PHYLLOSILICATES AND OTHER HYDRATED MINERALS ON MARS: 2. DETAILLED ANALYSIS.

J. Carter[1], F. Poulet[1], J.-P. Bibring[1], S. Murchie[2], Y. Langevin[1], J.F. Mustard[3], B. Gondet[1], F. Seelos[2]
[1]IAS, CNRS/Université Paris-Sud, 91405 Orsay, France, john.carter@ias.u-psud.fr, [2]Applied Physics Laboratory, Laurel, MD, [3]Dept. of Geological Sciences, Brown University, Providence, RI 02912.

Introduction: Hydrated minerals preserve a record of past aqueous conditions on Mars. Recently, phyllosilicates, hydrated sulphates, hydrated silica have been detected in surface rocks by near-infrared spectrometers on orbiting spacecraft [1-4]. At the kilometer-scale resolution of the OMEGA instrument, phyllosilicate exposures are widespread and number in the dozens [5,6], while early discoveries from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) on board MRO include several new phyllosilicates and a large number of new exposures, particularly in the Noachian southern highlands. In a companion abstract [6] we discussed the global distribution of new hydrated deposits on Mars as seen by the MEx/OMEGA instrument. In this paper we mainly focus on the spectral diversity of phyllosilicates encountered and on their geological setting.

Mineralogy: Unambiguous identification of the exact mineral(s) present at each site is in most cases quite challenging. Hence, rather than sorting the detections according to minerals, they are divided into spectral groups. Each group represents a type of OMEGA spectrum for which a few minerals could be acceptable matches.

The groups are the following: i) *Saponite - Vermiculite* (both Mg-rich phyllosilicates), ii) *Illite - Montmorillonite* (both Al-rich phyllosilicates), iii) *Pumpellyite - chlorite - clinochlore* (a sorosilicate and two phyllosilicates), and iv) *Lizardite - Serpentine* (both Mg-rich phyllosilicates).

Vermiculite–saponite (Fig. 1). This group of two minerals is widely seen throughout the southern highlands. It accounts for over 50% of the identifications. Vermiculite can be a nearly perfect match to OMEGA spectra, but usually seems to be spatially mixed with other phyllosilicates which have stronger 1.4 um bands, as well as with ferric iron oxides such as ferrihydrite. This group is found in cratered terrains located north of the Hellas basin, north of Terra Tyrrhena, South of Syrtis Major Planum, in Margaritifer Terra, Thaumasia Planum and in the north of Terra Sirenum. Saponite, although a poorer match to the OMEGA spectra, could be considered as a possible candidate.

Illite–Montmorillonite (Fig. 2). While montmorillonite is frequently found in the Mawrth Vallis and in Nili Fossae regions, it has seldom been identified in this study. 3 of the 4 tentative detections are scattered over the southern highlands and associated with craters. The fourth is within Lyot crater, located in the northern plains.

Pumpellyite-chlorite–clinochlore (Fig. 3). This spectral group is identified in 7 sites, and is co-detected on one CRISM overlapping observation (Fig. 2). At the exception of one site located west of Meridiani Planum, all detections are in the Terra Tyrrhena area and are associated with craters.

Lizardite-serpentine (Fig. 4). These detections are highly tentative; they each may have been detected on few observations, mixed with other phyllosilicates. There is usually a slight shift in the 2.30 µm band when trying to match lizardite/serpentine spectra, albeit an overall consistent shape.

Other minerals have been tentatively identified on rare occasions: prehnite, kaolinite, nontronite, hydrated hydroxides, and zeolites. Goethite may be found mixed with ferrihydrite in Aureum Chaos. The spectral unit has a signature very similar to one of the hydrated units found in the nearby Aram Chaos [7]. Kaolinite proved a good match for spectra in a crater in Terra Sirenum both with CRISM and OMEGA spectra [8,9]. Prehnite has a series of bands in the 2.35 µm region only, which makes its identification uncertain. They are two highly tentative detections in which it could be mixed with other phyllosilicates. Both sites have minerals of the *pumpellyite* group (ii) close-by. One site NW of Terra Tyrrhena shows spectra relatively close to that of certain zeolites, however their lack of sharp bands and their spectral proximity to other hydrated minerals make this detection extremely uncertain.

