AN UPDATE ON RESULTS FROM THE MAGNETIC PROPERTIES EXPERIMENTS ON THE MARS EXPLORATION ROVERS, SPIRIT AND OPPORTUNITY.

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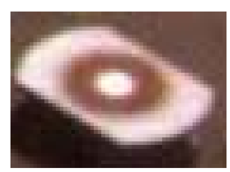
Introduction: The Magnetic Properties Experiments were designed to investigate the properties of the airborne dust in the Martian atmosphere. A preferred interpretation of previous experiments (Viking and Pathfinder) was that the airborne dust is primarily composed by composite silicate particles containing as a minor constituent the mineral maghemite (γ-Fe_2O_3)[1]. In this abstract we show how the magnetic properties experiments on Spirit and Opportunity provide information on the distribution of magnetic mineral(s) in the dust on Mars, with emphasis on results from Opportunity.

The Sweep Magnet Experiment: One aim of the sweep magnet experiment is to evaluate the fraction of non-magnetic particles present in the airborne dust. The sweep magnet experiment is placed next to the Pancam Calibration Target[2]. The magnet itself is a ring magnet with inner radius of 2.0 mm and outer radius of 4.5 mm. The ring is embedded in an aluminum structure and the active surface of the sweep magnet is horizontal. The combination of surface magnetic field and field gradient (B = 0.42 T and 450 Tm^{-1}) is strong enough to deflect the paths of arriving particles so that even particles that are weakly magnetic (specific magnetic susceptibility $\kappa < 0.5\ 10^{-6} m^3 kg^{-1}$) will be attracted to the magnetic ring of the magnet. The sweep magnet ring will therefore attract and hold most iron containing minerals including most paramagnetic materials leaving the inner center free of magnetic particles.

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)[2]. The dust settles on a circular surface of high purity aluminum, where the central part (25 mm in diameter) is magnetically active. The capture magnet was designed to be as strong as possible by maximizing the magnetic field and gradient. The strength of the filter magnet was chosen such that it attracts mainly dust particles with high magnetic susceptibility (hence the "filtering"). Both magnets are tilted an angle of 45 degrees with respect to horizontal enabling them to sample airborne dust settling out of the atmosphere – and to some degree enabling less magnetic or non-magnetic particles to escape capture by the magnets[3].

Differences in elemental composition between the magnetically attracted dust and the surface dust and soil as measured by the APXS is of significance because for example titanomagnetite is typical for igneous rocks, while pure iron oxides could be a result of processes involving liquid water.

Results and discussion: A Pancam image of the sweep magnet, Sol 173, and the reflection spectrum of different areas on the Opportunity rover sweep magnet is shown in fig. 1.



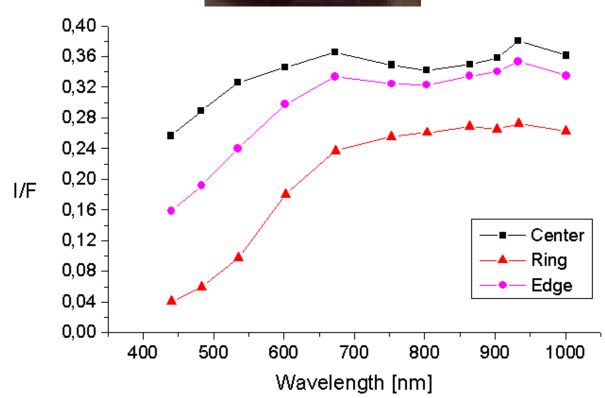


Figure 1. Top: Pancam Image of the sweep magnet on Opportunity, Sol 173. Reddish dust has settled in a ring-shaped pattern on the magnets. Below: Spectra from: the circular area inside the ring (Center), the dust on the ring (Ring), and the area outside the ring (Edge).

