EVIDENCE OF AN ADDITIONAL NORTH POLAR COMPONENT IN THE MARTIAN 3 MICRONS WATER BAND OBSERVED BY OMEGA.

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Introduction: The OMEGA experiment onboard the ESA Mars Express orbiter [1] is an imaging spectrometer that had observed the Martian surface in the 0.38–5.1 µm spectral range from 2004 to 2010. The dataset contains thousands of hyperspectral cubes covering most of the Martian surface with a typical spatial sampling of 1 km. Repeated observations of the same region have been frequently obtained aver the mission, especially in the high latitudes where time sampling can be about 10° of L_s over most of the year [2]. This spectral range covers water-related spectral signatures of the surface the most prominent being located at 1.9 and 3 µm [3-6]. Previous studies of the water content derived from the 3 µm band have shown an overall increase of water hydration in the polar regions that may correspond to a water weight% increased by a factor greater than two, especially in the northern polar latitudes. Although several hypotheses exist to explain this increased hydration, such as adsorbed water [5] or surface/ice interaction [6], the exact nature of this water enhancement is not yet fully understood.

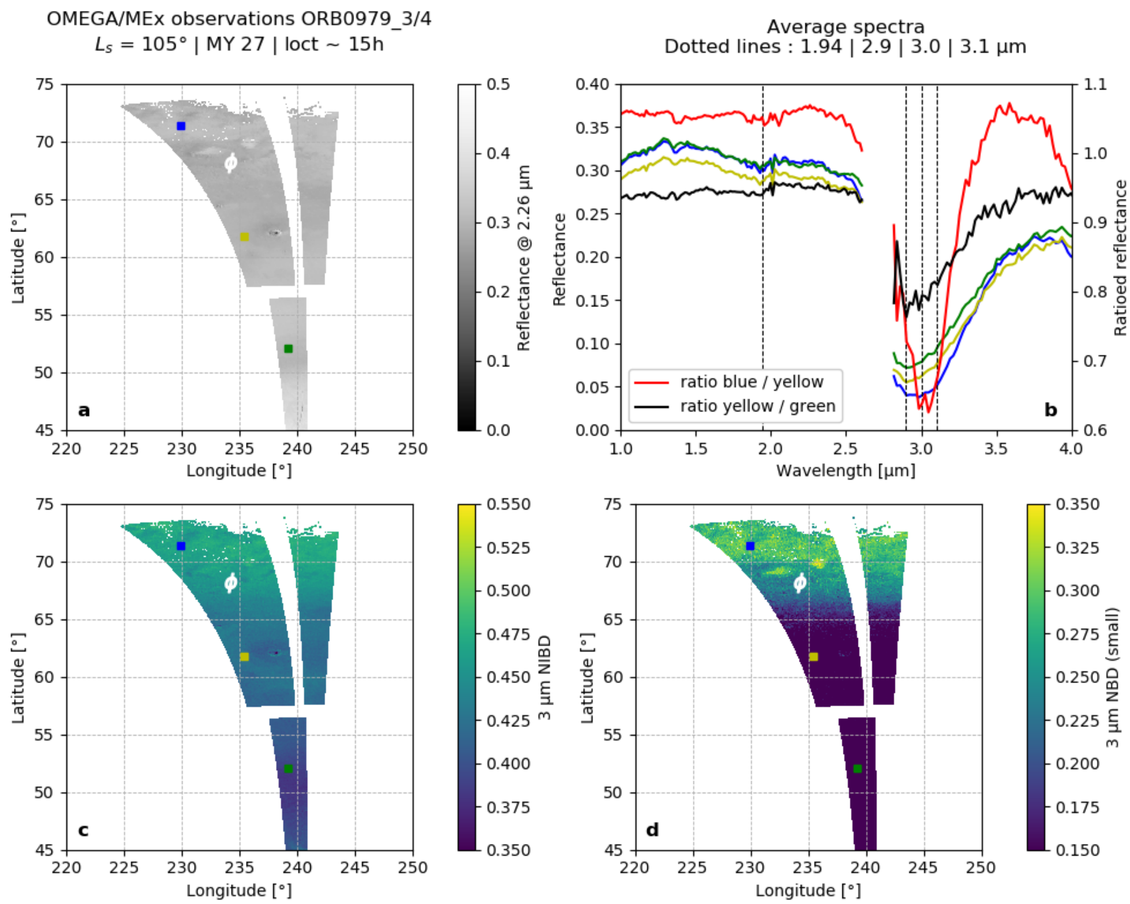

__Figure 1__ – Maps of OMEGA cubes #3 & #4 from orbit 979 showing the surface reflectance at 2.26 µm (a), the 3 µm NIBD (c) and the coverage of the additional 3 µm component (d). The white "Φ" indicates the position of the Phoenix lander. The blue, yellow and green spectra of the panel (b) are averaged on a square of 3×3 pixels whose position are indicated by the colored squares on panels (a),(c)&(d). We observe on panel (b) that the evolution between 60°N and 70°N (purple line) is very different than between 50°N and 60°N (black line) with a narrow signature centered around 3 µm, which results in a shift of the position of the maximum of absorption of the widespread Martian 3 µm band from 2.9 µm (yellow & green) to 3.0 µm (blue).