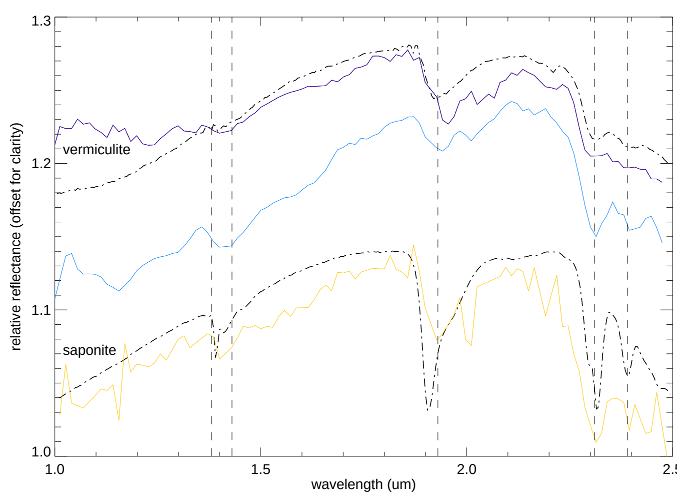

Figure 1. OMEGA ratioed spectra (color lines) compared to laboratory spectra (dashed lines) of saponite-vermiculite group.

Context: Most of identifications are very well correlated to a geomorphological unit that can be discriminated from the surrounding terrain by its morphology and albedo. Phyllosilicates are also very often associated with high night-time temperature units, evocative of a bulky material.

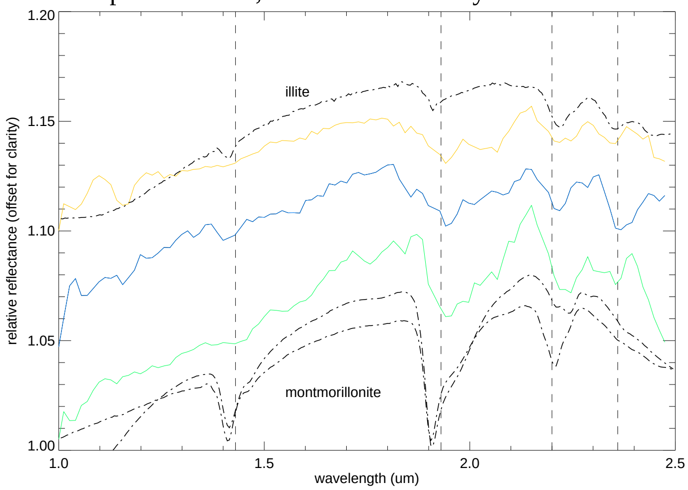

Figure 2. OMEGA ratioed spectra compared to laboratory spectra (dashed lines) of illite and two montmorillonites.

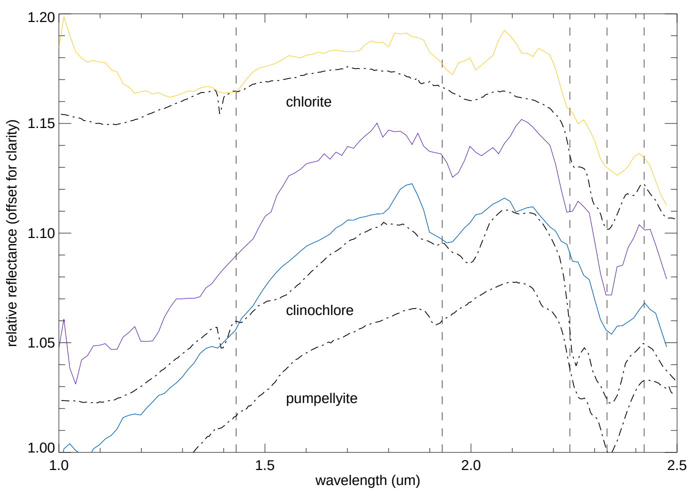

Figure 3. OMEGA ratioed spectra (color lines) compared to laboratory spectra (dashed lines): of pumpellyite, chlorite and clinochlore.

