WATER-OF-HYDRATION NEAR-IR BANDS ON MARS: DISTINGUISHING BETWEEN THE EFFECTS OF HYDRATION STATE AND SURFACE TEXTURE USING OMEGA AND TES DATASETS. A. Pommerol[1], B. Schmitt[1] and the OMEGA Team. [1]Laboratoire de Planétologie de Grenoble, UJF/CNRS, Bât. D de Physique, B.P. 53, 38041 Grenoble Cedex 9, France. (Email: antoine.pommerol@obs.ujf-grenoble.fr).

Introduction: The OMEGA (Mars express) imaging spectrometer has permitted the mapping of the near-infrared water-of-hydration absorption bands on Mars with a global coverage ([1],[2]). The strength and shape of these bands are influenced by the surface mineralogy, the amount of water, the type of interaction between water and minerals, surface textural parameters (grain size, mixing mode…) and the geometry of the observation (incidence and emergence angles). This study is an attempt to discriminate some of these effects on the Martian surface.

In a first step, we used laboratory experiments and radiative transfer numerical modeling to study the effects of grain size, mixture between materials with different albedo ([3]) and observation geometry ([4]) on the 1.9 and 3 µm bands. Results show that variations of surface albedo and regolith particle size have a strong influence on the hydration band strengths. Quantitative relationships have been derived between these parameters.

In a second step, we use these results to treat the case of the Martian surface. The correlation between band strength and albedo can be investigated directly from the OMEGA dataset whereas an independent dataset is required to retrieve the spatial variations of particle size on Mars surface.

Methods: From our laboratory work, we concluded that the "Integrated Band Area" (IBA) between 2.9 and 3.8 µm calculated in reflectance units is the most appropriate spectral criterion to distinguish between the effects of albedo, particle size and hydration state. Therefore, we calculated this criterion for each pixel of about 500 OMEGA observations (orbits 41 to 519 and 920 to 1220) for which the calibration signal is nominal for the two infrared spectral channels. Spectral calibration includes conversion of signal to bidirectional reflectance using a synthetic solar spectrum, atmospheric correction (CO_2 and H_2O absorptions) and surface thermal emission removal.

One of the most promising result from our laboratory work is a strongly linear correlation observed between the IBA criterion and the reflectance level in spectrum continuum that looks valid for any mixing mode used to vary sample albedo ([3]). We use this property to distinguish a "pure albedo artifact" from variations of band strength due to other processes (hydration state, particle size…). For this aim, we produce statistics on spatial sequences of OMEGA measurements to analyze the relationships between the IBA criterion and reflectance in the continuum at different spatial scales.

Thermal inertia is used as a proxy for spatial variations of surface texture and mean particle size on Mars. We use the 20 ppd (pixels per degree) global map produced by [5]. Every OMEGA spectrum from the about 500 selected observations were projected on a regular global grid at a resolution of 10 ppd while thermal inertia values were also re-projected at this resolution to permit a statistical study between the two datasets at identical spatial resolution.

Results: Figure 1 presents the relationship between IBA and albedo for all pixels of the 10 ppd global grid with latitudes between -50° and +50°. As expected, a linear correlation is the first order trend. Slope and ordinate origin are coherent with the values obtained in laboratory experiments and modeling. Dispersion around the best fit line is related to variations of hydration state, particle size or other parameters.

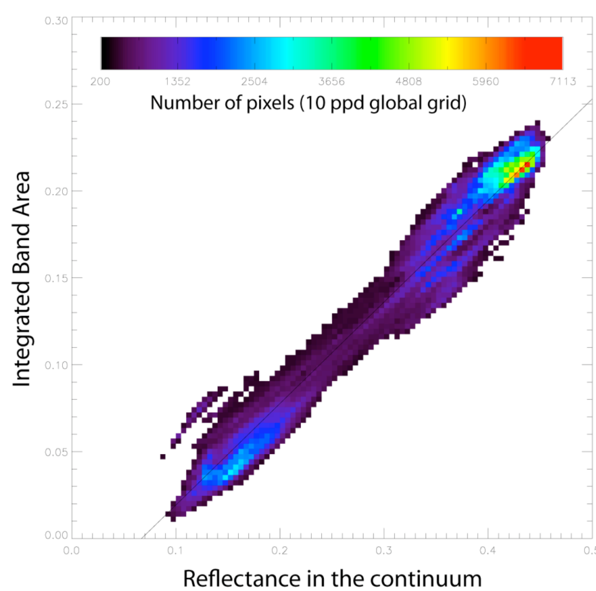

Figure 1: Relationship between Integrated Band Area (IBA) at 3 µm and continuum reflectance. Data extracted from all OMEGA observations for latitudes between -50 and +50° and nominal calibration signal for the two infrared channels.

