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Martian surface aqueous alteration from the study o evolution of the 1.9 and 3 microns band with OMEGA

Aurélien Stcherbinine et al.

Introduction: The OMEGA experiment onboard the ESA Mars Express orbiter [1] had observed the $1.9\text{--}3\ \mu\text{m}$ spectral range from 2004 to 2010. Additional observations with a limited spectral coverage are still thousands of hyperspectral cubes covering most of the Martian surface with a typical spatial sampling of the same region have been frequently obtained over the mission, in particular in the high latitudes within 10° of L_s over most of the year [2]. This spectral range covers water-related spectral signatures of H_2O being located at 1.9 and $3\ \mu\text{m}$ [3–6]. Previous studies of the water content derived from the $3\ \mu\text{m}$ band of water hydration in the polar regions, with a modeled weight% increased by a factor greater than two which presents the highest hydration state levels [5, 6].

The origin of this latitudinal trend is not yet fully understood, although two main hypotheses have been discussed: adsorption of water molecules at the surface (e.g. [5]) and chemical alteration from water minerals or amorphous materials at the surface [6, 7]. We e.g. know that northern polar regions harbor localized deposits of sulfates [8] or at low level in soils [9], as revealed in particular by the in-situ perchlorates and carbonates from Phoenix [10, 11] not yet identified with orbital observations [12].

In addition, the presence of a significant amount of sub-pixel water ice patches in the polar region increase of the $3\ \mu\text{m}$ feature when observed at OMEGA resolution. Indeed, recent studies have shown that expose the perennial near-surface water ice contained in the permafrost at latitudes about 55°N [13] to a few centimeters at high latitudes while exposed ice stability increases [14], so such subpixels could participate to the apparent increase of the $3\ \mu\text{m}$ band depth with latitude.

Results: We have conducted a study of the joint variations of the 1.9 and $3\ \mu\text{m}$ bands in the northern polar latitudinal variations of near-IR “albedo” (reflectance factor at $2.5\ \mu\text{m}$), 1.9 and $3\ \mu\text{m}$ band depths in northern summer. To minimize the impact of the well-established dependence of the $3\ \mu\text{m}$ feature on albedo on a limited albedo range ≥ 0.3 . In agreement with previous studies [3,5,6], we observe that the

increases from 45% to 55% between 50°N and 70°N. We also observe a similar trend for the 1.9 μm band, which increases from 0.015 to 0.025. Thus, there seems to be a correlation between the latitude dependence of these two bands at 3 μm and 1.9 μm , notably expected in the case of adsorbed water [4]. It may also result from an increase in the amount of hydrated sulfates that contains a 1.9 μm band, that may be also widespread at polar latitudes [9]. In the following, we present one of these two possible explanations.

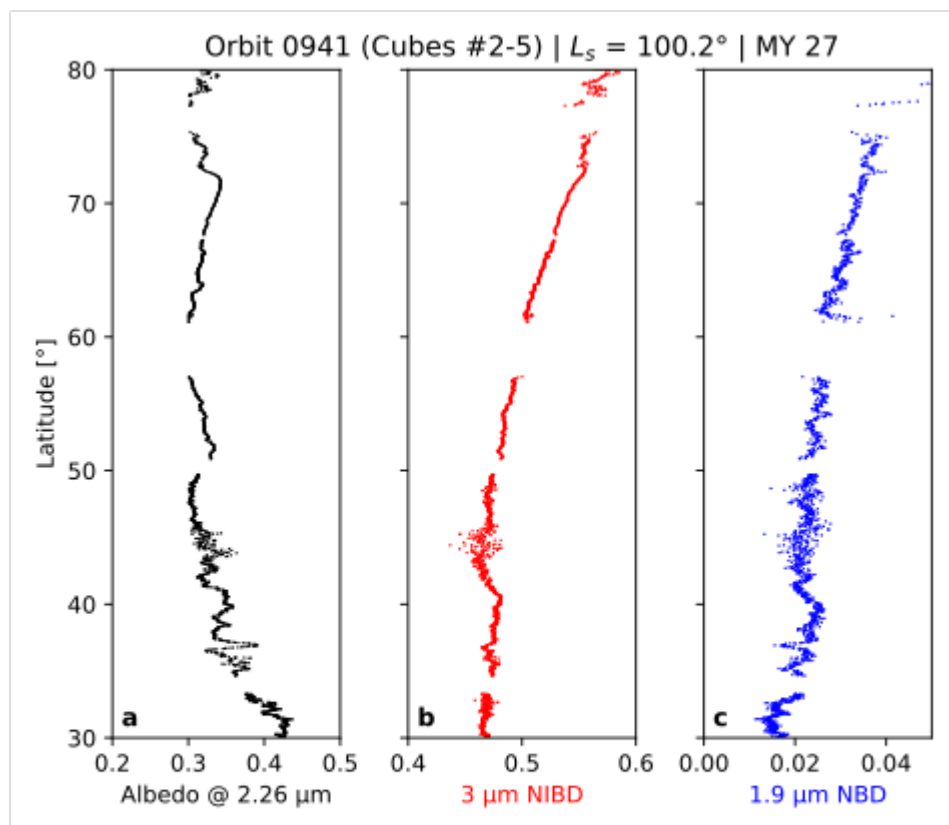


Figure 1. Latitudinal evolution of the reflectance at $\lambda = 2.26 \mu\text{m}$ (a), the 3 μm integrated band depth (b) and the 1.9 μm band depth (c), from OMEGA observations (#2-4) of orbit 941 ($L_s = 100.2^\circ$, longitude $\sim 5^\circ\text{E} - 15^\circ\text{E}$).

