DYNAMIC DUST ACCUMULATION AND DUST REMOVAL OBSERVED ON THE MARS EXPLORATION ROVER MAGNETS.

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Introduction: The Mars Exploration Rovers [1] each carry a set of Magnetic Properties Experiments designed to investigate the properties of the airborne dust in the Martian atmosphere. It is a preferred interpretation of previous experiments (Viking 1 & 2, 1976 and Mars Pathfinder, 1997) that the airborne dust in the Martian atmosphere is primarily composed by composite silicate particles containing one or more highly magnetic minerals as a minor constituent [2]. The ultimate goal of the magnetic properties experiments on the Mars Exploration Rover mission is to provide some information/constraints on whether the dust is formed by volcanic, meteoritic, aqueous, or other processes. The first problem is to identify the magnetic mineral(s) in the airborne dust on Mars. While the overall results of the magnetic properties experiments are presented in [3, 4], this abstract will focus on dust deposition and dust removal on some of the magnets.

The Capture and Filter Magnet Experiment: The capture and filter magnets are located in front of the Pancam Mast Assembly, such that the attracted dust can be studied by the Panoramic Camera (Pancam), the Mössbauer Spectrometer (MB), the Alpha Particle X-ray Spectrometer (APXS), and the Microscopic Imager (MI). The dust settles on a circular surface of high purity aluminum (45 mm in diameter), where the central part (25 mm in diameter) is magnetically active. The capture magnet is designed to be as strong as possible, and strength of the filter magnet was chosen such that it attracts mainly dust particles with high magnetic susceptibility (hence the "filtering").

Figure 1 shows the dust pattern on the filter magnet on Opportunity, sol 167 (upper image) and 274 (lower image). Both images are acquired using the Microscopic Imager [5] with a resolution of approximately 30 μm per pixel. Both images show an area of dimensions 25mm x 25mm.

In the first image, a homogenous layer of dust covers the magnet, and the fine dust particles seem to have formed aggregates with a preferred orientation (vertical).

In the lower image, taken 107 sols later, the dust layer has clearly become thinner on the outer part of the magnet (where the magnetic force is weakest). Strong wind activity is believed to have caused this dust removal. Pancam observations of the filter magnet

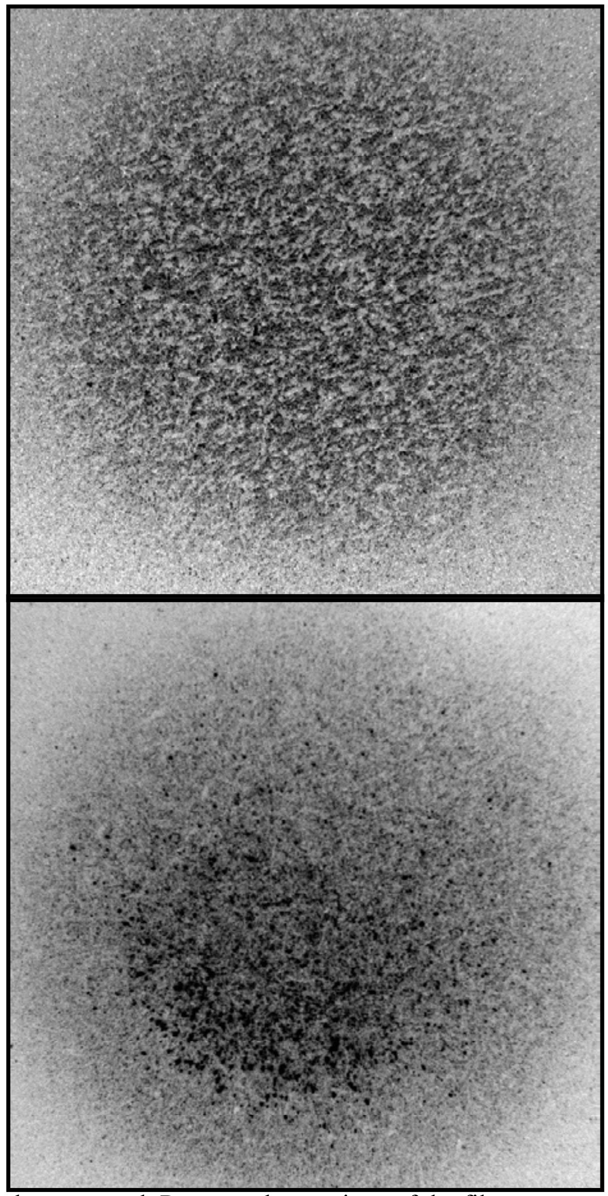

Fig 1. *Two raw images of the dust on the filter magnet, acquired by the Microscopic Imager on Opportunity, sol 167 (top, ID: 1M143009478) and sol 274 (bottom, ID=1M152419233) .*

also show that dust was removed around sol 200. This is illustrated in figure 2, where the reflectance at 440 nm on the Opportunity capture and filter magnet is shown. The reflectance is normalized relative to the reflectance of the aluminum surface outside the magnets. In the beginning of the mission, the reflectance In the center – and below – some very dark particles are present. These particles seem to have a significantly higher magnetization than the average airborne dust (they are not removed by strong wind). Additional related images and results will be presented at the conference.

