A FIRST LOOK AT THE MINERALOGY AND GEOCHEMISTRY OF THE MER-B LANDING SITE IN MERIDIANI PLANUM. Richard V. Morris[1], S. Squyres, R. E. Arvidson, J. F. Bell III, P. C. Christensen, S. Gorevan, K. Herkenhoff, G. Klingelhöfer, R. Rieder, W. Farrand, A. Ghosh, T. Glotch, J. R. Johnson, M. Lemmon, H. Y. McSween, D. W. Ming, C. Schroeder, P. de Souza, M. Wyatt, and the Athena Science Team, [1]NASA Johnson Space Center, Houston TX 77058 (richard.v.morris@nasa.gov).

Introduction: The second MER rover (Opportunity) landed on Meridiani Planum on January 24, 2004 inside a shallow crater. The science rational for the selection of the landing site centered on detection of the mineral hematite from martian orbit by the Mars Global Surveyor Thermal Emission Spectrometer (MGS-TES) [1,2]. Other smaller occurrences of hematite are in Aram Chaos and several isolated spots in Valles Marineris. Proposed formation pathways for martian hematite include both aqueous (e.g., low-temperature precipitation of Fe oxides/oxyhydroxides in a lacustrine environment, laterite-style weathering, and precipitation from fluids having a hydrothermal origin) and dry (e.g., oxidation of magnetite rich ash) processes [e.g., 1,2,3]. The crystallographic c-face of martian hematite must be exaggerated to account for the thermal emissions spectra and it must be gray in color so as to account for the absence of the characteristic spectral signature of red hematite at visible wavelengths [e.g., 1,4].

Identification of accessory phases is key to understanding the formation processes for Martian hematite. Detection of goethite and/or silica rich phases would imply aqueous formation processes. Detection of magnetite could be evidence for anhydrous processes. To date, none of these precursor phases has been identified from martian orbit. Opportunity is characterizing the mineralogical and chemical composition of its landing site, in part looking for hematite accessory phases. Its field site is currently a shallow crater which has an outcrop of bedrock. Results are limited to 12 sols on the surface (4 off the lander).

Pancam [5, 6]: Pancam is a multispectral stereo camera with 11 geology filters between 0.4 and 1.0 microns. Extensive multispectral imaging has been done while the rover was still on the lander. Typical early results for dusty sky, the outcrop, and soil at Meridiani Planum are shown in Figure 1. For each type of sample, there is a near continuum of similarly shaped spectra between the "brighter" and "darker" spectra for each shown in the figure. The spectra plotted are the average of the five brightest (or darkest) spectra. The y-axis is I/F (incident over flux) so that the spectra have not been corrected for viewing angle. However, this correction will not change the general spectral shape.

The spectra of dusty sky, outcrop, and soil are all characterized by a ferric absorption edge extending between 440 and 750 nm. The absence of well-defined features in the absorption edge implies the presence of poorly-crystalline ferric-bearing phases similar to those found in palagonitic tephra, a martian bright regions spectral analogue [e.g., 7]. Spectra for darker outcrop and brighter soil are essentially the same. This results because the two components occur in places as mechanical mixtures of each other. Reflectivity spectra for the rock outcrop and the rock Scooby Doo at the Mars Pathfinder site are similar [e.g., 8]. Because of its soil-like bulk composition, Scooby Doo is considered to be indurated soil [e.g., 9].

All three types of materials also seem to have a very shallow band centered near 900 – 930 nm. The band position is not mineralogically diagnostic and can be associated with both ferric-bearing (e.g., goethite, schwertmannite, and maghemite) and ferrous-bearing phases (e.g., orthopyroxene and pigeonite) [7]. The band position for olivine is >1000 nm. Ongoing high spatial resolution imaging of soil and rock patches may provide additional details regarding the spectral properties of thier components.

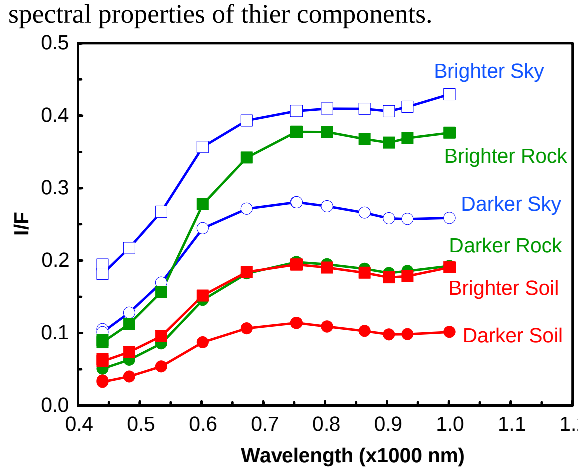

Figure 1. Pancam multispectral data showing the spectral ranges for dusty sky, rock outcrop, and soil.

Mini-TES [10,11]: The detection of hematite by MGS-TES from orbit was confirmed by Mini-TES at Meridiani Planum. The hematite is heterogeneously distributed, with the highest concentrations above and on the west side of the outcrop (Figure 2). The lander and current rover location are in a area where the hematite content is low. Curiously, the hematite content in the impressions made by the air bags is low relative to surrounding undisturbed material.

