DUST AND SAND DEPOSITION ON THE MER SOLAR ARRAYS AS VIEWED BY THE MICROSCOPIC IMAGER. Geoffrey A. Landis[1], Kenneth Herkenhoff[2], Ronald Greeley[3], Shane Thompson[4], Patrick Whelley[3] and the MER Athena Science Team, [1]NASA John Glenn Research Center, 21000 Brookpark Road, m/s 302-1, Cleveland OH 44135, geoffrey.a.landis@nasa.gov, [2]U.S. Geological Survey, Flagstaff, AZ 86001, kherkenhoff@usgs.gov, [3]Arizona State University, Tempe, AZ 85287, greeley@asu.edu; pwhelley@asu.edu, [4]University of Nevada Reno, Geol. Sci., MS 172, Reno, NV 89557, thomp102@unr.nevada.edu.

Introduction: The Martian atmosphere contains a significant load of suspended dust. Dust settles out of the atmosphere onto exposed surfaces; the effect of the dust coverage can be directly seen in the output of the solar arrays [1-3]. To characterize this deposition, we used the Microscopic Imager (MI) to examine the surface of the solar array on the Mars Exploration Rovers (MER) Spirit and Opportunity.

Microscopic Imager. The MI is mounted on the extendable Instrument Deployment Device (IDD) on the MER. The MI has a pixel resolution of 31 microns/pixel across a 1024 × 1024 pixel image, for a total frame size of 32 × 32 mm at the best focus position. Instrument details can be found in Herkenhoff *et al.* [4], and recent imaging results are presented by Herkenhoff *et al*. [5]. The IDD had been designed to allow the MI access to surface in front of the rover and the to the magnet arrays, but was not designed with the intention of allowing it to reach the solar panel of the rover. However, ground testing on the engineering model showed that portions of three solar cells on the front edge of the rover deck were within reach of the IDD placement of the MI. During the extended mission, images of these cells at MI resolution were made on both the Spirit and Opportunity solar arrays. The placement of the MI on the array is shown in figure 1. The solar cells are approximately 0.8 meter above the ground.

Array details are found in Ewell *et al.* 2005 [2].

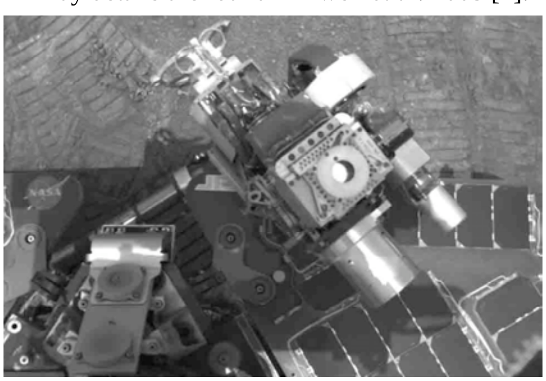

Figure 1: View from the pancam of the MI placed on the Spirit solar array on sol 505.

Solar Array Images: Figure 2 shows a mosaic of three images from the initial MI imaging of the solar array on Spirit, eleven months after landing. The two

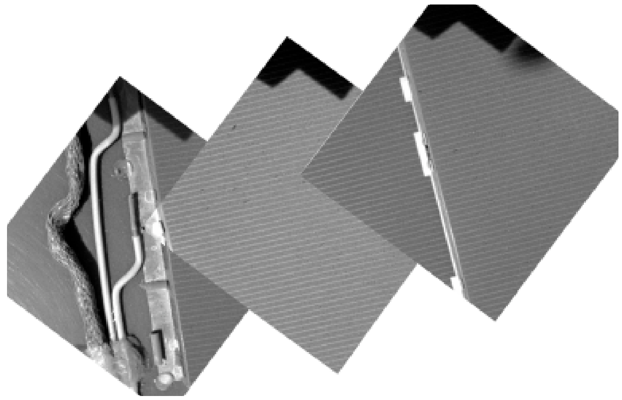

Figure 2: three frames from the microscopic imager view of the Spirit solar array on sol 350.

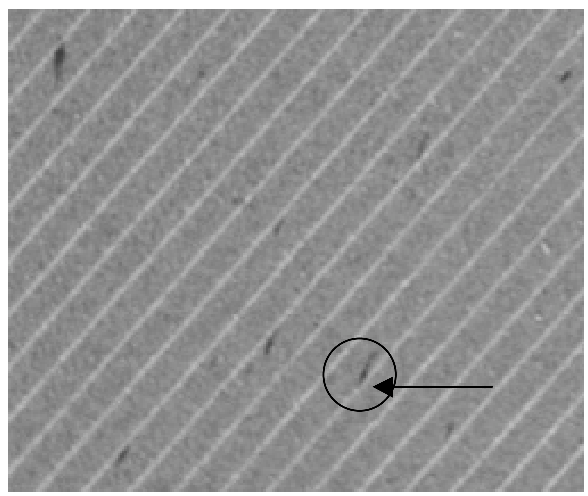

Figure 3: Enlarged portion of a frame, with an arrow showing one of the dark marks on the panel.

frames to the right show the glass surface of the cells, with parallel metal lines on the solar cells visible through the glass; the left frame shows interconnect wires. Dark areas on the top of images are shadows.

Figure 3 shows an enlargement of a portion of one of the frames. Dust-related features are evident. Before launch, the solar arrays were specular glass surfaces, covering a solar cell featuring parallel lines of metallization spaced at 0.625 mm on a dark cell surface. (These metallization lines are useful to show scale on the images). After 11 months of exposure, the surface reflection is markedly diffuse in both pancam and MI views.

