THERMOPHYSICAL PROPERTIES OF MERIDIANI PLANUM, MARS. B. M. Hynek, B. M. Jakosky, S. Martínez-Alonzo, N. E. Putzig, N. Murphy, M. T. Mellon, and S. Pelkey, Laboratory for Atmospheric and Space Sciences, University of Colorado, 392 UCB, Boulder, CO 80309. brian.hynek@lasp.colorado.edu

Introduction: The layered materials in Meridiani Planum, the landing site of the MER Opportunity rover, exhibit a wide range of thermal properties. In many cases, there is a strong correlation with geomorphology indicative of local control of composition and physical properties. We used data from the Thermal Emission Imaging System (THEMIS) and Thermal Emission Spectrometer (TES) in conjunction with other remotely-sensed data to examine the thermophysical properties of the landing site and associated stratigraphy, allowing a better understanding of the geologic history of this region of Mars. In situ results from Opportunity will provide ground truth for our analysis, and help us to extrapolate properties globally.

Geologic Setting: Meridiani Planum lies in a region of Mars that has undergone a complex history of deposition and erosion. In the Late Noachian, extensive fluvial denudation acted to dissect and erode up to a kilometer of crust in this portion of the highlands, stretching from Margaritifer Sinus to the south up through western Arabia Terra to the north [1]. Finely layered materials, including the hematite-rich unit, were subsequently emplaced. These materials, as identifiable in high-resolution visible and infrared images, contain many layers of varying competency, albedo, and thermophysical properties. Aeolian erosion has acted to differentially erode and expose the stratigraphic sequence. The likelihood of prolonged surface-water interactions in this region makes it a site of high astrobiological interest.

Methods: Many data sets were utilized in our analysis, however, here we will focus on THEMIS- and TES-derived products from the thermal infrared portion of the spectrum. TES-derived thermal inertias (3 km resolution) were calculated using established methods [2,3] and updated to include data acquired through May, 2003. Daytime and nighttime THEMIS data acquired through September, 2003, were used to produce calibrated radiance and brightness temperature maps. Specifically, band 9 (12.57 microns) images covering the region of interest were radiometrically and geometrically corrected using Integrated Software for Imagers and Spectrometers (http://isis.astrogeology.usgs.gov/). These geo-referenced images were then mosaicked using an in-house program that adjusts the radiance of overlapping scenes by applying a linear regression. This correction is necessary because the images were acquired at different times of the year and local times and are thus subject to seasonal and time of day effects. The daytime and nighttime calibrated radiance mosaics were converted to brightness temperature maps via a look-up table created by the THEMIS team. These maps have 100-meter resolution and coverage is essentially contiguous over the region of interest. Finally, thermal inertias were calculated for the THEMIS mosaics using a similar method to the TES derivation (see [4]).

Results and Discussion: Figure 1 shows a THEMIS-derived nighttime brightness temperature mosaic of the Meridiani Planum landing site. Temperatures range from 162-210 K in the vicinity of the landing area with the landing ellipse itself showing >15K variance. The average nighttime temperature of the scene is ~70 K less than during the daytime. Abundant structure is evident in the mosaic. Some of these features correspond to albedo features or landforms such as craters while others have no signature at visible wavelengths.

In Figure 1, the hematite-bearing unit is outlined and the western lobe exhibits some of the lowest nighttime temperatures in the region (labeled A). Daytime temperatures of this area are high, indicative of a general surface comprised of relatively unconsolidated or fine grained material. Exposed to the north of this feature are bedforms stratigraphically below the hematite unit. High-resolution Mars Orbiter Camera Narrow-Angle (MOC NA) images show copious differential erosion of this thinly layered set of materials. Unlike the hematite unit, these materials have been eroded into mesas, pits, buttes, and troughs [5]. This "etched" terrain is composed of many individual layers and is unique in terms of its high albedo and thermal inertia [6]. As expected, the outcrops of this unit are relatively cool in the daytime and warm at night. Combined with their high albedo and erosional characteristics, this suggests that the bulk of these bedforms are more lithified than the hematite-rich unit. Within the etched sequence are adjacent layers with brightness temperature differences of up to 10 K, indicative of very different thermophysical properties within the etched unit itself. The etched terrain is areally extensive and individual layered sequences can be mapped for hundreds to over a thousand kilometers, with most exposures north and east of the hematite unit [5].