Methods: Here we have reprocessed OMEGA IR spectra acquired during Northern spring / summer (L_s = 90° to L_s = 150°) from Martian year (MY) 27 to 30 to look for 3 µm band shape variability. In addition to the overall increase of the 3 µm band in the polar latitudes [5,6,7], we observe the presence of two different shapes of this band, with the position of the maximum of absorption that can move from 2.9 to 3.0 µm. Spectra ratio shows that this shift toward redder wavelength is produced by the presence of an additional narrow absorption feature in the spectra between 2.9 and 3.1 µm, as shown in figure 1.b.

Thus, we compute a new specific criterium to trace this component: the absorption at 3.0 µm relatively to a continuum taken as linear between 2.9 and 3.2 µm, hereafter referred as the "*3 µm small NBD*" (Normalized Band Depth), as opposed to the usual 3 µm NIBD which cover the full band from 2.9 to 3.7 µm.

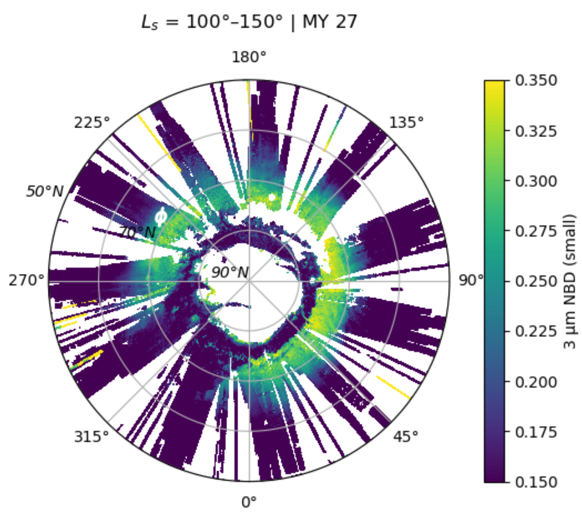

Figure 2 *– Map of the 3 µm small NBD, organized along an anular structure in the North polar regions. The white "Φ" indicates the position of the Phoenix lander.*

Results: As shown in figure 2, this additional 3 µm component is spread along an annular structure from ~70°N to ~78°N in the bright northern soil. We can see in figure 1.d that the 3 µm small NBD goes from < 0.15 to ~0.3 in just a few degrees of latitude, without any obvious associated modification of other surface properties such as overall reflectance ("albedo") or geomorphology (cf figure 1.a). This effect differs from the usual 3 µm band increase, as when the latter shows an overall continuous increase [7], here we have a sharp distinction between two different states: with and without this new signature.

This signature has been observed to be stable in our dataset across the years (from MY 27 to MY 30), and at various local time (from ~10h to ~18h). Thus, this signature appears at the same position whatever the temperature of the surface is. It has been only observed in the Northern regions, and never in the South hemisphere. This specific signature appears without any change in terms of surface reflectance. This narrow 3 µm additional feature seems to be correlated with a spectral absorption at larger wavelengths, starting at 3.5 – 3.8 µm (cf figure 1.b, red spectrum). No clear association with additional IR signatures has been firmly identified so far, although investigations of the spectral behavior in the 1.8 – 2 µm and ~ 1.4 µm ranges are ongoing.

According to these observational constraints, we currently favor the hypothesis of a specific stable surface component, or surface property as opposed to an atmospheric effect or a transient surface phenomenon such as frost.

Identification of this signature is still ongoing, using comparison with laboratory measurements of adsorbed water [4,8], mixtures with potential contaminants expected at North polar latitudes (e.g., sulfates observed by OMEGA [9] or carbonates, perchlorates and other aqueous trace minerals observed by Phoenix [10, 11, 12]). We are also investigating the possible spectral impact of perennial subpixel water contamination, through e.g. permafrost exposures.

Conclusion: We present here evidence for the identification of a new spectral component within the 3 µm Martian band specific to North polar latitudes. If further work is still required to fully understand this signature, it may be of importance in the search for the origin of the strong increase of surface aqueous alteration in the Martian polar regions [13].

Acknowledgments: The OMEGA/MEx data are freely available on the ESA PSA at https://archives.esac.esa.int/psa/#!Table%20View/OMPEGA=instrument .

References: [1] Bibring et al. (2004) *ESA Publication Division, 1240,* 37–49. [2] Langevin et al. (2007) *JGR*, *112*, E08S12. [3] Milliken and Mustards (2005) *JGR*, *110*, E12001. [4] Pommerol et al. (2009) *Icarus*, *204*, 114-136. [5] Jouglet et al. (2007) *JGR*, *112*, E08S06. [6] Audouard et al. (2014) *JGR Planets*, *119*, 1969-1989. [7] Stcherbinine et al. (2020), *EPSC 2020*, Abstract EPSC2020-738. [8] Pommerol and Schmitt (2008) *JGR*, *113*, E10009. [9] Lanvegin et al. (2005) *Science*, *307*, 1584-1586. [10] Boynton et al. (2009) *Science*, *325*, 61-64. [11] Hecht et al. (2009) *Science*, *325*, 64-67. [12] Smith et al. (2009) *Science*, *325*, 58-61. [13] Stcherbinine et al. (2020) *51st LPSC*, Abstract #1969.