THE COMPOSITION OF MARTIAN LOW ALBEDO REGIONS REVISITED. F. Poulet, S. Erard, *IAS, Université Paris-Sud, 91405 ORSAY Cedex, France (francois.poulet@ias.u-psud.fr)*, N. Mangold, *Orsayterre, Université Paris-Sud et CNRS, 91405, Orsay Cedex, France*.

Introduction: Low albedo regions on Mars are often interpreted as outcrops of volcanic rocks. Mineral models of the thermal emission spectra obtained by TES indicate that the martian dark regions are characterized by basaltic surface material: large fraction of feldspar and one high-calcium pyroxene [1]. The data from the IR spectrometer ISM onboard Phobos-2 show that the composition of these layers is rich in pyroxenes and contains a significant signature of hydratation [2]. A systematic comparison of TES and ISM data suggests that variations in the vis-NIR observations could be controlled by dust or other thermally neutral materials [3]. The purpose of this work is to revisit the surface composition of dark regions by modeling ISM spectra representative of dark regions with a radiative transfer theory and taking in account new high resolution images which give a new view of the surface texture of these regions. Syrtis Major and dark spots inside chasmata of Valles Marineris are of particular interest. Even if it is important to remember that the different observational techniques (visible, NIR and thermal) are sensitive to different characteristics of the martian surface, the understanding of discrepancies of the compositional analysis from different measurements and the nature of low albedo layers is essential 1- to understand their erosional history, and 2- to interpret the IR data of future spectrometers like OMEGA and PFS onboard Mars Express.

Geomorphic analysis: Low albedo regions were usually interpreted as bedrock despite the fact that fields of dark dunes have been observed at Viking images scale. The study of MOC high resolution images and THEMIS IR data show that the proportion of bedrock in these low albedo regions is small. First, in Valles Marineris, many dark areas correspond to dark sand sheets [4]. These area are typically smooth and devoid of craters at MOC scale (Fig. 1). They have the thermal response of sandy materials on THEMIS IR images. On the other hand, MOC images of Syrtis Major shows a surface texture different of volcanic bedrock (Fig. 2). No lava flows are observed and large craters are partially filled by smooth material. Furthermore, there are few small craters showing the occurrence of a process of resurfacing in recent times, less than ten million years ago. Only progressive dust deposition and eolian filling can explain such youthful smooth mantling, similar to that observed in regions like Arabia Terra for bright dust. Such filling is observed in most locations West of the two pateras, so in the very low albedo region. THEMIS data confirm that material at surface has mainly the thermal response of silt-sand size grains but not of bedrock, except on the pateras. Thus the low albedo regions, in which we can look for the composition using ISM data, are correlated with dark sand dunes, sand sheets and eolian dust mantling but not obviously bedrock. Dust is usually bright material but dark silt, maybe in a bit coarser particles compared to bright dust, has been proposed to exist in the past from both spectroscopic or geomorphic analysis [5,6]. Its existence is still controversial and the composition of such dark silt able to be transported in suspension in the atmosphere is questionable.

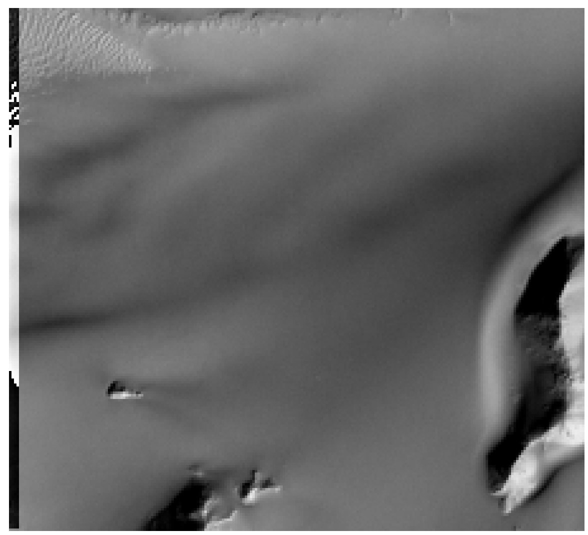

Fig. 1: MOC images (width: 2 km) of sand sheet inside dark region on the floor of West Ganges Chasma. Note smooth wave typical of sandy material.

Spectral data: The data used are from the PDS archive on www ias fr cdp Base ISM INDEX HTM . Two ISM windows (Aurorae and Syrtis-Isidis) were used in this study. The basic approach is to extract the spectra with albedo (with aerosols scattering and photometric corrections) lower than 15%. This selection (about 700 spectra for each window) should cover most of the terrains studied previously with the MGM method [2]. The spectra are characterized by 1- and 2-micron absorptions and gray/slightly red slope between 0.8 and 2.5 microns.

Choice of the scattering model: We choose to use the Shkuratov radiative transfer theory for fitting the spectra [7]. This geometrical optics model based on the slab approximation for calculating the albedo of a particle has been compared to other scattering models [8] and tested with laboratory mineral mixtures [9].