Interestingly, MOC NA images of the landing ellipse show presumably exhumed pieces of etched terrain outcropping within the hematite-rich unit [6]. These are visible on a larger scale outside the ellipse in THEMIS daytime and nighttime images and the relatively large range of temperatures across the hematite unit probably reflect these different units. The visible and thermal IR images also show many small craters that have "poked through" the relatively low albedo and thermal inertia hematite-rich unit and excavated underlying etched terrain. These observations suggest that the layer comprising the hematite is only a fraction of the stratigraphy and may only be a few meters thick. It is therefore possible that the Opportunity rover will have a chance to sample multiple lithostratigraphic units. In fact, a string of secondary craters cut through the central portion of the landing ellipse, strengthening this possibility.

In this region of Mars, TES-based thermal inertia maps and preliminary THEMIS maps show a strong correlation with geomorphology and therefore we interpret this region as being relatively dust-free. Derived thermal inertia values for the geographic extent of Figure 1 range from 180-365 J m^{-2} K^{-1} $s^{-1/2}$ with the landing ellipse ranging from 210-240. This range is at the low end of previous landed missions to Mars [7] and lower rock abundance is predicted.

Conclusions: The hematite-bearing unit is one layer in a thick and complicated stratigraphy that is mappable for thousands of kilometers. It exhibits a low albedo and thermal inertia while underlying etched terrain has high values of these parameters. Many geologic features are clear in THEMIS IR images including >10 layers subjacent to the hematite unit. These layers have contrasting albedos, temperatures, thermal inertias, and erosional characteristics. Numerous formation mechanisms have been proposed for the hematite including lacustrine deposition [8-9], hydrothermal precipitation [5,8], burial metamorphism [10], thermal oxidation of tephra [5], and rock coatings [11]. The many alternating laminar layers with differing thermophysical properties suggest periodic deposition of facies with different sedimentary compositions possibly related to clast size, grain orientation and packing, or mineralogy. This idea remains consistent with a lacustrine or volcanic origin. The layered units may, however, have been later subject to hydrothermal alteration or metamorphism.

The Opportunity rover has the ability to test the above hypotheses with a suite of instruments [6]. Within the hematite unit, THEMIS and MOC NA images show exposures of underlying etched terrain and impacts that have excavated buried materials. A temperature range of >15 K in the landing ellipse probably reflects these different units. It is therefore quite likely that the Opportunity rover will sample multiple contrasting layered materials. In situ identification of accessory minerals, oxidation states, and fine-scale texture of rocks will help elucidate the geologic and climatic histories of this region.

References: [1] Hynek B.M. and Phillips R.J. (2001) *Geology, 29*, 407-410. [2] Jakosky B.M. et al. (2000) *JGR, 105*, 9643-9652. [3] Mellon M.T. et al. (2000) *Icarus*, *148*, 437-455. [4] Putzig N.T. et al. (2004) *LPSC XXXV* (this meeting). [5] Hynek B.M. et al. (2002) *JGR, 107, E10*, doi:10.1029/2002JE001891. [6] Arvidson R.E. et al. (2003) *JGR, 108, E12*, doi:10.1029/2002JE001982. [7] Putzig, N.T. et al. (2003) *LPSC XXXIV*, #1429. [8] Christensen P.R. et al. (2000) *JGR, 105,* 9623-9642. [9] Newsome H.E. et al. (2003) *JGR, 108, E12,* doi:10.1029/2002JE001993 [10] Lane M.D. et al. (2002) *JGR, 107, E12,* doi:10.1029/2001JE001832 [11] Kirkland L.E. et al. (2003) *LPSC XXXIV*, #944.

Figure 1. THEMIS-derived nighttime brightness temperature mosaic surrounding the Meridiani Planum landing ellipse.