To minimize albedo dependency effects, only pixels with albedo ≥ 0.3 are considered here.

On the other hand, we can also observe some regional differences of the co-evolution of these two bands and that presents similar albedo values like in the northern latitudes of Acidalia Planitia. Indeed, we can see there is a darker region between 290°E and 350°E (a). This region is associated with high and stable values of the 1.9 μm band; on the other hand, the 3 μm band changes significantly with longitude over the region (c), from 46% at 30°N and red spectra on figure 2(b) show averaged spectra from two spots in this darker region, and the black (low 3 μm) and the blue (high 3 μm) spectra. We observe with this ratio that there is actually a correlation between these two bands, whereas variations are notable for the 3 μm band.

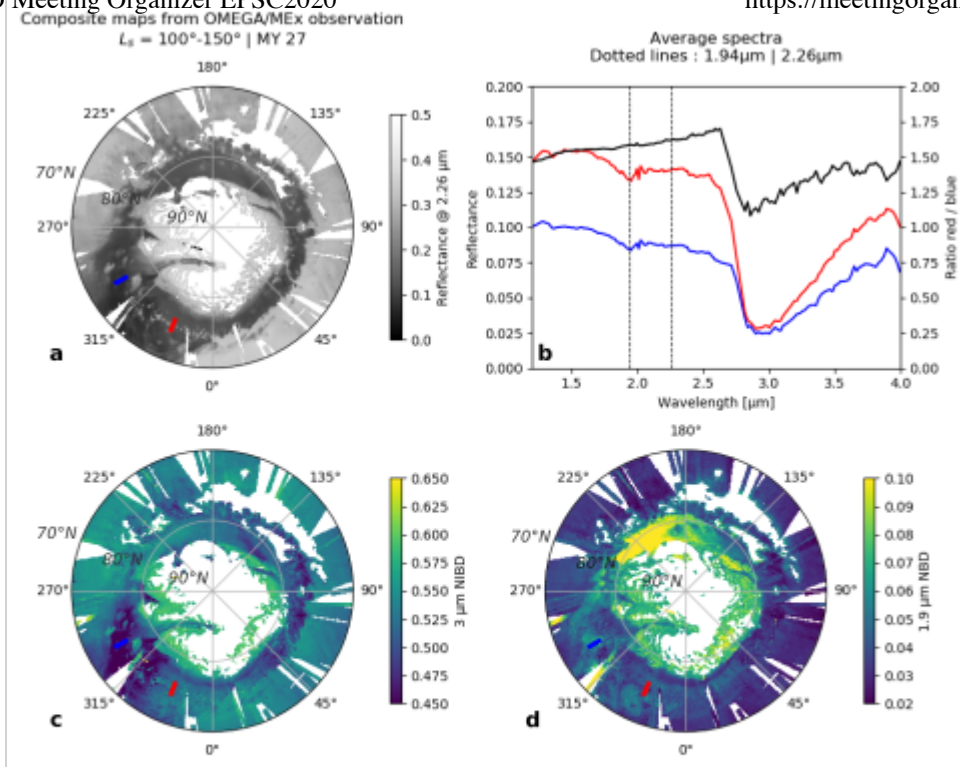


Figure 2. Composite maps from OMEGA observations during the north hemisphere summer of Martian Year 27 : reflectance at 2.26 μm (a), 3 μm integrated band depth (c) and 1.9 μm band depth (d). Panel (b) shows the averaged spectra respectively from the blue and red regions, and the black spectrum represents the ratio between the red and blue spectra. Red spectrum is an average of spectra from 74°N – 76°N and 299°E – 301°E. Blue spectrum is an average of spectra from 74°N – 76°N and 337°E – 339°E.

Conclusion: These first investigations have highlighted the multiplicity of evolution behavior of the 1.9 scales. Further work will be dedicated to deeper investigations of the co-evolution of the two band possible link with other spectral signatures. Our objective is to extend the amount of observational increase of the surface hydration observed in the 3 μm spectral range, to bring new constraints about considered hypotheses: adsorbed water versus chemical alteration.

Acknowledgments: The OMEGA/MEx data are freely available on the ESA PSA at <https://archives.esa.int/OMEQA=instrument>.

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