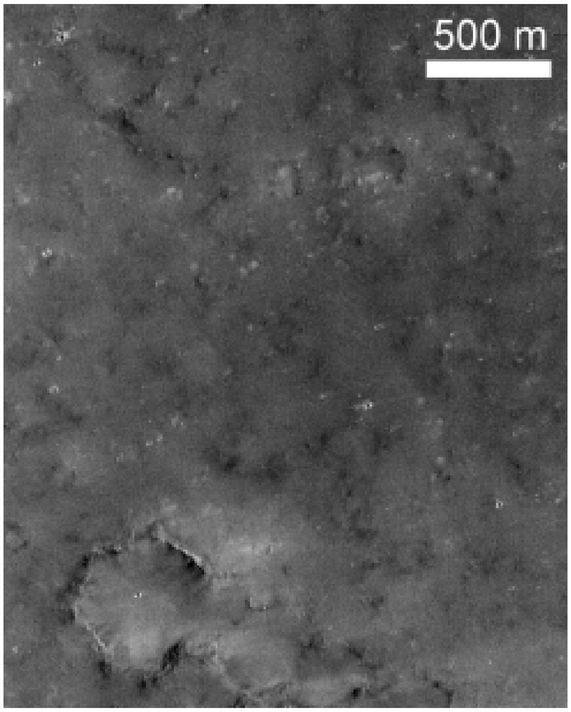

Fig. 2: MOC image of West Syrtis Major. Smooth texture with few craters and no lava flows visible.

Choice of the optical constants and end-members: We select the surface composition of each spectrum by trying to satisfy the following spectral characteristics: low albedo, shape and depth of 1- and 2-micron absorptions and spectral slope. Low- and high-calcium pyroxenes were obviously included in the scattering calculations. Spectrally featureless low albedo component in near-infrared to lower the average spectral reflectance is also required. Oxides such as magnetite display this neutral opaque behavior. Hematite (ferric oxide) was also considered because of its low albedo and its 0.85 micron absorption. Other minerals such as common amphiboles, obsidians and phyllosilicates were included in some scattering calculations. However, the presence of such minerals is unlikely because they present prominent OH- and H20- features with only a very few amount (5%) as shown in Fig. 3. Other common minerals with weaker absorptions such as feldspar and olivine were considered. The optical constants of endmembers were calculated from endmember reflectance spectra extracted of the RELAB library by following the procedure described in [9].

Choice of the type of surface and results: Three types of surface are investigated: dust (mixture of particles of size << wavelength), sand (intimate mixture of particles of size >> wavelength), dust/sand mixture. The optimization of abundances and grain sizes of endmembers is done by a downhill simplex technique.

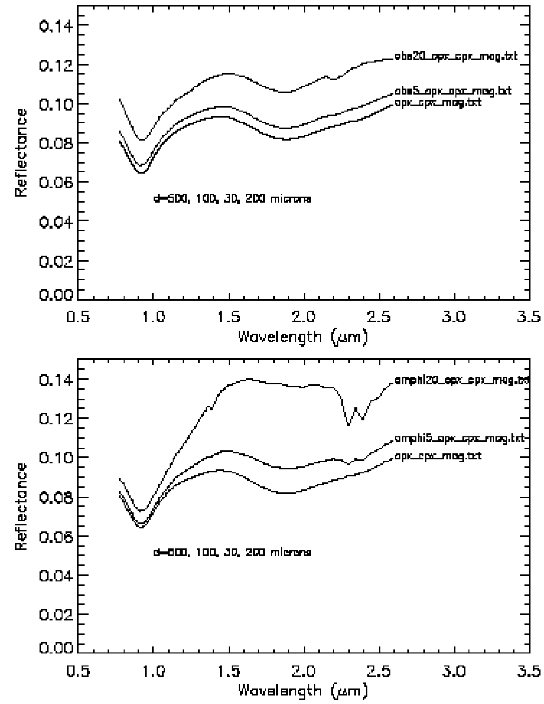

Fig. 3: (top): Three synthetic spectra of an intimate mixture of one obsidian, two pyroxenes and a dark component (here magnetite). The size of coarse particles for each components indicated. The concentration of obsidian is 20%, 5% and 0%. (bottom): Same except for obsidian replaced by amphibole.

The dust mixture fails to reproduce the spectra (Fig. 4). The spectra are well reproduced by a mixture of coarse particles pyroxenes / hematite / magnetite / olivine / feldspar. However, the very large proportion (> 50%) of hematite and magnetite coarse particles (size of several hundred microns) necessary for achieving the low albedo would have been detected by TES observations [1]. The best fits of the 0.8-2.5 micron spectra are obtained with a mixture of five components: a four component intimate mixture of two pyroxenes, olivine, and hematite mixed with a large proportion of dusty grains of hematite and magnetite (55%). We outline that both low- and high-calcium pyroxenes are required in agreement with [2]. The presence of large quantity of feldspar is very unlikely because this mineral is quite bright in the near-infrared. By contrast, the calculated large fraction of dust is in favor of a surface dust-coated rather than rock outcrops. Fig. 5 shows the distribution of the mixing ratios of the five components for low albedo regions located in the eastern part of Valles Marineris. The low dispersions suggest that