The Sweep Magnet Experiment: The Sweep magnet experiment is placed on the upper surface of the rover (on the –X solar panels away from the PMA camera mast) next to the Pancam Calibration Target. The magnet itself is a ring magnet with inner radius of 2.0 mm and outer radius of 4.5 mm. The thickness (height) of the ring is 5 mm. The ring is embedded in an aluminum structure. The magnet is designed with a maximum surface magnetic force and it is strong enough to attract and hold most iron containing minerals including most paramagnetic materials.

The purpose of the Sweep magnet experiment is to try to detect if any 'non-magnetic' minerals are present in the atmospheric dust in any significant abundance. At present, no particles have been observed in the center of this magnet (and if any almost 'non-magnetic' particles were present at some point, they were probably removed by the strong wind events). Therefore, the center of the sweep magnet is indeed the cleanest part of the rovers, and it may serve as a reference/calibration surface. An example of this is shown in figure 3.

The calibrated reflectance, I/F, is not easy to determine in a constant way during the mission because the surfaces of the calibration target are covered with a red dust layer of varying (unknown) thickness – and because the illumination conditions differ. Therefore, the reflectance of the sweep magnet ring at 440 nm is divided by the reflectance of the 'clean' surface in the center. The same is done for the area outside the ring. As shown in figure 3, the relative reflectance on the magnet ring decreases exponentially with time. This is consistent with a random distribution of dust particles on the surface. The reflectance outside the ring appear to decrease linearly (or very slow exponentially). The deposition rate on the magnet ring is ≈ 10 times larger than the deposition rate outside the ring (where the magnetic force is zero). The deposition rate on the sweep magnet on Spirit seems identical to the deposition rate on Opportunity, which is consistent with the fact that the amount of dust in the atmosphere was roughly the same at the two landing sites during the primary mission [6] and the assumption that the dust is homogenously mixed around the planet.

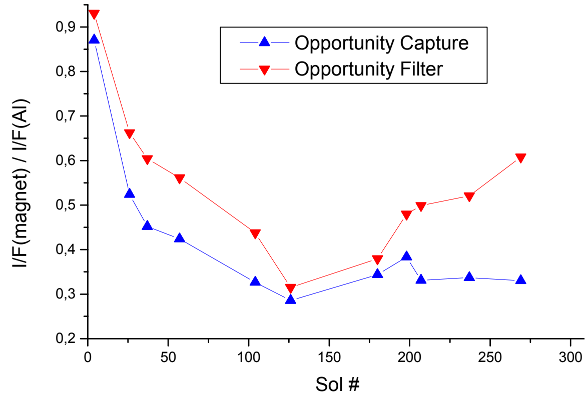

Fig 2. *The reflectance at 440 nm for the dust on the Opportunity capture magnet and filter magnet – normalized by dividing with the reflectance of the aluminum area outside the magnetic part of the surface.*

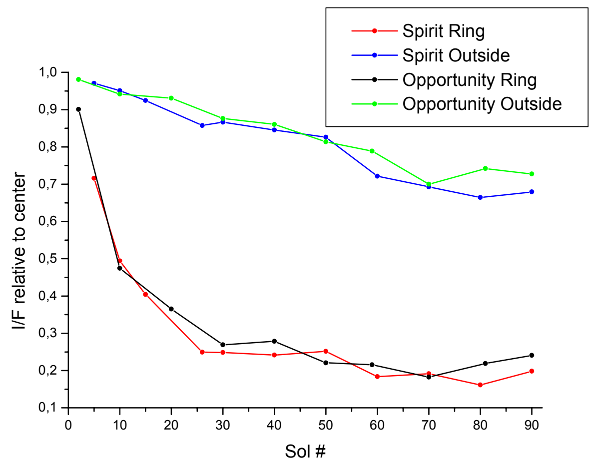

Fig 3. *The reflectance at 440 nm for the sweep magnet ring and the area outside the ring – normalized by dividing with the reflectance of the 'clean' area in the center of the ring.*

References:

[1] Squyres S. W., et al. (2004), Science, 306, p1698. [2] Madsen, M. B, et al. (1999) J. Geophys. Res., 104, 8761. [3] Bertelsen et al. (2004) Science, 305, 827. [4] Madsen et al. (2005), 36th LPSC. [5] Herkenhoff et al. (2004) Science 305, 824. [6] Lemmon et al. (2004) Science 306, 1753.