

COMPOSITION OF THE DUST ON MARS DERIVED FROM OMEGA HYPERSPECTRAL IMAGES. S. Le Mouélic¹, C. Sotin¹, J-P. Combe¹, L. Ledet¹, A. Gendrin², J. Mustard², J-P. Bibring³, Y. Langevin³, B. Gondet³, P. Pinet⁴, ¹Laboratoire de Planétologie et Géodynamique, 2 rue de la houssinière, 44300 Nantes, France, ²Department of Geological Sciences, Brown University, Providence, RI, ³Institut d'Astrophysique Spatiale, Orsay, France, ⁴UMR 5562, Observatoire Midi-Pyrénées, Toulouse, France. [stephane.lemouelic@univ-nantes.fr]

Introduction: The OMEGA imaging spectrometer onboard Mars Express has completed a near global coverage of Mars in 352 spectral channels from 0.3 to 5.1 μm at a spatial resolution ranging from 300 m to 4 km. This unprecedented data set provides the opportunity to investigate the mineralogy of the very top surface of Mars by looking at diagnostic spectral features in the visible and near infrared domains.

The dust issue : The TES thermal imaging spectrometer onboard MGS has provided maps of the dust component of the martian surface, which is found mostly in the northern hemisphere [1]. TES identified a mixing with intermediate to calcic plagioclase [2]. Early telescopic studies [3,4] and Pancam spectra measured by Pathfinder [5] or MER rovers [6] suggested that the dust was dominated by a ferric oxide component. The APXS experiment mounted on the Pathfinder rover revealed that soils were significantly enhanced in Fe and Mg relative to the rocks, suggesting that soils composition are not dominated by the physical weathering products of local rocks [7,8]. [5] concluded that the dust was enriched in ferric oxides, and that a ferrous component may also be present. In situ measurements have been performed by the MER A and MER B rovers in order to characterize this ubiquitous dust. This led to the conclusion that the bright dust deposits on opposite sides of the planet are part of a global unit [6].

Processing of OMEGA data: In order to extract the mineralogical information contained in the OMEGA spectrum, we have developed an approach based on the linear unmixing strategies (see the accompanying abstract Combe et al.). In this approach, we find for each pixel the best linear combination of a suite of laboratory spectra of pure minerals (and water ice) which matches the OMEGA spectra. A pure slope component is included in the library to account at first order for photometric effects and grain size variations. We have focused our analysis on the 1-2.6 μm spectral domain, which contains very diagnostic absorption bands. This allows a perfect registration of OMEGA spectral channels.

Results: We have performed two series of analysis both at the local and global scale. In a first step, we have included in our input library a typical dust component, corresponding to an averaged spectrum acquired in the bright regions north of Syrtis Major (white square in fig. 1a). With the linear unmixing

analysis performed on a global scale, we obtain the dust image fraction shown in fig. 1b. The corresponding spectral model is given in fig. 2a for a typical bright area north of Aram Chaos (arrow a in fig. 1a). This OMEGA spectrum is modeled mainly by the dust endmember, plus an additional ferric oxide and a minor orthopyroxene component. This global dust endmember distribution (fig. 1b) is at first order consistent with the TES results [1], even if time dependent variations are observed from the sessions acquired more than one year apart.

In a second step, we performed the linear unmixing analysis without including the typical dust spectrum in the library (thus keeping only 27 spectra of pure laboratory minerals and water ice). In this case, the major outcome of the analysis is that the bright regions in the northern hemisphere are modeled mainly by a ferric oxide with a minor contribution of orthopyroxene. Image fractions of the most contributing endmembers are given in Figure 1 c, d and e. The comparison between the modeled spectra and OMEGA data is shown in fig. 2 b for the same area as fig. 2a

The exact nature of the ferric oxide phase is still under investigation. Local enrichment in ferric oxides are observed (for example in Aram Chaos), with a spectral contribution four times higher than that observed in the mean bright dust.

Most spectra of bright regions display a subtle broad feature at $\sim 1.8 \mu\text{m}$ with a typical depth of 4-5% (see for example figure 3 in Gusev). Some care should be taken because of non linearity effects which may be responsible for a bump in the spectra around 1.3-1.4 μm , hampering the analysis of such small absorptions features. This 1.8 μm feature is attributed in the mixing model to a minor orthopyroxene contribution, which can also provide an explanation. This possible orthopyroxene signature in the bright regions of the northern hemisphere is much lower than the one we find in the southern hemisphere and in localized regions (such as Syrtis Major where the OPX band depth reaches 15-20%). It should also be noted that no clinopyroxene component is found in the dusty bright unit. The ferric oxide component which shows up from our unmixing analysis is consistent with previous telescopic studies [3,4] and with the analysis made by the rovers which indicated the presence of a nanophase ferric oxide. The bright III soil component at Pathfinder site was interpreted in [5] as nanophase iron oxide with

a minor ferrous component consistent with pyroxene (whereas the spectral domain did not allow to identify which type of pyroxene). The enhancement in Fe and Mg observed by Pathfinder might be consistent with this ubiquitous subtle $\sim 1.8 \mu\text{m}$ feature we observe in bright regions with OMEGA, and which could correspond to hypersthene, a Magnesium-Iron silicate mineral relatively common on Earth.