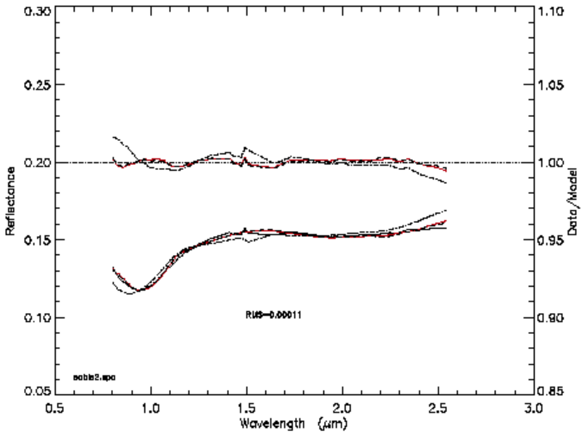

Fig. 4: A representative low albedo spectrum (thick line) and three synthetic spectra made of seven-component dust (dotted-dashed line), seven-component intimate mixture(dashed line), and four-component mixture mixed with dust(thick red line). The data/model ratio allows a rapid qualitative assessment of the accuracy of the fits. The value of the RMS for the sand/dust mixture is indicated.

most units are similar in composition, hidden by homogenized surface materials, or some combination of both. Even if further modeling need to be done, no significant difference of composition between the two studied ISM windows (Aurorae and Syrtis) were found so far. Also, the disconnect between ISM and TES observation modeling may result from the fact that NIR data are much more sensitive to thin coatings than thermal IR data, so that TES data may not detect large amounts of oxyde mineral dust.

References: [1] Hamilton et al. (2001) *JGR* 106, 14733–14746. [2] Mustard et al. (1997) *JGR* 102, 25605–25615. [3] Cooper C.D. and Mustard J.F. (2002), *AGU* P51C-07. [4] Mangold et al. (2003) EGS/AGU abstract. [5] e.g. Dollfus et Deschamps, (1993) JGR, 98, 3413-3429. [6] Edgett and Malin (2000) JGR, 105, 1623-1650. [7] Shkuratov et al. (1999) *Icarus* 137, 235–246. [8] Poulet F. et al. (2002) *Icarus* 160, 313–324. [9] Poulet et al. (2003) *LPSC* XXXIV, abstract.

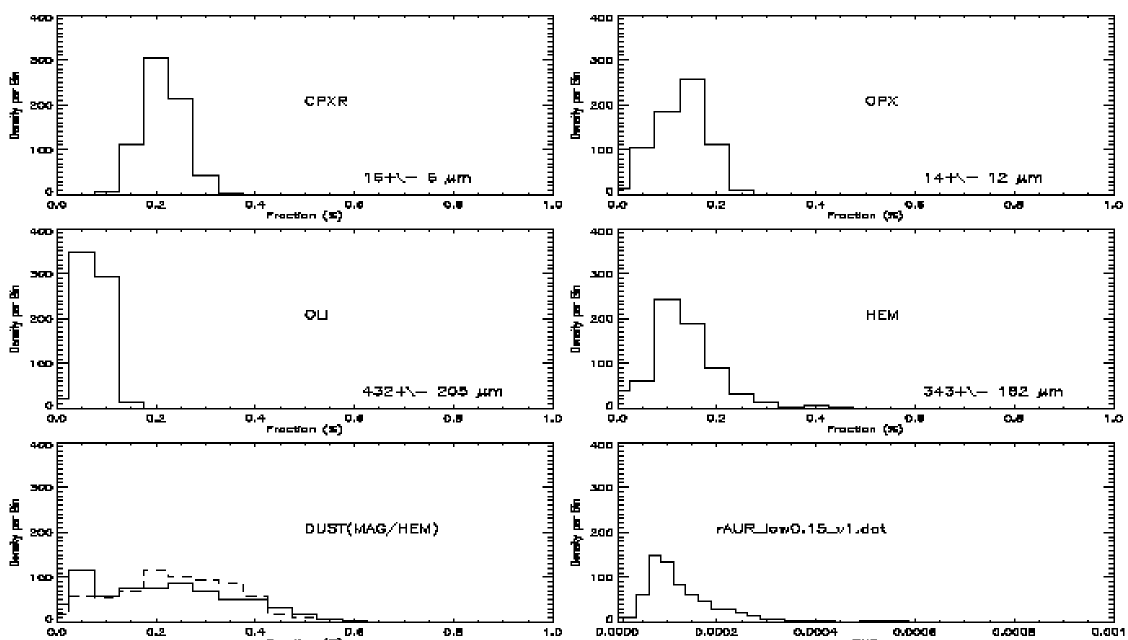

Figure 5: Histograms of calculated mixing ratios of each component and RMS of fits for the low albedo spectra extracted from the ISM Aurorae window. A sand+dust mixture is considered. The mean value of coarse grain size for each component is indicated.