The dust on the ring shows an absorption spectrum similar to the spectrum of the reddish bright soil on Mars. The spectrum of the area outside the magnet demonstrates that some dust has accumulated on the outside by sedimentation. The third spectrum (circular area inside the ring) shows that essentially no dust particles have settled in this area. The sweep area appears brighter than the area outside the ring magnet. The area has evidently – at least to some degree – been kept clean by the magnet although all other surface areas of the rover are now much more dusty. Therefore nearly all of the airborne particles must contain a small amount (a few percent) of a ferrimagnetic phase, and thus be sufficiently magnetic to be attracted to the magnet. Somewhat similar results have been found on Spirit [5] where the center seems to be even cleaner than on the Opportunity sweep magnet.

Figure 2. Left: A Pancam image of the capture and filter magnets, Sols 180. The total amount of dust on the capture magnet is substantially higher than the amount of dust on the filter magnet. This difference is further enhanced around Sol 200where some kind of a partial dust cleaning event took place – maybe it was a dust devil passing over the rover. The results of this event is directly visible in MI images of particularly the filter magnet [4]. If the magnetic mineral in the airborne dust had been present for example as pure reddish-brown maghemite, i.e. single phase, ferrimagnetic particles, the amount of dust attracted would have been much more similar on the two magnets and the dust layer would have been much less susceptible to effects of wind gusts. Figure 2c shows the visible - near infrared spectrum of the most dusty area on each magnet. The low values of reflectivity is caused by the very low incidence angle. The dust on the filter magnet is significantly darker than the dust on the capture magnet. At wavelengths above 670 nm, the dust accumulating on the filter magnet is clearly darker than the aluminum surface, while the opposite is true for the material accumulating on the capture magnet. The distribution of magnetization of the particles that has been attracted must therefore be different for the two magnets. A simple explanation of the results is that the particles suspended in the Martian atmosphere contain a ferrimagnetic mineral, the amount of which varies somewhat from particle to particle and the filter magnet attracts preferentially the more strongly magnetic particles. These results support the view that the airborne particles are composite. Very similar results have been found for Spirit [5].

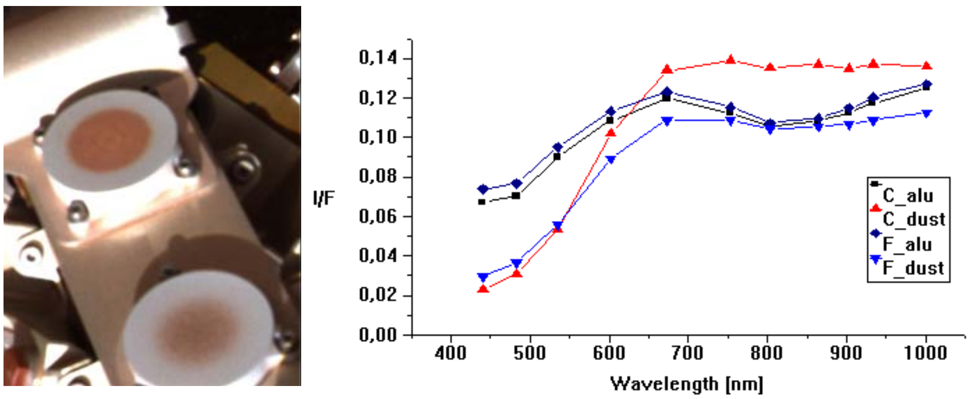


Figure 2. (a) The filter and capture magnets imaged by Pancam on Opportunity, Sol # 180. (b) Spectra of the area where dust has accumulated on the two magnets, and of the aluminum surface outside the dust covered area.

Analysis of the results of APXS measurements of the dust on the filter and capture magnets are in progress, as are analysis of a few long integration time Mössbauer spectra that have been acquired [6]. Preliminary results indicate that the mineral that is mainly responsible for the magnetic properties of the dust is magnetite and not maghemite as previously believed and at the same time that water did not play any significant role in formation of the magnetic dust. Examples of these results and possible interpretations and more will be shown at the conference.

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