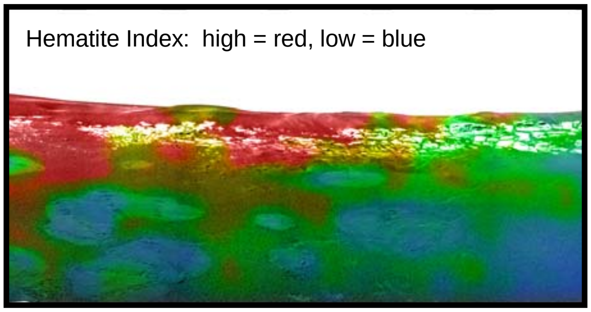

Figure 2. Hematite index from Mini-TES

Figure 3 compares Pancam multispectral data for a hematite-rich surface region to a hematite-poor surface region near the current rover location. Shown for reference is the spectrum of the red calibration target on the rover, which has a red hematite pigment. The multispectral data for the two surface regions are essentially identical, showing that there is not a detectable manifestation of the hematite found by Mini-TES in Pancam multispectral data. That is, the hematite is gray (spectrally neutral) at Pancam wavelengths, in agreement with previous observations.

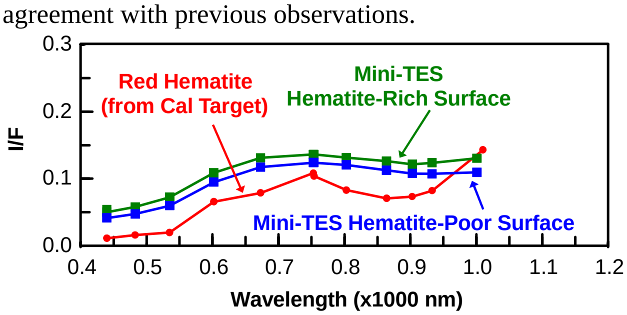

Figure 3. Comparison of Pancam multispectral data for hematite poor and hematite-rich regions on the basis of Mini-TES spectra.

Moessbauer [12,13]: A Moessbauer spectrum has been obtained for one soil (Figure 4) near the lander in a region having low hematite content according to Mini-TES. The Microscopic Imager imaged this location before the Moessbauer measurement, and the APXS obtained elemental analyses after Moessbauer analyses. Preliminary analysis indicates the Moessbauer spectrum is described by two ferrous doublets, a ferric doublet, and a magnetic sextet with very broad lines, possibly from a distribution of sites and/or more than one magnetic phase. The most intense doublet is assigned to forsteritic olivine, based on its Moessbauer parameters (P. de Souza, unpublished database). Preliminary results indicates that the olivine found here in Meridiani Planum and the olivine identified on the other side of the planet at Gusev Crater are not distinguishable on the basis of their Moessbauer parameters. Olivine has also been identified from orbit by MGS TES in the Nilli Fosse region [14].

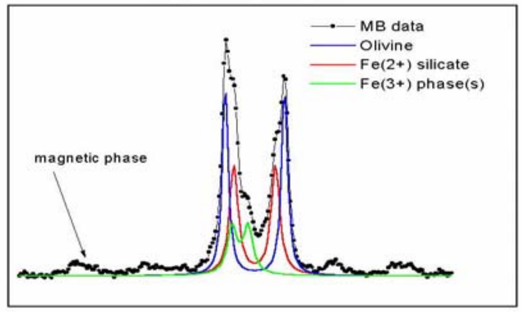

Figure 4. Moessbauer spectrum of soil near the lander.

APXS [15,16]: Only very preliminary analyses are available for the soil. It is basaltic in composition, and contains levels of S and Cl comparable to those found at Gusev, Mars Pathfinder, and the Viking landing sites.

Microscopic Imager [17,18]: At Pancam spatial resolution, the surface soil appears to be a mixture of dark material with lighter particles randomly distributed over the surface. At the spatial resolution of the MI (~30 microns/pixel), the field of view shows fragments of various sizes (1-3 mm) and shapes (rounded, subrounded, and angular) distributed on top of a surface with sand-sized grains (90-200 microns). The round objects commonly contain holes or surface indentations, some are broken, and they appear to have been size sorted (broken and whole particles have comparable sizes). Occasional fragments seem to show evidence of layering. The target for the Moessbauer measurements (determined by the MI image of the impression of the contact ring) is about 20% fragments and 80% sand-sized particles, implying that the olivine can not be associated exclusively with the fragments.

Summary: The gray hematite identified from orbit by MGS-TES was detected on the ground by Mini-TES. No accessory phases have been detected to date. Analyses of soil by the Moessbauer spectrometer indicate the presence of olivine, an additional ferrous phase, a ferric phase, and a magnetic sextet. Planned near-term rover movement is toward the outcrop and hematite-rich (by Mini-TES) surface regions.

References: [1] Christensen et al., *JGR*, *105*, 9642, 2000; [2] Christensen et al., *JGR*, *106*, 23873, 2001; [3] Hynek et al., *JGR*, *107*, 5088, 2002; [4] Lane et al., *JGR*, *107*, 5126, 2002; [5] Bell et al., *JGR*, *108*, 8065, 2003; [6] Bell et al., this volume; [7] Morris et al., *JGR*, *105*, 1757, 2000; [8] Bell et al., *JGR*, *105*, 1721, 2000; [9] McSween et al. *JGR*, *104*, 8679, 1999; [10] Christensen et al., *JGR*, *108*, 8064, 2003; [11] Christensen et al., this volume; [12] Klingelhoefer et al., *JGR*, *108*, 8067, 2003; [13] Klingelhoefer et al., this volume; [14] Hoefen et al., *Science*, *302*, 627, 2003; [15] Rieder et al., *JGR*, *108*, 8066, 2003; [16] Rieder et al., this volume; [17] Herkenhoff et al., *JGR*, *108*, 8065, 2003; [18] Herkenhoff et al., this volume.