

ABUNDANCE OF HYDRATED SILICATES AT MARS DERIVED FROM ORBIT – IMPLICATIONS FOR THE WATER CONTENT STORED AT THE SURFACE. L. Riu¹, J. Carter², F. Poulet², ¹European Space Astronomy Center (ESAC/ESA), Spain, ²Institut d'Astrophysique Spatiale (IAS), France. Contact: lucie.riu@esa.int

Introduction: In the past decades, thanks to the numerous missions dedicated to the study of the red planet, both from remote sensing and *in situ* investigations a large number of locations at the surface of Mars have been identified to harbor hydrated minerals (*e.g.*, [1], [2], [3] amongst others). The detections of hydrated minerals that were likely formed in the presence of stable liquid water offer unique insights on the past water activity at Mars. Based on these previous detections, summarized and gathered in the MOCCAS catalog [4], we applied a radiative transfer model based on Shkuratov theory [5] to reproduce the near-infrared spectra of these specific locations. The NIR spectra used are from the OMEGA (Observatoire pour la Minéralogie, l'Eau, les Glaces et l'Activité) instrument. This additional modelling step enable to obtain the modal composition (*e.g.*, the weight percent, wt%) of each identified specie. The methodology has previously been explained in [6] (preliminary results) and detailed in [7].

Modal composition: Millions of OMEGA NIR-spectra have been modelled to extract the modal composition of the hydrated locations, excluding sulfate-rich units. The model is such that the each end-member have to be selected beforehand in order to obtain the corresponding abundance. Based on the prior detections [4] and the availability of optical constants, the lithology is summarized with 11 compositional maps: Fe,Mg,Al-phyllsilicates, Al-smectite, AlSiOH, Opal, Mg-carbonates, Chlorite, Fe/Mg-Micas, Serpentine and Fe-hydroxide. A set of non-hydrated minerals is also included in the mixture (see [7] and [8] for more details). Fe,Mg,Al-phyllsilicates, Al-smectite, AlSiOH, Opal, Mg-carbonates, Chlorite, Fe/Mg-Micas, Serpentine and Fe-hydroxide. The hydrated mineralogy is dominated by the end-member of Fe-hydroxide, Fe- and Al-phyllsilicates and Fe/Mg micas which have on average an abundance > 6vol% and are spread globally on the identified regions. Locally, spots with high abundance (>20vol%) of Al-smectite and Chlorite are also identified. The abundance of hydrated minerals is highest in Marwth Vallis, Nili Fossae and Meridiani Planum. However, the primary minerals almost always account for more than 50% of the composition. A detailed analysis at the global scale of each map and of the correlation within end-members is available in [7]. The modelling also offers an opportunity to do local analysis of prospective landing sites and prepare for the upcoming landed missions. In the landing site for the Exo-Mars2022 and Mars2020 rovers, the obtained

composition is well in agreement with the expected detected mineralogy [7] which demonstrates the robustness of the model and also it offers a representation of the compositional variability. These compositional maps provide the opportunity to derive the chemical water content (as stored in the hydrated silicates) and thus bring new clues on to refine and discover new alteration scenarios at Mars and provide information about the ISRU potential [3].

Water content: The purpose of extracting water content is many fold: i) to focus on the potential for *in situ* resources utilization (ISRU), ii) to confront the results to independent quantifications of surficial water in Mars soil (*e.g.*, [9]) which origin remains poorly constrained, and iii) to better ascertain the current and past reservoir of water and the fate of volatiles on early Mars. We focus here on the two first bullet points.

To derive the water content, we use each of the hydrated mineral individual map and extract the H₂O content of each end-member based on its assumed chemical composition. We show in Table 1 the H₂O content used for each end-member.

| Phase | End-member | % of H ₂ O |
|------------------|--------------|-----------------------|
| Fe-phyllsilicate | Nontronite | 18.16 |
| Mg-phyllsilicate | Saponite | 18.76 |
| Al-phyllsilicate | Kaolinite | 13.96 |
| Fe/Mg-Micas | Celadonite | 4.2 |
| Al-smectite | Beidellite | 9.26 |
| Mg-Carbonates | Magnesite | 0 |
| Serpentine | Lizardite | 13.0 |
| Opal | Opal | 31.02 |
| AlSiOH | AlSiOH | 20.01 |
| Chlorite | Chlorite | 12.11 |
| Fe-hydroxide | Ferrihydrite | 5.34 |

Table 1 – Summary of the phases and corresponding end-member with their individual H₂O content.

The resulting H₂O is thus constrained by the end-member used prior in the modelling. We then sum all the individual H₂O content and scale each contribution to the abundance of the end-member considered. The resulting water content map is a global map of 64 px/degree which corresponds to a sub-kilometric resolution. The average water content stored within the hydrated

silicates as estimated through the modelling is: 6.75 wt% (as indicated with a dotted line on Figure 1). The values span between 0 and ~20 wt%.