The same method was also applied at smaller spatial resolution on smaller groups of pixels inside individual observations. Using the robustness of the linear correlation between IBA and albedo, we separate regions where albedo is responsible for most of the variability (dominant in equatorial regions at large scale) and regions where other parameters are required to explain the band strength variability (hydration gradient at higher latitudes). Using other spectral criteria, authors of previous studies attributed most of the band strength variability in equatorial regions to an artifact caused by albedo ([6,7]) while other authors proposed a plausible alternative physical hypothesis to explain this correlation ([1]). In some cases, a first-order correction of this supposed "albedo artifact" permits to retrieve fine spatial and temporal variations of material hydration state, even in the equatorial regions.

Figure 2 presents the relationship between IBA, albedo and thermal inertia (used as a proxy for surface texture and mean particle size).

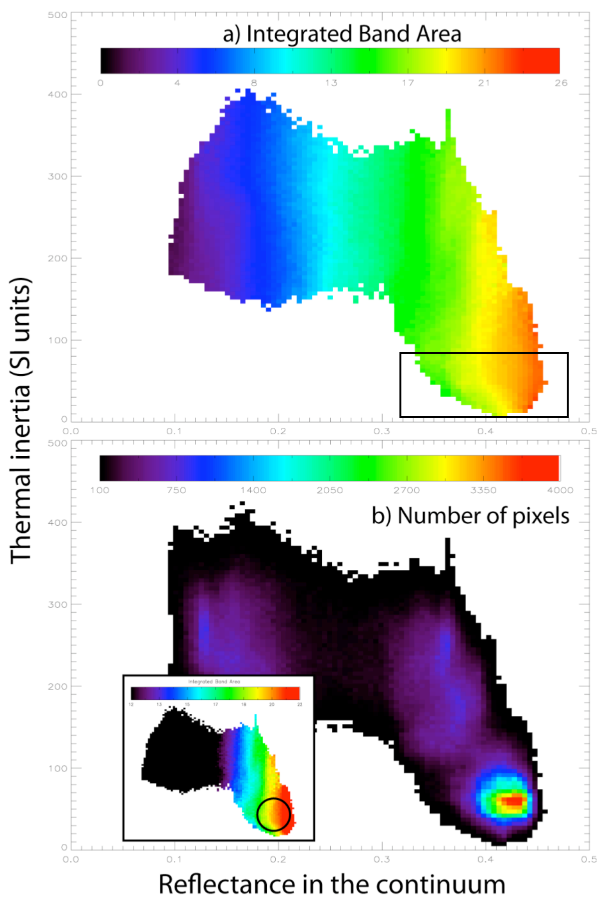

Figure 2: Relationship between 3 μm Integrated Band Area (from OMEGA), reflectance in the continuum (from OMEGA) and surface thermal inertia (from TES). Data extracted from OMEGA observations for latitudes between -50 and +50° and nominal calibration signal for the two infrared channels.

These diagrams clearly show that albedo variations totally control the variations of the IBA spectral criterion for high thermal inertia values (above 80 SI). A positive gradient of IBA with increasing albedo (horizontal) is observed regardless of thermal inertia variations (vertical). However, the effects of mean particle size variations on the 3 μm band strength become evident as thermal inertia decreases: IBA values decrease when thermal inertia decreases below 80 SI at constant continuum reflectance level. This result confirms on the Martian surface what was expected from laboratory work: the effect of particle size variations is only noticeable for the smallest particle size fractions. However, as show on figure 3 (plot b), the area of the diagram where effects of particle size variations are the most important correspond to the maximum of the pixel repartition in the albedo/thermal inertia space. Thus, variations of particle size are likely to influence the strength of the 3 μm water-of-absorption-band on a large fraction of the Martian surface.

Conclusion: The strong linear correlation between the IBA criterion and the continuum reflectance is a good tool to handle the problem of the correlation between hydration band strength and albedo. Statistics on hundreds or thousands of pixels at different spatial resolutions allow for the distinction between an "albedo artifact" linked to band strength derivation method and regolith hydration state variations. A first-order correction of this artifact reveals spatial and temporal variations of band strength between observations that are related to mineralogy, hydration state and surface texture.

Comparison between OMEGA and TES datasets (global grids at 10 ppd spatial resolution between latitudes -50 and +50°) confirm the relative decrease of the 3 μm band strength for the smallest values of thermal inertia. We find a good consistency between results from TES and OMEGA in terms of surface texture/regolith particle size even if the thickness of the surface probed by the two instruments is different. The possibility to work both with TES and OMEGA datasets is helpful to study the spatial variations of the 3 μm band strength as the effect of particle size variations cannot be neglected on a large part of the Martian surface corresponding to area covered by fine dust.

References: [1] Jouglet D. et al. (2007) JGR, 112. [2] Bibring J.-P. et al. (2006) *Science, 312*, 400-404. [3] Pommerol, A. and Schmitt, B. (2007a), submitted to JGR. [4] Pommerol, A. and Schmitt, B. (2007b), submitted to JGR. [5] Putzig, N. E. and Mellon, M. T. (2007) *Icarus*, 191, 68-94. [6] Milliken R.E. et al. (2007) JGR, 112. [7] Calvin W. M. (2007) LPS XXXVIII, 1390.