The nature of Martian airborne dust. Indication of long-lasting dry periods on the surface of Mars.
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The ubiquitous atmospheric dust on Mars is well mixed by periodic global dust storms. As a result, the dust carries information about the environment in which it once formed and hence about the history of water on Mars. The Mars Exploration Rovers (MER) carry permanent magnets to collect atmospheric dust for investigation by instruments on the rovers. In particular, dust attracted to the strong Capture magnet and the somewhat weaker Filter magnet (both located on the front part of the rover deck, figure 1) can be studied by instruments mounted to the end of the robotic arm: Microscopic Imager (MI), Alpha-particle-x-ray spectrometer (APXS) and Mössbauer spectrometer (MB). In this abstract we focus on data acquired by MER-B. Corresponding MER-A data are not as suggestive, but clearly favor the conclusions drawn below.

Figure 2 plots the abundance of iron in dust on the MER-B Capture magnet as a function of sol number. The monotone increase in iron abundance and the quality of the straight-line fit suggest that the dust accumulation on the magnet is far from saturation within the range of sol numbers shown (MER-B sol 53, 168, 280, 335). In particular a strong wind gust that was observed around sol 331 [1,2] did apparently not affect the steady increase in iron abundance over time. APXS data further constrain the nature of the material accumulated on the magnet (figure 3): A clear correlation between titanium and iron and between chromium and iron is observed.

An MI image acquired on sol 337 (figure 4) reveals the formation of magnetic chains on the active surface of the magnet. Based on laboratory simulations this observation implies the presence of strongly magnetic particles (i.e. rich in magnetite or maghemite) that can be separated out of the airborne dust by the action of the magnet [2].

Finally, an MB spectrum of the dust on the magnet (acquired during sols 328-330) is shown in figure 5 together with spectra of a typical bright Martian soil and of a magnetite (Fe_3O_4) rock slab: About half of the iron atoms turn out to belong to a magnetite phase, while the majority of the remaining iron atoms are interpreted to belong to olivine and pyroxene [2,3]. Note that this spectrum has been acquired only a few sols before the earlier mentioned wind gust of sol 331. Figure 2 suggests that most of the iron remained on the surface of the magnet during this event. As a result, the MB spectrum would likely have shown an even stronger magnetite signature, if it had been acquired post sol 331.

The above described data (MI, APXS, MB) support the following conclusions: 1) The magnetism of the aeolian dust clearly stems from its content of magnetite. This suggests that the dust is derived from mechanical weathering of magnetite-rich surface rocks [3]. 2) The strong correlation between titanium and iron suggests that the magnetite responsible for the magnetization of the dust is actually titanomagnetite [2]. The latter mineral frequently occurs in terrestrial basalts and is suspected to occur in basaltic rocks on the surface of Mars [4]. 3) The strong correlation between chromium and iron may suggest that some ferric iron (likely the octahedral one, [5,6]) in magnetite is replaced by Cr(III). Alternatively, the chromium as detected by APXS belongs to any other mineral phase(s) that – together with titanomagnetite – makes up the strongly magnetic particles of the dust.

So far, all conclusions did concern the magnetic phase of the dust. This phase turns out to be important, since it provides a direct and quantifiable link between the dust and the rocks that have been recognized as two end members on the surface of Mars [3]. Slow and dry weathering of basaltic rocks can apparently account for the formation of the global dust. This view is further supported by finding olivine in the dust, i.e. a mineral that is known to be easily reworked by the action of liquid water. The presence of olivine in aeolian dust and in virtually all soils (both landing sites) as well as in the large majority of rocks encountered by MER-A implies that the Martian surface must have been devoid of liquid water for a long time.

References: [1] Kinch, K.M. *et al.*, J. Geophys. Res. Planets (accepted, Feb. 2007). [2] Goetz, W. *et al.* (2007), in: J.F. Bell III (ed.), The Martian Surface: Composition, Mineralogy and Physical Properties, Cambridge University Press. [3] Goetz, W. *et al.* (2005), Nature 436, 62–65. [4] Morris, R.V. (2006), private communication. [5] Gillot, B. *et al.* (1977), J. Solid State Chem. 21(4), 375-385. [6] Clark, T.M. and B.J. Evans (1997), IEEE Transactions on Magnetics 33(5), 4257-4259.