No clearly evident structure can be seen at MI resolution, with no visible aggregation, signs of wetting, or "Fairy castle" structure. The size of particles suspended in the atmosphere at the MER sites is estimated from optical scattering measurements to be 1.5±0.2 μm [6], which is consistent with size measurements at the Pathfinder site [7]. Hence, it was not expected that any features would be visible at the resolution of the MI. Surprisingly, however, a distinct granularity is visible in the MI images. Figure 4 shows an enlargement of one frame, with the contrast greatly stretched to show detail. The fact that such details are visible is strong evidence that the deposits on the surface are significantly larger than the particles measured in the atmosphere by optical scattering. This could be either distinct larger particles, or conglomerate particles formed by agglomeration of micron-scale particles.

Sand. An additional feature of interest is the presence of dark streak marks on the surface, such as the one indicated with a circle in figure 3. These marks very in width from a few pixels for the smallest, to as roughly 0.25 mm for the larger marks, with length from 0.2 to 0.9mm. We interpret these as streak marks in the dust coating, made by the impact of saltating sand grains as they bounce off the dust-coated surface, removing dust to reveal the dark surface of the solar cell beneath the glass. On Mars, the particle size most easily lifted by wind has been calculated to be a fine sand, 80-100 μm in radius. The trajectories average a height of 10 to 20 cm off the surface [8]. At Mars atmospheric pressure of about 8 mb, saltation initiates at a threshold wind of about 15 m/s [6], a speed seen during brief gusts at the Viking lander sites.

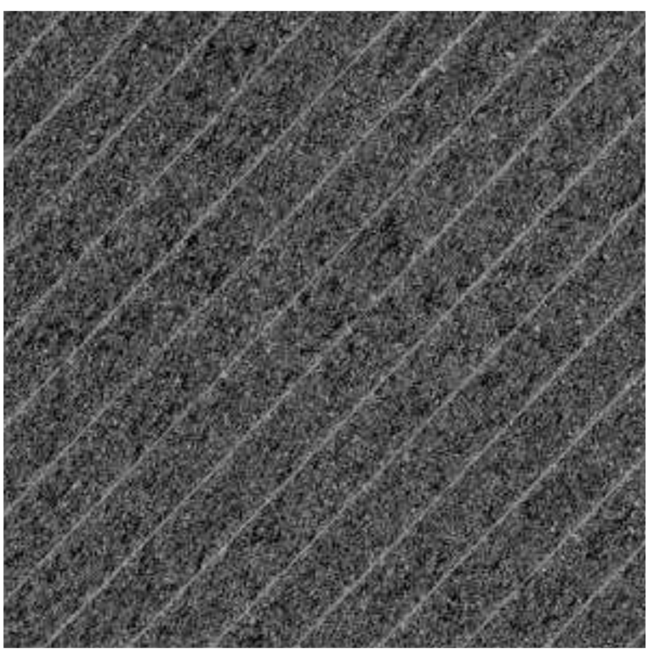

Figure 4. Enlarged MI view of the solar array surface, with the contrast greatly enhanced to show features.

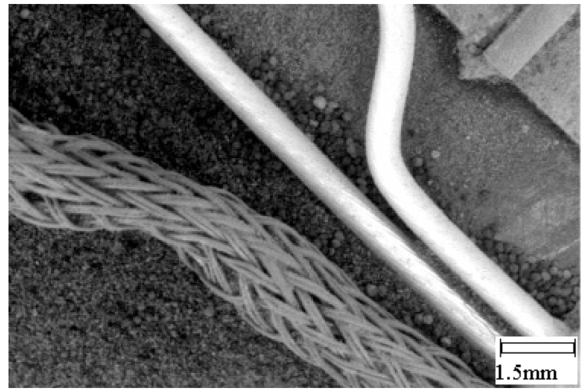

Figure 5: MI showing sand grains accumulating at the edge of one panel on Spirit, sol 505.

In addition to the surfaces of the solar cells, one frame of each three-frame mosaic was at the edge of the solar cell, with the exposed solar-cell wiring. A portion of one of these frames is shown in figure 5. The pockets formed by the wiring have accumulated a load of sand-sized particles, evidently brought to the rover deck by wind, with number of particles seen trapped in this region increasing during the mission. The largest of these particles has a radius of ~150 μm.

Three-component particle distribution: Dust settling on solar array has different properties from that of atmospheric dust measured from solar scattering properties. We see evidence for a three-component particle distribution:

Atmospheric dust: Primarily particles of ~1-2 μm radius, which stay suspended in the atmosphere for long periods.

Settled dust: Particles > 10 μm radius, which are raised into the atmosphere by wind or dust-devil events, but settle out of atmosphere.

Saltating particles: Particles > 80 μm, which move primarily by saltation.

Conclusion

Settled dust particles are much larger than anticipated. There is no sign of structure in the dust at MI resolution, with no visible clumping or "Fairy castle" structure. Settled dust is different in character (larger particles) than suspended dust. Saltating particles are seen to reach rover deck, a meter above the surface.

References: [1] Landis, G. and Jenkins, P. (2000) *JGR*, *105* E1, 1855-1857. [2] Stella, P., Ewell, R. and Hoskin, J. (2005) *Proc. 31st IEEE Photovoltaic Specialist's Conf.*, 626-630. [3] Landis, G. (2005) *Proc. 31st IEEE Photovoltaic Specialist's Conf.*, 858-861. [4] Herkenhoff, K. *et al.* (2003) *JGR*, *108*, 8065. [5] Herkenhoff, K. and the MER Athena Science Team (2006) *LPS XXVII.* [6] Lemmon, M. *et al.* (2004) *Science*, *360*, 1753-1756. [7] Tomasko, M. *et al.* (1999) *JGR*, *104* E4, 8987-9007. [8] Greeley R. *et al.* (1992) *Mars*, Chap. 22, 835 (U. Arizona Press).