PHYLLOSILICATES AND OTHER HYDRATED MINERALS ON MARS: 1. GLOBAL DISTRIBUTION AS SEEN BY MEx/OMEGA.

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Introduction: Hyperspectral mapping of the Martian surface in the NIR region has led to a better understanding of the planet's aqueous past through a study of its mineralogical composition. In 2005, hydrated minerals - phyllosilicates and sulfates - where first detected in several extended regions by the MeX/OMEGA instrument [1,2,3]. Since then, a large number of new and small exposures, particularly in the Noachian southern highlands have been identified with OMEGA as well as with CRISM [4,5,6]. Studying the spatial distribution, the composition and the geological context of these smaller deposits can prove valuable to better constrain the various environments that may have triggered the formation of many types of hydrated minerals. This abstract focuses on their spatial distribution, while a companion abstract presents their detailed mineralogy [7].

Datasets: This study uses the MeX/OMEGA experiment orbiting Mars since December 2003, as well the MRO/CRISM experiment which arrived later in September 2006. Both are hyper-spectral instruments whose purpose is the observation of the Martian surface and atmosphere in the visible and NIR region (1-5um). OMEGA samples the surface between 4.8 and ~ 0.35 km/pix while CRISM can achieve a higher spatial and spectral resolution (down to ~ 15m/pix) at the expense of a limited coverage of the planet. In this study we focus on the surface reflectance in the [1.0-2.5] µm region where hydrated minerals have bands induced by combinations and overtones of molecular vibrations, thus allowing some spectral discrimination.

Data analysis: The OMEGA dataset was systematically studied from orbits 0022 to 3795, (plus a few late additions). These data cover more than 80% of the planet's surface with a resolution better than 1.8 km/pix for latitudes under 60°. Potentially relevant sites on Mars were identified based on the depth of the 1.9 µm absorption band. This spectral feature is due to the combination overtone of bending of the H-O-H and stretching of the O-H bonds in water molecules. It is common to many phyllosilicates, sulfates and other hydrated minerals [8,9,10,11]. As a result, roughly 3500 sites were identified from the ≈300 OMEGA observations. To rapidly identify key spectral variations ~40 OMEGA spectral parameter maps is generated. Each map corresponds to a specific NIR wavelength region where absorptions by hydrated minerals, mafic minerals (olivine and pyroxene) or ice take place. They are computed using either ratios between wavelength bins or Gaussian / polynomial fits to the absorption bands. Voigt-function apodization is sometimes used on low S/N spectra prior to implementing the maps.

All band maps are thresholded in order to minimize false detection using the following criteria: ice bands at >0% absorption depth, olivine and pyroxene bands at >1% and most hydrated mineral bands at >2%. A few hydrated mineral band maps are thresholded at >1% (where we expect weak bands, in the 1.4, 1.8 and 2.2 µm regions). Observations at high latitudes (typically <60°S or >60°N) are discarded here, because they have been analyzed in a previous work [12].

We augment the OMEGA analyses with CRISM observations when the OMEGA detections are of low confidence due to confounding factors such as instrumental noise, atmospheric noise or low spatial resolution.

The spectra are compared to earth analog samples from various spectral libraries [13] in order to qualitatively assess the composition of the material. We compare our spectra to several mineral classes: phyllosilicate, sulphate, zeolite, sorosilicate, hydroxide.

Sites of interest are then registered with high resolution imagery data and the geomorphological context is studied [7].

Results: Most of the detections correspond to extended hydrated bearing deposits located in Nili Fossae, Mawrth Vallis, Meridiani Planum, Aram Chaos and Valles Marineris. These regions have been extensively studied in previous works and are thus excluded from this study. This results in 73 sites of which ~5 are classified as tentative because of the weak signatures found in these sites.

A detailed discussion of the spectral signatures is presented in [7], but we can here summarize that Mg-rich phyllosilicates with saponite and vermiculite as best candidates are the most frequent. Al-rich phyllosilicates with illite and montmorillonite, chlorite (and/or clinochlore), the sorosilicate pumpellyite are also found. Serpentines (lizardite, serpentine) could explain the spectral signatures of a few sites. Only 2 of the 73 sites have sulfate detections: one in Schiaparelli Crater and another one in Terra Sirenum where they may be associated with phyllosilicates [14]. At least two sites have signatures that do not match phyllosilicate nor sulfate spectral features. One is located in Aureum Chaos and is best matched by hydroxides, the other one is located in NW Terra Tyrrhena and has signatures best fitted by zeolites.

