Global Mapping of Minerals on Mars with OMEGA Hyperspectral Data : Results of a Linear Unmixing Approach.
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Introduction: Since December 2003, the OMEGA imaging spectrometer onboard Mars Express has completed a near global coverage of Mars in 352 spectral channels from 0.3 to 5.2 µm, covering two martian years [1]. We have analyzed the global data set, up to orbit 5300, with the Multiple-Endmember Linear Spectral Unmixing Model (MELSUM) described in Combe et al. [2]. The objective is to retrieve global maps of the main minerals contributing to the signal recorded by OMEGA on the very top surface of Mars.

Methodology : For each OMEGA pixel, we seek by an automatic least-squares adjustment the best linear combination of a suite of laboratory spectra of pure minerals covering the main families (mafics, sulfates, oxides, carbonates, phyllosilicates). This corresponds physically to macroscopic (areal) mixtures. Two ices endmembers (H_2O and CO_2) are included in the input library to account for atmospheric clouds and surface frost. Artificial pure slopes endmembers complement the spectral library in order to correct at first order for aerosol scattering and albedo variation due to grain size effects. The analysis is restricted to the 1-2.6 µm spectral domain, which contains very diagnostic absorption bands.

A global distribution maps at 32 pixels per degree has been produced for each endmember of the input library. One of the challenges in computing these maps (representing ~500 GB of raw data), is to filter the data in order to account for the variations in atmospheric conditions, viewing geometry, seasonal frost or dust cover, and instrumental effects. Several filters have been used, such as an ice detection criterion, a spectrum quality index, an incidence angle threshold, and the Root Mean Square (RMS) residue of the linear spectral unmixing algorithm, which proved to be a very efficient mask. This process provides homogeneous maps of the distribution of the main mineral families.

Results: Fig. 1a shows a visible color composite (R=0.70 µm, G=0.58µm, B= 0.50 µm) of the full data set covering two martian years. Clouds and seasonal ices appear readily in this composite. Fig. 1b shows a partially filtered infrared composite (R=1.50 µm, G=1.27 µm and B= 1.08 µm) which emphasizes ice composition. CO_2 ice appears in white and H_2O ice appears in Blue. Fig. 1c shows a filtered false color composite (Red=olivine, Green= orthopyroxene, Blue= clinopyroxene) of the mafic endmembers derived from MELSUM. High-Calcium pyroxenes or clinopyroxenes (CPX) mixted with various amounts of Low-Calcium pyroxenes or orthopyroxenes (OPX) are found mostly in the southern hemisphere, which is consistent with previous studies [3, 4]. The ancient crust corresponds to a mixture of the two pyroxenes, whereas more recent lavas (such as the Syrtis Major volcanic edifice) appears depleted in OPX compared to CPX. It should be noted that a small OPX signature is found within dusty areas. This possible orthopyroxene signature in the bright regions does not corresponds to the crust but rather to a possible minor component of the mobile dust.

Olivine (in red in figure 1c) is found in very localized spots such as Nili Fossae or Nili Patera, which agrees with detailed investigations of the area [5].

Iron oxides (fig. 1d) appear with a low signal in the northern bright areas, and with a very strong signal in very localized areas such as Meridiani Planum and Aram Chaos, or in the vicinity of light toned layered deposits in Valles Marineris [6,7].

Extensive deposits of gypsum are found to be confined only to the Olympia Planitia formation, with a distribution consistent with the one found by [8]. The Ferrihydrite endmember map indicates a possible occurrence of this mineral in northern Meridiani Planum and in Aram Chaos, and in the oldest terrains surrounding Syrtis Major.

Conclusion and Perspectives : This first order modeling of OMEGA spectra with a modified linear unmixing model reveals the distribution of the main mineral families. It also provides a way to improve the global maps by providing a powerful quality index with the RMS of MELSUM. Further studies will be conducted to optimize the choice of the input library spectra.

Bibliography : [1] Bibring et al. (2004), *Eur. Space Agency Spec. Pub.*,1240, 37. [2] Combe et al. (2008) *Planet. Space. Sci.*, Vol 56, Issue 7, p. 951-975, doi:10.1016/j.pss.2007.12.007 [3] Bibring et al. (2005) *Science*, vol. 307, 5715, 1576-1581. [4] Bandfield (2002), *J. Geophys. Res.* 107, 5092. [5] Mustard et al. (2005) *Sci.*, vol. 307, 1595-1597. [6] Massé et al. (2008), 113, E12006, doi:10.1029/2008JE003131. [7] Le Deit et al. (2008), Vol. 113, E7, doi:10.1029/2007JE002950. [8] Langevin et al. (2005), *Science*, vol. 307, 1584-1586.

