ORIGINS OF THE SPATIAL VARIATIONS OF THE WATER-OF-HYDRATION NEAR-INFRARED ABSORPTION BANDS OBSERVED BY OMEGA/MARS EXPRESS ON THE MARTIAN SURFACE.

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Introduction: The OMEGA mapping spectrometer (on-board Mars Express) covers the whole spectral range of reflected solar light in the visible and near infrared. The largest spectral feature in this range is the broad absorption band located between 3 and 4 μm ("3 μm band") due to the presence of water linked to surface minerals. This strong absorption is detected on all the spectra collected so far [1]. On the contrary, the 1.9 μm band, also due to water-of-hydration, is only observed on localized areas [2]. The strength and shape of the water-of-hydration absorption bands are influenced by the amount of water, the type of interaction between water and minerals, textural parameters (grain size, mixing mode…) and the geometry of the observation (incidence and emergence angles). This study is an attempt to discriminate the effects of these parameters and to determine the origins of the spatial variations of the 3 μm absorption band on the Martian surface.

Methods: We used laboratory experiments and radiative transfer numerical modeling to isolate the effects of grain size, mixture between materials with different albedos and observation geometry on the 1.9 and 3 μm bands. Methods and results of these studies are presented in a separate abstract [3]. In a second step, we used the OMEGA dataset to characterize the spatial variations of the 3 μm absorption band strength on the Martian surface. OMEGA data were reduced to obtain bidirectional reflectance spectra. This process includes the correction of the thermal emission between 3 and 5 μm to retrieve the correct shape of the 3 μm band. This was done using a method similar to the one described by [1]. Unexpected variations of the sensitivity of the OMEGA long wavelength channel are currently the major sources of uncertainties. However, this problem should only affect the absolute values of hydration band strength allowing the study of relative variations of band strength inside isolated OMEGA hyperspectral cubes. The different criteria used on laboratory measured and modeled spectra to extract the 3 μm band strength are then calculated in the same way on the OMEGA data. These criteria include simple reflectance ratios and integration methods on reflectance spectra or spectra converted to apparent absorbance and single scattering albedo [3].

Correlation of band strength with albedo: Relationships between hydration band strength and albedo can directly be investigated from OMEGA data. Previous studies have established a systematic positive correlation between the level of reflectance in the spectrum continuum and the 3 μm band strength estimated by integration or by a simple spectral ratio [4,5,1]. The interpretation of this correlation remains difficult because different processes implying variations of the hydration state, variations of surface texture or a simple bias due to band strength extraction can explain it. To address this particular question, we compare the correlation of band strength to albedo obtained from OMEGA data and from laboratory-measured and modeled spectra of an hydrated smectite mixed with a neutral component with variable grain size (fig.1). Simple integration of the band area (graph 1a and 1c) shows a highly linear dependence of the Integrated Band Area (IBA) with the continuum reflectance level on OMEGA data as well as laboratory and modeled spectra. Normalization of the IBA values to continuum reflectance values gives rise to a logarithmic dependence of the NIBA (Normalized IBA) values with the continuum reflectance values (graph 1b and 1d). This systematic correlation is probably the result of the arbitrary definition of the continuum above the absorption band. Solutions to this problem include refined definition of the continuum (such as the one proposed by [6] that suppresses dependence on albedo) or empirical correction of the linear dependence. We are currently testing this second solution and will discuss the results at the time of the conference.

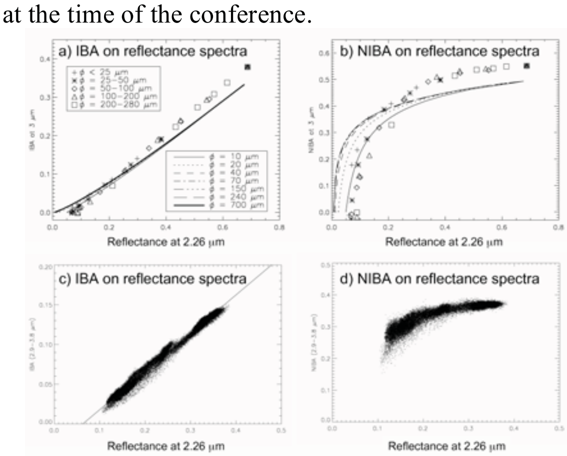

Figure 1: Illustration of the correlation of the 3 μm band strength with continuum reflectance (see text). Graph 1a and 1b: results from laboratory measurements and modeling. Graph 1c and 1d: Example of an OMEGA cube (orbit 243_2).