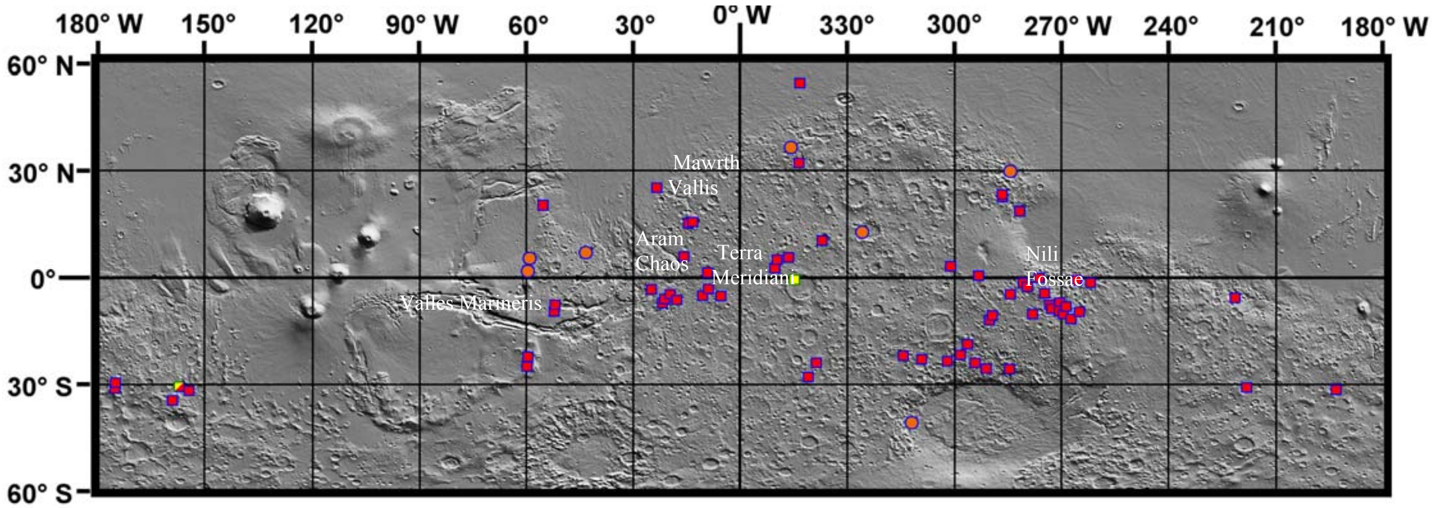

Figure 1. Map of the hydrated mineral-bearing deposits as seen by OMEGA (over MOLA altimetry). A large number of the deposits (in red and orange) are phyllosilicates. Sulphate-bearing deposits are plotted in yellow. The well-studied and extended regions (Terra Meridiani, Nili Fossae, Mawrth Vallis, Aram Chaos, Valles Marineris) are not shown here.

Statistics derived from this sample are probably biased since they have been detected thanks to the 1.9 um absorption feature, thus leaving out perhaps numerous detections of hydrated minerals with weak to no signature at this wavelength (such as biotite or chlorite).

The spatial distribution is not uniform. With the exception of a tentative detection in Lyot crater which is located in the northern plains, all sites are located in the southern cratered highlands at latitudes smaller than 45°. Most of them are found north of the Hellas Basin, in Terra Tyrrhena, Terra Sirenum and Margaritifer Terra. There is an apparent depletion in Arabia Terra, which could be explained by the presence of a thick dust mantle [15]. Of special interest is the very rare detection in Terra Cimmeria and Noachis Terra areas. The absence of hydrated deposits between 40-60°S may not however, be intrinsic to the surface composition but be due to the presence of a well documented latitude-dependant ice mantle that obscures the surface composition [16,17].

All sites have small spatial extension (a few OMEGA pixels, less or of the order of 10 km), except the hydrated dark deposits in lowlands north of Nili Fossae. About half of the 73 sites are directly correlated with a crater rim, floor, central mound or ejecta. In addition, a few deposits (orange circles in Figure 1) are well correlated with dark material as first reported by [2]. An example of this type of deposit is shown on Figure 2.

References: [1] Gendrin et al. (2005) *Science, 307, 1587-1591*. [2] Poulet et al. (2005) *Nature, 438, 623-627*. [3] Bibring et al. (2006*) Science, 312, 400-404*. [4] Poulet et al. (2007*) 7th Mars Conference, Pasadena*. [5] Langevin et al. (2008) *COSPAR* [6] Mustard et al. (2008) *Nature, 454, 305-309.* [7] Carter et al. (2009) *This conference*. [8] Milliken et al. (2008) *Geology, 36(11), 847-850.* [9] Clark et al. (1990) *JGR, 95*, 12653-12680 [10] Bishop et al. (2008) *Clay Minerals, 43.1, 35-54*. [11] Cloutis et al. (2006) *Icarus, 184.1, 121-157*. [12] Poulet et al. (2008) *GRL, 35.20, L20201*. [13] USGC spectroscopy lab; MRO/CRISM spectral library; Winnipeg University Planetary spectroscopy facility; Brown University RELAB; JPL ASTER library. [14] Swayze et al. (2008) *AGU abstract #P44A-04*. [15] Scott and Tanaka (1986) *U.S. Geological Survey, I-1802-A.* [16] Mustard et al. (2001) *Nature, 412, 411-414.* [17] Head et al. (2003) *Nature, 426, 797-802.*

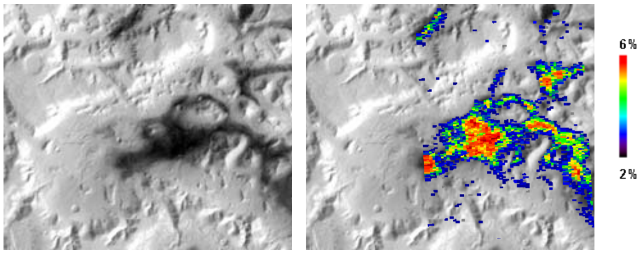

Figure 2. (left) HRSC context image showing a dark structure centered at 73°E, 29.3°N. **(right)** OMEGA map of the 1.9 µm band depth.