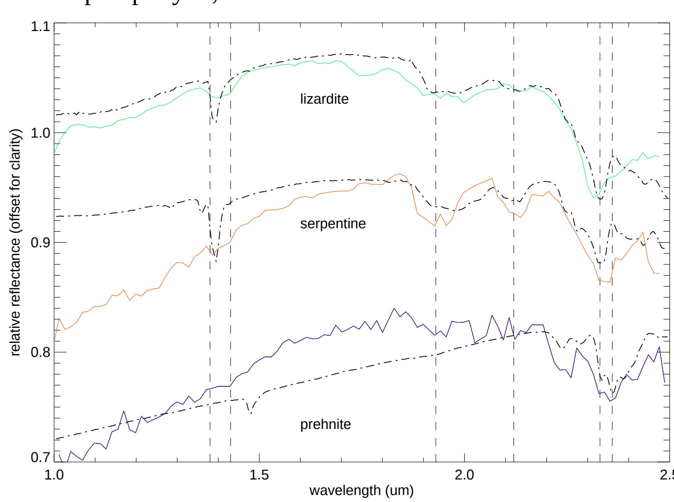

Figure 4. OMEGA ratioed spectra (color lines) compared to laboratory spectra (dashed lines) of prehnite, lizardite and serpentine.

Observations of the vermiculite-saponite spectral group tend to be associated with eroded structures: outcrops in cratered terrains (Fig. 5); crater rims of ancient, lava-filled craters; eroded terrains within ancient crater floors.

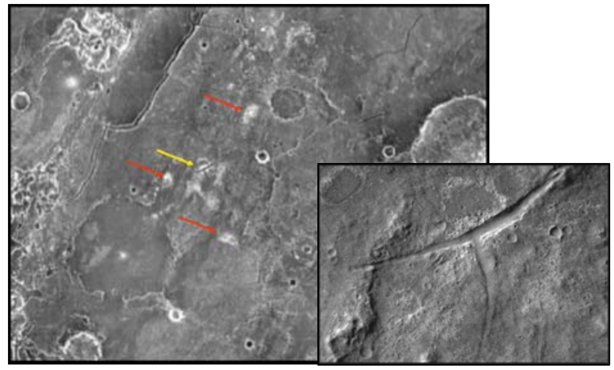

Figure 5. Context of some vermiculite/saponite-bearing deposits. Left: THEMIS night-time IR flux (the red arrows indicate the hydrated units). Right: HRSC visible close-up image of one of the outcrops (bright unit indicated by the yellow arrow).

The pumpellyite-clinochlore-chlorite spectral group is always associated with craters as exemplified by Figure 6. Although spatial resolution does not always allow accurate registration, it seems that in most cases the hydrated area is correlated with the central mound, and perhaps with crater floor and ejecta [9] in some cases.

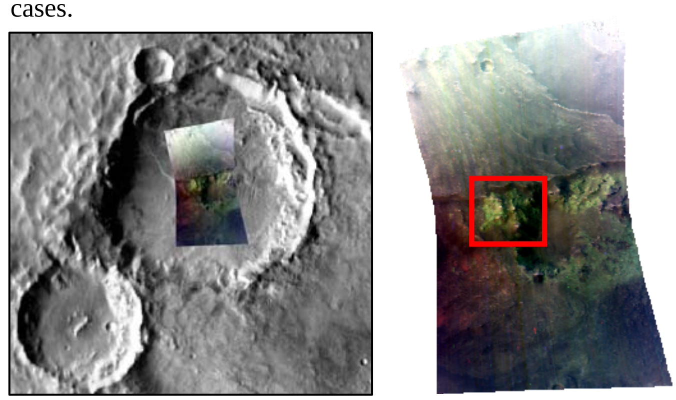

Figure 6. Context of a deposit exhibiting the signatures of the Pumpellyite-clinochlore-chlorite spectral group. Left: CRISM scene of a central crater mound over THEMIS day-time IR flux. Right: close-up of the CRISM observation. The red square indicates the peak of the crater where the hydrated minerals are found.

References: [1] Poulet et al. (2005) *Nature, 438, 623-627*. [2] Gendrin et al. (2005) *Science, 307, 1587-1591*. [3] Milliken et al. (2008) *Geology, 36(11), 847-850*. [4] Mustard et al. (2008) *Nature, 454, 305-309*. [5] Poulet et al. (2007) *JGR, 112(E8)*. [6] Carter et al. (2009) *This conference*. [7] Massé et al. (2008) *JGR, 113(E12)*. [8] Gondet et al. (2006) *EGU*. [9] Swayze et al. (2008) *AGU abstract #P44A-04*.