Effects of materials texture: Results from experiments and modeling revealed the strong effect of grain size on the 3 μm band strength [3]. Therefore, it is crucial to isolate the effects of this parameter on the Martian surface. Influence of grain size on the hydration band strength is studied through the comparison between OMEGA data and the TES thermal inertia global map [7] that indicates relative variations of the surface mean particle size. In a tentative to discriminate the effects of albedo, particle size and the influence of other parameters on the band strength, we plot the values of band strength from different OMEGA observations as a function of the continuum reflectance and the thermal inertia of the considered pixels. Fig. 2 presents two examples of these diagrams. In the first case (2a), the correlation of band strength with albedo and the effect of particle size are dominant. In the second case (2b), we see a different pattern related to variations of the surface materials water content in the regions surrounding the North polar cap.

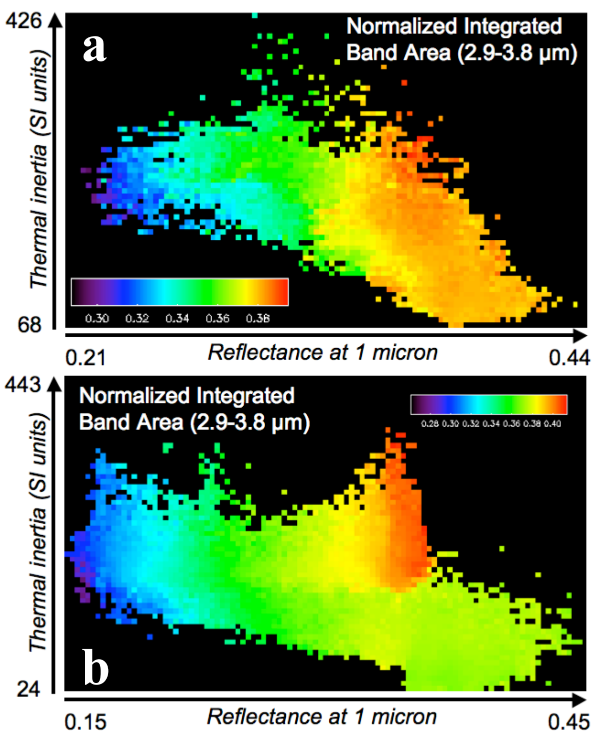

Figure 2: Diagrams presenting the 3 μm band strength as a function of reflectance at 1 μm and thermal inertia for orbit 925_4 (2a) and the southern part of orbit 270_3 (2b). On graph 2a, correlation of band strength with albedo is evident. Effect of surface texture is also noticeable as band strength is usually higher for the largest thermal inertia values for a given albedo. On the contrary, the color pattern looks different on graph 2b due to a gradient of hydration toward the north polar cap.

Effects of observation geometry: We compared the variations of the 3 μm band strength observed on measurements and modeling under various geometries with those measured on OMEGA spot-pointing observations (observation of the same scene with a continuously varying emission angle). We can confirm the diminution of band strength when phase angle increases, especially for high values of phase angle, first observed on laboratory-measured and modeled spectra. Therefore, this effect has to be taken into account in the case of OMEGA observations acquired over a large range of latitudes implying large variations of phase angle.

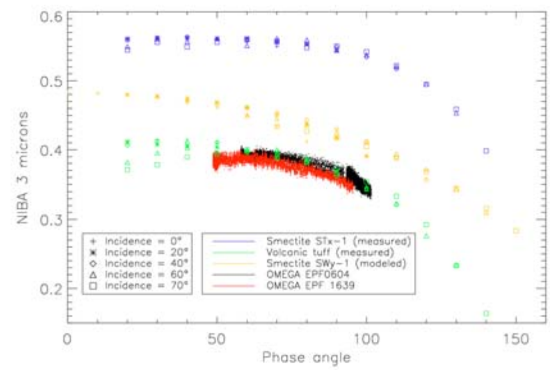

Figure 3: Effect of phase angle on the 3 microns band strength (Normalized Integrated Band Area). Comparison of results from OMEGA data (orbits 0604 and 1639), laboratory-measured spectra and modeled spectra.

Conclusion and perspectives: Laboratory work and radiative transfer modeling are necessary to investigate the effects of the different parameters susceptible to influence the 3 μm absorption band strength. A precise knowledge of the effects of these parameters on band strength permits in some cases to determine the origins of the spatial variations of the 3 μm absorption band: variations of surface texture, observation geometry or surface materials water content. We plan to complete this work in order to get a more global view of the role of each of these parameters. In a next step, correction of these effects should allow us to extract the spatial distribution of water-of-hydration and its temporal variations, providing new constraints on past and present water cycle on Mars.

References: [1] Jouglet D. et al. (2006) *LPS XXXVII*. Abstract #1741. [2] Bibring J.-P. et al. (2007) *Science, 312*, 400-404. [3] Pommerol A. et al. (2007) *This conference*. [4] Calvin W. M. (1997) *JGR, 102*, 9097-9108. [5] Murchie S. L. et al. (2000) *Icarus, 147*, 444-471. [6] Milliken R. E. et al. (2006) *LPS XXXVII*. Abstract #1987. [7] Putzig N. E. et al. (2005) *Icarus, 173*, 325-341.