharp contrast in thermal inertia and can be mapped out for large portions of the studied region, though it tends to be less straightforward in places characterized by significant dust coverage and eolian features. On the other hand, a straightforward correlation between geological and thermophysical units does not exist elsewhere. Several units inferred from the analysis of textural and morphological characteristics are not differentiated by the thermal inertia maps (e.g. young volcanic materials in the NE corner of the map). In other cases, the thermal inertia maps show rather obvious anomalies possibly indicative of geological contacts, which are, in fact, not visible in the imagery and thus likely the result of secondary alterations (e.g. windblown craters and wind streaks clearly oriented in a NE-SW direction)

Summary: In our first 1.5 years of funding, significant progress has been made on stratigraphic and thermophysical analyses and initial delineation of major geologic units. A stratigraphic analysis of the region has been completed and we have found that most of the benchmark horizons are coherent over the 100-km-scale and are similar in dip azimuth and direction to the underlying long wavelength topography [1]. Mapping of the surficial units in THEMIS/TES data and comparison with MER Opportunity results show that some bedrock units have a strong correlation with thermal inertia while others do not. This work has helped identify the utility and pitfalls of using thermal data and provides input into our geologic mapping. Completion of the formal geologic/geomorphic mapping is slated for the upcoming year.

References: [1] Squyres, S. W., et al., *Science*, DOI: 10.1126/science.1170355. [2] B. M. Hynek and R. J. Phillips, *Earth and Plan. Sci. Lett.*, 274, 214-220. [3] B. M. Hynek and K. Singer, *Geophys. Res. Lett.*,

doi:10.1029/2007GL029687, 2007. [4] B. M. Hynek et al., *J. Geophys. Res.*, doi:10.1029/2002JE 001891, 2002. [5] Edgett, K. S., and M. C. Malin, *Geophys. Res. Lett.*, doi:10.1029/2002GL016515, 2002. [6] Hynek, B. M., *Nature*, doi:10.1038/nature02902, 2004. [7] Edgett, K.S., *Mars*, doi:10.1555/mars.2005.0002, 2005. [8] R. E. Arvidson et al., *Science*, doi:10.1126/science.1109509, 2005.

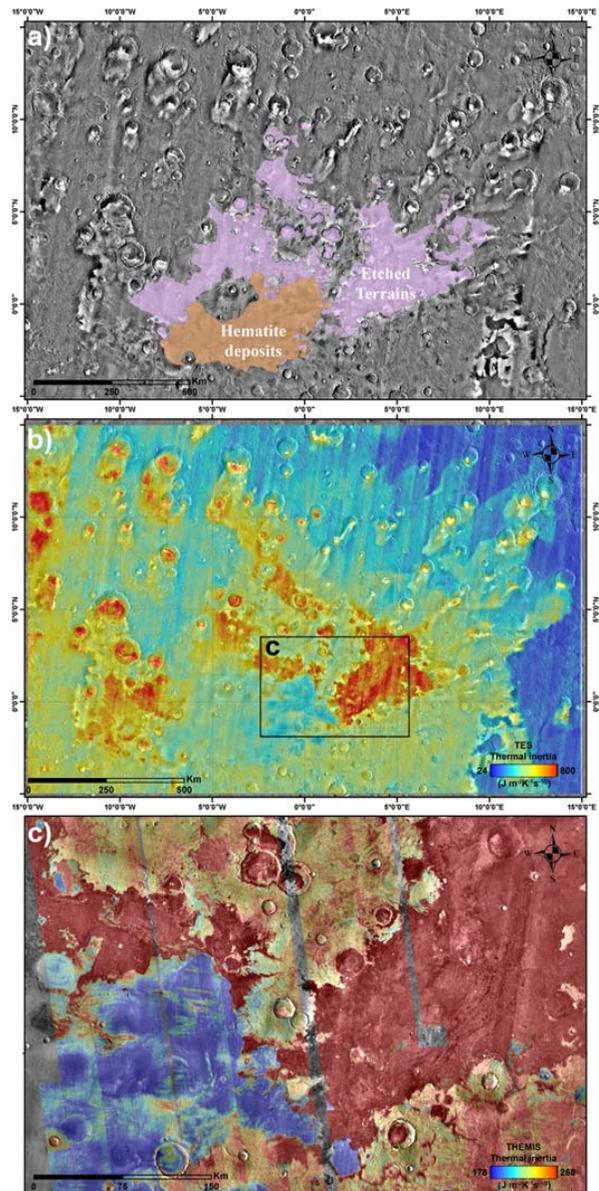


Figure 1. a) THEMIS mosaic showing the studied area and the extent of the *Etched terrains* and *Hematite-rich* units; b) TES thermal inertia shows the correlation between the above geological units and their corresponding physical properties; c) Close-up from the THEMIS thermal inertia showing the geological contacts between the *Etched* and the *Hematite-rich* units.