# PRELIMINARY RESULTS OF THE MAGNETIC PROPERTIES EXPERIMENTS ON THE MARS EXPLORATION ROVERS, SPIRIT AND OPPORTUNITY.

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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 air-borne 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], this minor constituent probably being dominated by the mineral maghemite ($\gamma$-$Fe_2O_3$). 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. In detail, the objectives are: a) To identify the magnetic mineral(s) in the dust, soil and rocks on Mars. b) To establish if the magnetic material is present in the form of nanosized *(d* < 10 nm) superparamagnetic crystallites embedded in the micrometer sized airborne dust particles. c) To establish if the magnets are culling a subset of strongly magnetic particles or if essentially all particles of the airborne dust are sufficiently magnetic to be attracted by the magnets. d) Detect compositional differences between the airborne dust and the soil and rock sites which are investigated at two landing sites. To accomplish these goals the Mars Exploration Rovers each carry a set of permanent magnets of several different strengths and sizes. Each magnet has its own specific objective [3].

**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 was designed to be as strong as possible by maximizing the magnetic field $\boldsymbol{B}$ (0.46 T) and gradient Ñ$\boldsymbol{B}$ (550 $Tm^{-1}$). The strength of the Filter magnet ($\boldsymbol{B}$ = 0.20 T and Ñ$\boldsymbol{B}$ = 34 $Tm^{-1}$) was chosen such that it attracts mainly dust particles with high magnetic susceptibility (hence the "filtering").
The APXS measurements will reveal differences in elemental composition between the magnetically attracted dust and the surface dust and soil. It is important to determine whether the magnetic minerals contain the element Ti or not. Titanomagnetite is typical for basaltic igneous rocks, while pure iron oxides could be a result of processes involving liquid water.
The Mössbauer spectrum of the magnetically attracted dust may differ from soil spectra, since the magnets collect airborne dust only, using magnetical 'filtering'. In case of very small ($\lessapprox$20 nm) superparamagnetic crystallites, the magnetic field will be helpful to identify the magnetic minerals.

**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) near the Pancam Calibration Target. The Sweep Magnet is therefore in view of the Pancam. The magnet itself ($Sm_2Co_{17}$) 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 has been designed with a maximum surface magnetic field B = 0.42 T and a maximum field gradient of 450 $Tm^{-1}$. This combination of field and field gradient is strong enough to attract and hold most iron containing minerals including most paramagnetic materials.
The Mars Pathfinder magnet array experiment showed that the magnets attracted a large fraction of the dust in the atmosphere. It was not, however, possible to exclude the presence of a fraction of the atmospheric dust not being affected by the magnets. The purpose of the Sweep Magnet experiment is twofold: 1) to try to detect if any non-magnetic minerals are present in the atmospheric dust in any significant abundance. 2) to provide a magnetically attracted dust layer suitable for spectroscopic investigation by the Pancam spectroscopy bandpass filters.

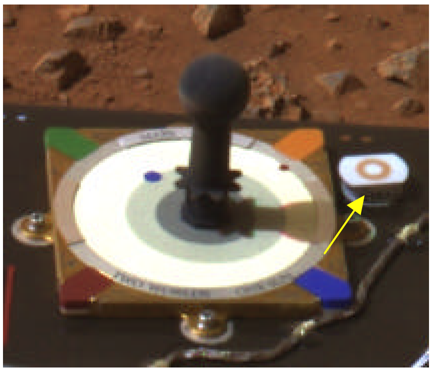

*Fig 1. The Pancam calibration target on Spirit (Gusev Crater) on Sol 14. The yellow arrow indicate the location of the Sweep Magnet Experiment. The red ring seen on the surface is dust attracted from the Martian atmosphere.*

**The RAT Magnet Experiment:**
Each rover carries a Rock Abrasion Tool (RAT) on the IDD, which is able to remove dust (by brushing) and weathering products (by grinding) from Martian rocks. Four RAT magnets are placed inside the RAT behind the grinding tool and the small brush. The purpose of these four magnets is to detect magnetic minerals in the dust (rock material) which is produced during grinding. The amount of dust and the color of the dust on the RAT magnets will be observed immediately before and after grinding. Utilizing the different strength of the magnets (magnetic field 0.07 T – 0.28 T, and gradient 80 $Tm^{-1}$ – 350 $Tm^{-1}$), it is possible to give a rough estimate of the magnetization of the rock material and the identity of the magnetic minerals in the rocks (if such are present).

**Preliminary Results:**
The reflection spectrum of the dust accumulated on the Sweep Magnet on Spirit (Gusev Crater) is shown in fig. 3. It should be noted that the shown spectrum represents the raw measured spectrum. This spectrum includes a significant spectral component from the underlying aluminum surface because the dust layer is not opaque. It has not been possible to detect any significant differences between the reflection spectrum measured on the Sweep Magnet on Spirit and the reflection spectrum measured at the dust on magnet #1 on the Magnet Array on Mars Pathfinder (Ares Valles). Therefore, the dust seem to be very homogenious on a global scale.

Preliminary results (at time of writing) shows a significantly faster dust accumulation rate than was observed on Mars Pathfinder (see fig. 1).

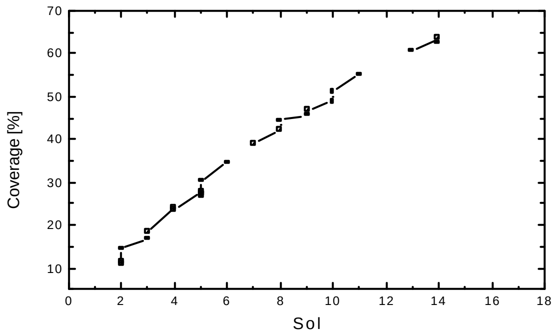


***Fig. 2.** Shows the growth of dust coverage as function of time for the first 14 sols on the sweep magnet on Spirit at Gusev Crater.*

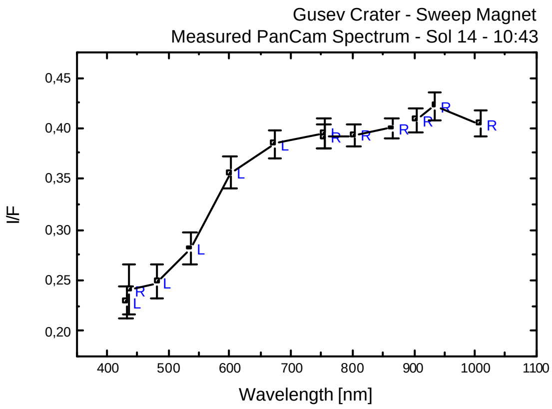


*Fig 3. The measured reflection spectrum of the dust accumulated on the sweep magnet on Spirit at Gusev Crater.*

The coverage observed on Sol 14 for the Spirit rover at Gusev Crater corresponds roughly to the dust coverage observed at the Mars Pathfinder landing site on Sol 83. This observation is consistent with the significantly higher optical opacity measured at the Gusev landing site as compared to Mars Pathfinder. Preliminary results from the Meridiani landing site shows roughly the same growth rate in coverage. This fact makes it likely that successful Mössbauer and APXS measurements will be possible before the end of the primary mission of the Mars Exploration Rovers.

**References:**
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