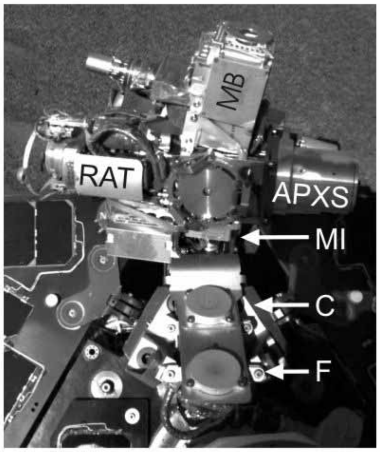

Figure 1. Context image (Navcam, MER-B, sol 328) showing the instruments mounted to the end of the robotic arm (APXS: Alpha-particle-x-ray spectrometer, MB: Mössbauer spectrometer, RAT: Rock Abrasion Tool, MI: Microscopic Imager) and the magnets (C: Capture magnet, F: Filter magnet).

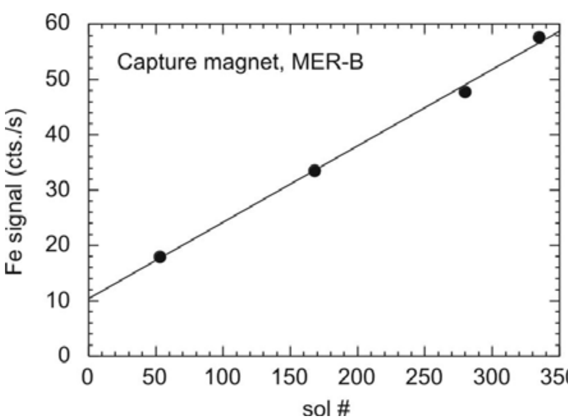

Figure 2. Iron abundance in dust on the MER-B Capture Magnet (APXS raw data) versus sol number.

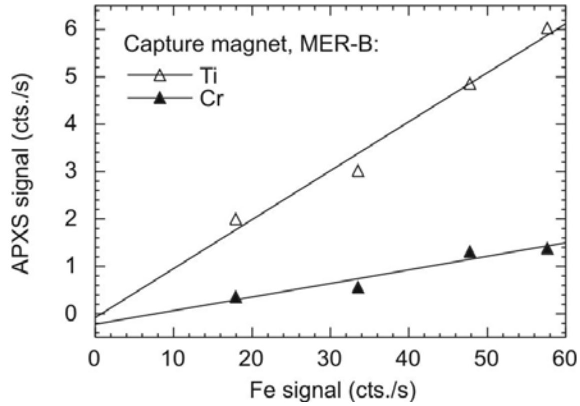

Figure 3. Correlations between element abundances in dust on the MER-B Capture Magnet (APXS raw data): Ti versus Fe and Cr versus Fe.

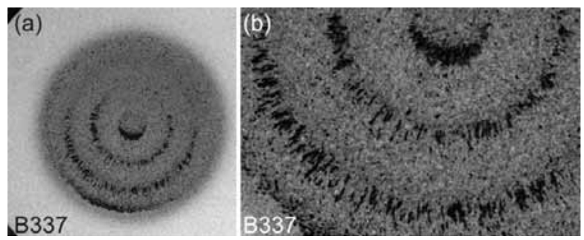

Figure 4. Magnetic chains observed on the MER-B Capture Magnet. (a) MI frame of sol 337. The area imaged measures 30 x 30 mm. (b) Zoom of lower part of (a).

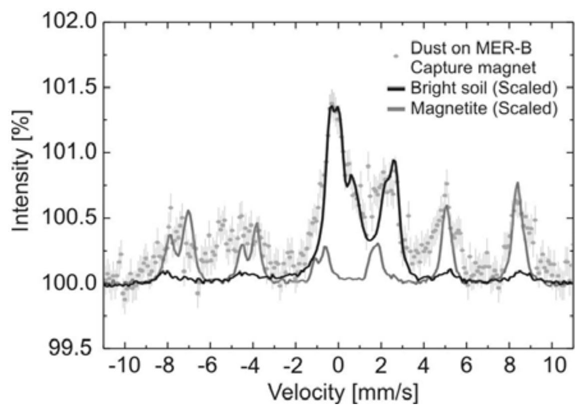

Figure 5. Mössbauer spectrum of Martian airborne dust (data points with error bars) as attracted to the Capture magnet (MER-B, sol 328-330). Also shown: Spectrum of bright Martian soil (black solid line) and magnetite on the calibration target onboard the rover (grey solid line).