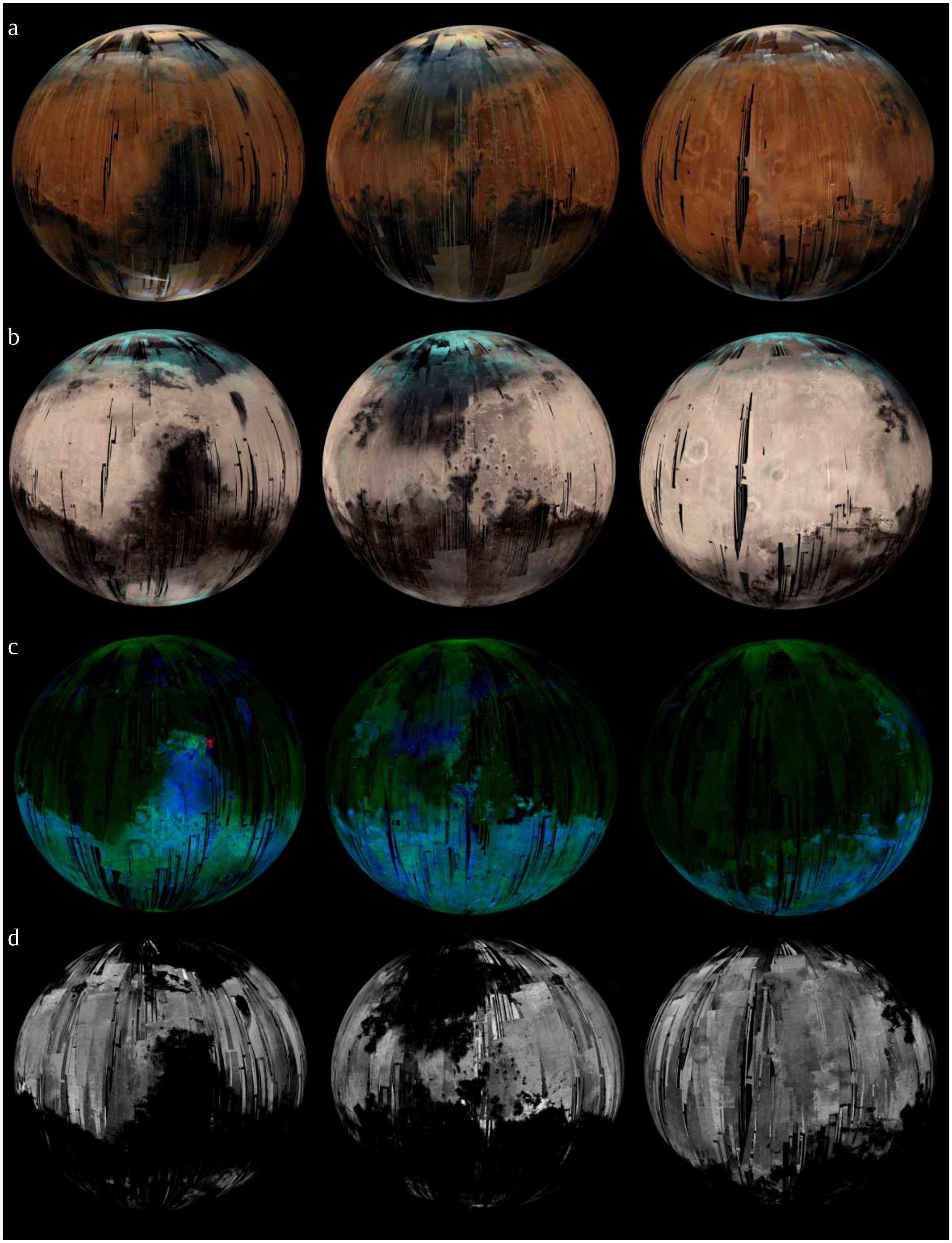

Figure 1: Orthographic projections centered at 50°E (Syrtis Major, left), 350°E (Aram Chaos, center) and 240°E (Ascraeus Mons, right). (a) Visible color mosaic of all data up to orbit 5300 (R=0.70µm, G=0.58µm, B= 0.50µm). (b) infrared color mosaic of data partially filtered by the RMS and quality index (R= 1.5µm, G=1.27µm, B= 1.08µm). (c) linear unmixing result for the mafics (R=olivine, G=orthopyroxene, B= clinopyroxene). Data have been filtered with an additional ice mask. (d) linear unmixing result for iron oxides (high values are in white).