Conclusion and Perspectives : This first order modeling of OMEGA spectra indicates that the dust on Mars constitutes a global unit corresponding to the bright areas in the northern hemisphere. The linear unmixing modeling indicates a content dominated by a ferric oxide with possibly a minor orthopyroxene component for this whole unit. Further deconvolution tests will be carried out in order to check the robustness of this subtle orthopyroxene identification. If confirmed, it might mean that the dust contains a large component of physically weathered Noachian crust. That might imply that the dust is very old, or simply that Noachian crust is a more readily accessible source for the dust (higher elevation, weaker strength, more exposed).

Bibliography : [1] Ruff S.W. and Christensen, P.R.(2002), *JGR*, 107, pp. 2-1, DOI 10.1029/2001JE001580 [2] J.L. Bandfield and M.D.Smith (2002), *Icarus* 161, 47-65. [3] McCord T. B. et al. (1977) *Icarus*, 31, 25–39. [4] Pinet P. and S. Chevrel. (1990) *JGR.*, 95, 14435. [5] Bell et al. (2000), *JGR*,105, 1721. [6] Yen A.S. et al. (2005) *Nature*, 436, 49-54.[7] Brückner et al. (2003), *JGR* 108, doi:10.1029/2003JE002060 [8] Bishop et al. (2002), *JGR* 107,doi:10.1029/2001JE001581

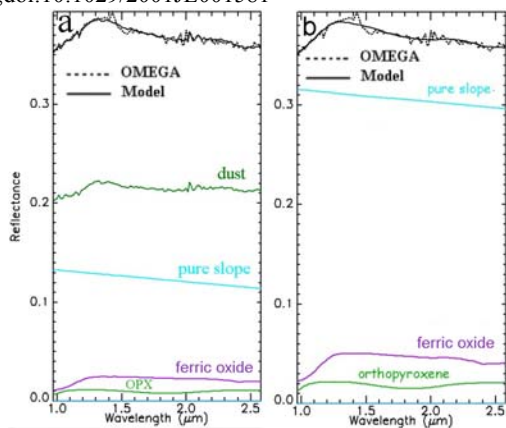


Figure 2 : comparison between OMEGA spectra (dotted black line) and linear mixing model (plain black line), with weighted individual component given in color, for a typical bright region with and without dust endmember in the input library.

Figure 3 (right) : bright dust spectrum at Gusev showing the 1.0-1.3 μm raise typical of ferric oxide and the broad 1.8 μm feature, possibly consistent with an orthopyroxene component (see continuum removed spectra at right)

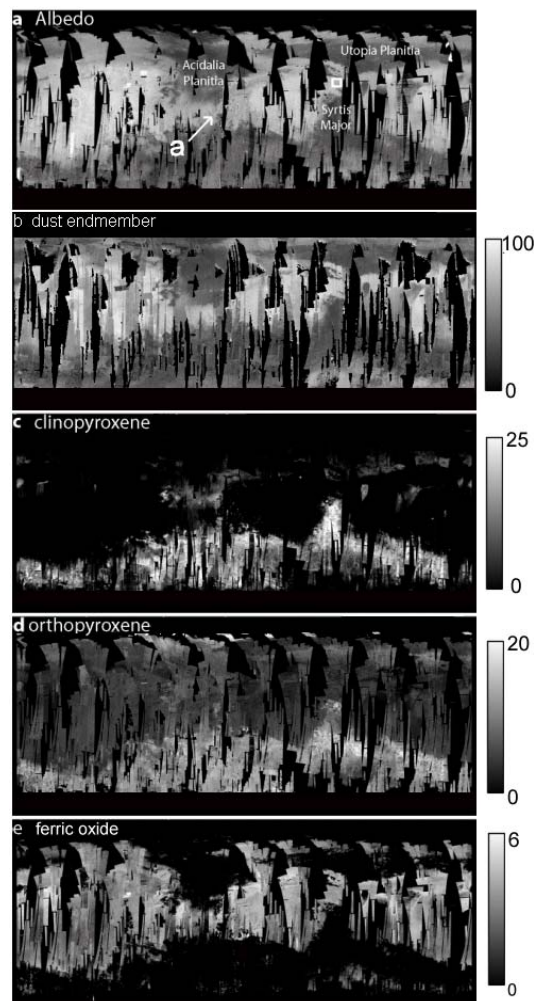


Figure 1 (a) albedo. (b) dust endmember. (c, d and e) images fractions of clinopyroxene, orthopyroxene and ferric oxide obtained by linear unmixing (without dust endmember in the input library). Scale bars correspond to the percentage of spectral component in the total spectrum (it is not absolute mineral proportions). The detection limits have still to be determined, and low levels should therefore still be taken with care.