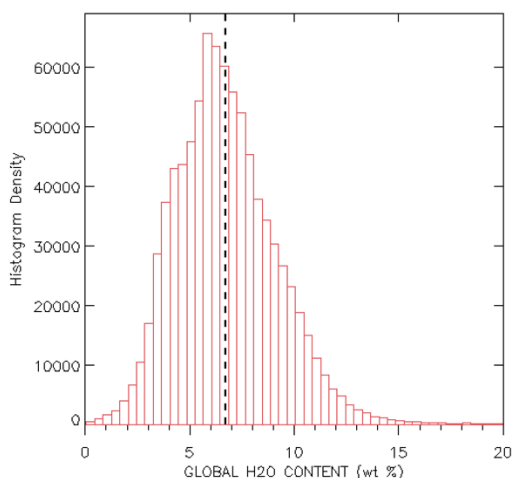


Figure 1 – Histogram of the global H₂O content in wt%. The dotted line represents the average value overall the hydrated locations modelled.

Spatially, the water content is slightly correlated with the total hydrated abundance (sum of all hydrated end-member's abundance) with a Pearson Coefficient [9] of ~0.4. Because all individual end-members are not enriched in water to the same extent, the correlation is not stronger. Although some locations (Marth Vallis, Meridiani Planum and Nili Fossae) seem enriched in water, there is no clear correlation of the H₂O content with the longitude (Figure 2a) or the latitude (Figure 2b).

Following local studies will be carried out in order to identified potential new interesting sites based on their water content as evaluated here. We will also perform a thorough comparison of the present H₂O content map with other published H₂O content maps based on the OMEGA dataset ([9], [10]). In previous studies, the methodology to derive H₂O content is very different and we wish to highlight differences and refine uncertainties. We envision that these subsequent analyses will, based on the global mineralogical maps [7] and water content map (this study), help address further geochemical implications regarding alteration processes at Mars.

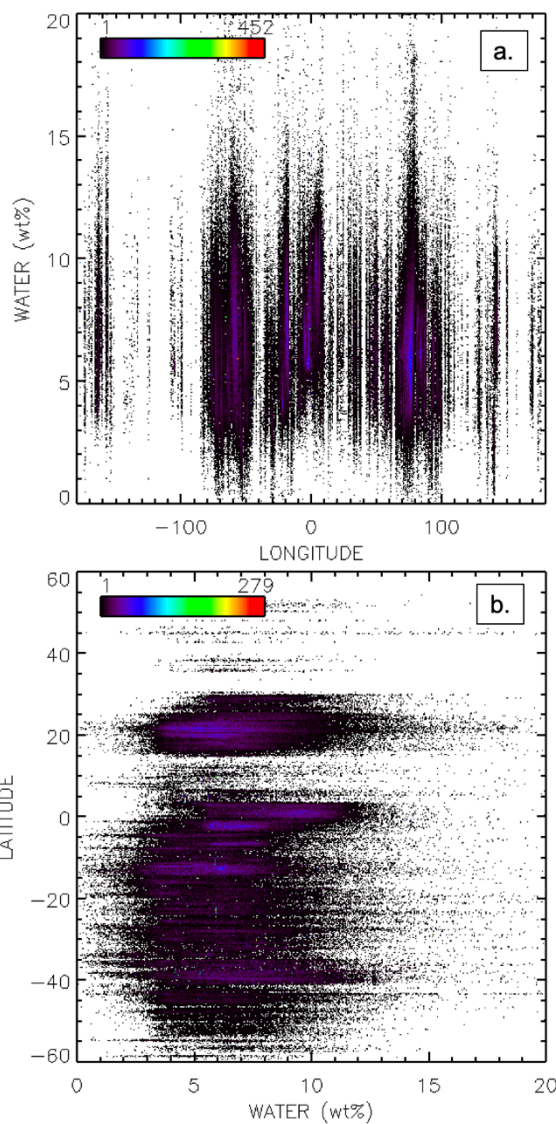


Figure 2 – Density plot of the water content (in wt%) with respect to (a) the longitude (x-axis); (b) the latitude (y-axis).

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References: [1] Bibring et al., 2006, Science, Volume 312. [2] Carter et al., 2013, JGR: Planets, Volume 118. [3] Murchie et al., 2008, JGR: Planets, Volume 114. [4] Carter et al., 2022, Submitted to Icarus. [5] Shkuratov et al., 1999, Icarus, Volume 137. [6] Riu et al., 2019, LPSC 50th, Abstract 1177 [7] Riu et al., 2022, Icarus. [8] Riu et al., 2019, Icarus, Volume 319. [9] Har-del and Simar, 2007, Applied multivariate statistical analysis, 2nd edn Springer, Heidelberg. [9] Audouard et al., 2014, JGR: Planets, Volume 114. [10] Milliken et al., 2007, JGR: Planets, Volume 112.