Mini-TES Observations of the Gusev and Meridiani Landing Sites. Philip Christensen[1], Raymond Arvidson[2], Joshua L. Bandfield[1], Diana Blaney[3], Charles Budney[3], Wendy Calvin[4], Sandra Ciccolella[5], Alicia Fallacro[4], Robin Fergason[1], Timothy Glotch[1], Noel Gorelick[1], Trevor Graff[1], Alex Hayes[8], Amy Knudson[1], Harry Y. McSween[5], Jr., Greg Mehall[1], Laura Mehall[1], Keith Millam[5], Jeffery Moersch[5], Richard Morris[6], Deanne Rogers[1], Steven Ruff[1], Anwar Saddat[1], Michael D. Smith[7], Steven Squyres[8], Michael Wolff[9], Michael Wyatt[1], and the MER Science Team, Dept. of Geological Sciences, Arizona State University; phil.Christensen@asu.edu, [2]Washington University, [3]Jet Propulsion Laboratory, [4]University of Nevada, Reno, [5]University of Tennessee, [6]NASA Johnson Space Center, [7]NASA Goddard Space Flight Center, [8]Cornell University, [9]Space Science Institute.

Introduction: The Miniature Thermal Emission Spectrometer (Mini-TES) has provided remote measurements of the mineralogy and thermophysical properties of the scene surrounding the Mars Exploration Rovers. The specific scientific objectives of this investigation are to: (1) determine the mineralogy of rocks and soils; (2) determine the thermophysical properties of surface materials; and (3) determine the temperature profile, dust and water-ice opacity, and water vapor abundance in the lower atmospheric boundary layer. The Mini-TES is a Fourier Transform Spectrometer covering the spectral range 5-29 m (339.50 to 1997.06 cm^{-1}) with a spectral sample interval of 9.99 cm^{-1}. The Mini-TES is mounted within the Rover and views the terrain looking up the hollow shaft of the Pancam Mast Assembly (PMA) to the rotating elevation scan mirror in the PMA head located ~1.5 m above the ground. Radiometric calibration was intended to be provided by two calibration V-groove blackbody targets instrumented with platinum thermistor temperature sensors with absolute temperature calibration of ±0.1° C. Unfortunately the temperature sensors mounted on the external calibration targets failed on both landers, necessitating the modification of the calibration procedure to use the pre-launch instrument response function with the internal calibration target used to determine the instrument radiance [1-3]. The radiometric precision for two-spectra summing is $\pm 1.8 \times 10^{-8}$ W cm^{-2} sr^{-1} /cm^{-1} between 450 and 1500 cm^{-1}, increasing to $\sim 4.2 \times 10^{-8}$ W cm^{-2} sr^{-1} /cm^{-1} at shorter (300 cm^{-1}) and longer (1800 cm^{-1}) wavenumbers. The absolute radiance error is currently estimated to be 1-5 $\times 10^{-8}$ Watt cm^{-2} sr^{-1} /cm^{-1}. The worst-case sum of the random and systematic radiance errors correspond to a best-fit absolute temperature error of ~0.4 K for a true surface temperature of 270 K, and ~1.5 K for a surface at 180 K. This temperature error is mapped into a smoothly varying offset in the emissivity spectrum that varies from 0.001 at 400 cm^{-1}, to a maximum of 0.005 at ~1000 cm^{-1}, to essentially 0 at 1400 cm^{-1} for a scene temperature of 270 K.

Results: Gusev Site. Mini-TES data from the Gusev site have shown the following results. The surface of Gusev is heavily coated with airborne dust, as predicted from orbital TES and THEMIS observations [4, 5]. Spectra of the surface show close agreement with the atmosphere-corrected TES spectrum of typical bright, fine-grained, dust surfaces [6]. The analysis of TES spectra showed the presence of carbonates at minor abundances, bound water at minor abundances, and the presence of a silicate transmission feature due to a framework silicate that is either feldspar [6] or zeolite [7]. On the basis of this analysis the dust at Gusev also has these components. The rocks at Gusev are dust coated. Spectra of the rock Adirondack show close agreement with olivine at long (>18 µm) wavelengths, consistent with olivine basalt. The spectra in the mid- (7-14 µm) wavelength region are dominated by the dust coatings. Laboratory spectra of basalt coated with varying thicknesses of basaltic and palagonitic dust [8, 9] show similar trends to those seen in the Gusev rocks - a decrease in spectral contrast and transition to the dust spectral shape in the 7-14 µm range, little change at long wavelengths, and a minor short-wavelength transmission effect. Comparison with laboratory spectra indicate a dust coating of ~10-20 µm. The dark rocks at Gusev are spectrally similar, suggesting that they are similar in composition and are coated to a similar degree with dust. Planned use of the Rock Abrasion Tool to remove the dust coating will provide the opportunity to collect Mini-TES spectra of dust-free rock surfaces.

Meridiani Site: Mini-TES spectra of Meridiani have confirmed the presence of crystalline hematite and basalt (Figure 1). Within the small crater in which Opportunity landed, the abundance of hematite varies markedly, from near 0% to >~20% (Figure 2). The hematite abundance increases toward the southwestern portion of the crater rim, and correlates with the increase in the abundance of dark cm-sized clasts observed in this region. The hematite observed in the crater may be derived from a rock layer that lies above the light-toned bedrock unit that is exposed in the crater wall. The hematite variation may be a transport/sorting phenomena in which hematite-bearing materials are eroded from an overlying rock layer and transported downslope into the crater. Variations in hematite abundance are seen in the bounce marks produced by the airbags (Figure 1). This variation is interpreted to be due to the disruption of a surface in which the hematite-bearing materials are vertically sorted. Hematite-bearing materials appear to be concentrated at the upper surface, and the airbag impacts have forced this material beneath the surface of a soil component that has lower hematite abundance.

Five components have been identified from Mini-TES within the soil and rock of the landing-site crater (Figure 1); hematite, basalt, the soil matrix seen in the bounce marks, the outcrop unit, and fine-grained dust, The soil that was initially sampled by the instruments on the rover arm has very low hematite abundance. Preliminary analysis of the spectrum of this soil shows it to be similar to the basaltic spectrum derived from TES orbital data [10]. The apparent separation of the basaltic and hematite components on small spatial scales indicates that basalt and hematite exist as separate phases in the source region at the scales of individual grains. The bedrock unit does not show any evidence of coarse-grained carbonates or crystalline silica. Material with a dust-like spectrum has been identified on portions of the outcrop. This material may either be derived from the outcrop, or may accumulate on this surface from atmospheric fallout. The motion of mobile, sand-sized particles in the dark soils at this site likely prevents dust accumulation on these soils. The lack of these particles on the outcrop may permit minor amounts of dust to accumulate.

Atmospheric Observations. Mini-TES calibrated radiance spectra have been obtained of the martian atmosphere at elevation angles from the horizon up to 30°. These spectra allow the determination the near-surface atmospheric temperature profile, the dust opacity, and potentially the abundance of water vapor and water ice [11].

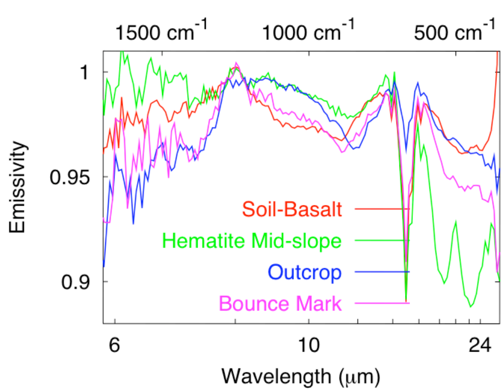

Figure 1. Mini-TES spectra of four components observed at the Meridiani landing site.

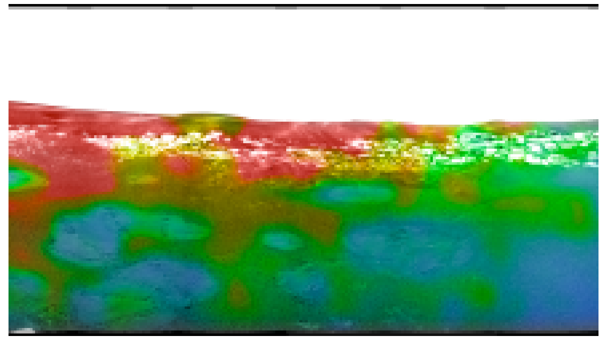

Figure 2. The spatial distribution of hematite in a portion of the Meridiani landing crater.

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