MINERALOGY OF THE HIGH LATITUDES OF MARS INCLUDING THE PHOENIX LANDING SITE.

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Introduction: The record of variations in the climate of Mars is imprinted in the spatial distribution of a variety of structures and features of the high latitude surfaces. Here, we report the surface distribution of some minerals in the high latitude (>50° North and South) regions of Mars (including the Phoenix landing site) from the OMEGA/MEx observations in the visible and near-infrared wavelength domains (0.4-4 µm).

Observations: The analyzed data were acquired during the northern and southern springs and summers of 3 Martian years (01/2004, 11-12/2005, 09-10/2007). The corresponding values of the solar longitude Ls are in the range of 45°-160° for the north and 220°-330° for the south. During this time, the seasonal frost is partly or totally sublimated over the study areas. Data were limited to spectra that do not exhibit water ice or CO_2 ice absorption bands. In addition, quality criteria where applied to the OMEGA database so as to eliminate anomalous data, including non nadir-pointing observations, saturated data, and spectra containing spurious values. A series of spectral criteria were developed in [1] for mapping a broad range of minerals of interest. Here, we use the following representative spectral parameters: band depth of the 2 µm pyroxene feature, olivine index based on the 1 µm band, and band depth at 1.9 µm indicative of the presence of H_2O-bearing minerals.

Results: The pyroxene signatures seen at high latitudes mainly correspond to low albedo terrains (Figures 1A and 1B). Some low albedo terrains also exhibit positive detection for olivine [2]. The mafic material could result from aeolian transport of fine-grained debris eroded from mafic-rich units located in numerous mid-latitude regions. However, their origin could be also found in local volcanic processes. It has been proposed that the Vastitas Borealis formation is underlain by a volcanic unit that flooded and smoothed the northern lowlands in the Early Hesperian [3]. The major units of the southern circumpolar terrains are part of the Plateau Sequence and are interpreted to consist of heavily crated flows, impact breccias, eolian deposits, and pyroclastic material [4,5].

Figures 1C and 1D show the depth of the absorption band at 1.93 µm due to the presence of H_2O (either adsorbed or structurally bound). We note that the 1.9 µm band increases with latitude larger than 60°, but heterogeneities in longitude are observed, especially in the north circumpolar terrains. The hydrated surface material of the northern regions exhibits some spectral diversity [2]. With the exception of Olympia Planitia, where Ca-sulfates are present [6], the northern regions do not however exhibit clear evidence of signatures in the 2.1-2.5 µm wavelength range, which could be indicative of sulfates, hydrated silica or phyllosilicates. The 1.9 µm band in the southern terrains is significantly broader and shifts to a slightly longer wavelength (Fig. 2). The large observed variations of albedo and overall slope can be interpreted in terms of differences in the optical depth of aerosols (Fig. 2).

The 3 µm absorption band depth, which is mainly due to the combinations and overtones of vibrational and rotational transitions of the adsorbed water molecule, also increases with latitude [7]. Thus, the observed latitude dependence suggests that the water content increases with latitude. This hydration enhancement was related to the increase of the hydrogen content of the sub-surface first meter detected by the GRS experiment [7]. Similarly, the presence and the increase of the 1.9 µm band in these regions are likely coupled with the sub-surface hydrogen enhancement. The lack of obvious phyllosilicate or sulfate features does not support hydration due to chemically bound water resulting from hydrous alteration during the formation of the minerals. Hydrous weathering would also be expected to alter the mafic minerals such as olivine, which are still present in these regions. Therefore, the strong absorptions at 1.9 µm and 3 µm indicate that the soil may harbor water in the form of adsorbed water and/or ice or capillary water in frozen wetted soil [8]. This could result from diffusive exchange of water between the sub-surface ice, the pore space of the regolith and the atmosphere.

Mineralogy of the Phoenix landing site: The Phoenix mission has landed in May 2008 at ~68.22°N, 234.25°E in the northern plains, a location where OMEGA sees evidence for hydrated (identification of 1.9 µm band) and ferric phases (Fig. 3). This is in contrast to the relatively dry soils indicated by instruments TEGA and TECP onboard Phoenix. The hydration is likely due to adsorbed water onto grains. The presence of carbonates (up to 5% wt.) in the first 2.5 cm of the soil is reported by TEGA. In the near-infrared all kinds of carbonate minerals exhibit two strong absorption bands at 3.4 and 3.9 µm, and others weaker features at 2.3 and 2.5 µm. However, no signature of carbonate has been found in the OMEGA spectra with a detection limit of 6% in band depth, which corresponds to a mixture of 95%palagonite-5%calcite.

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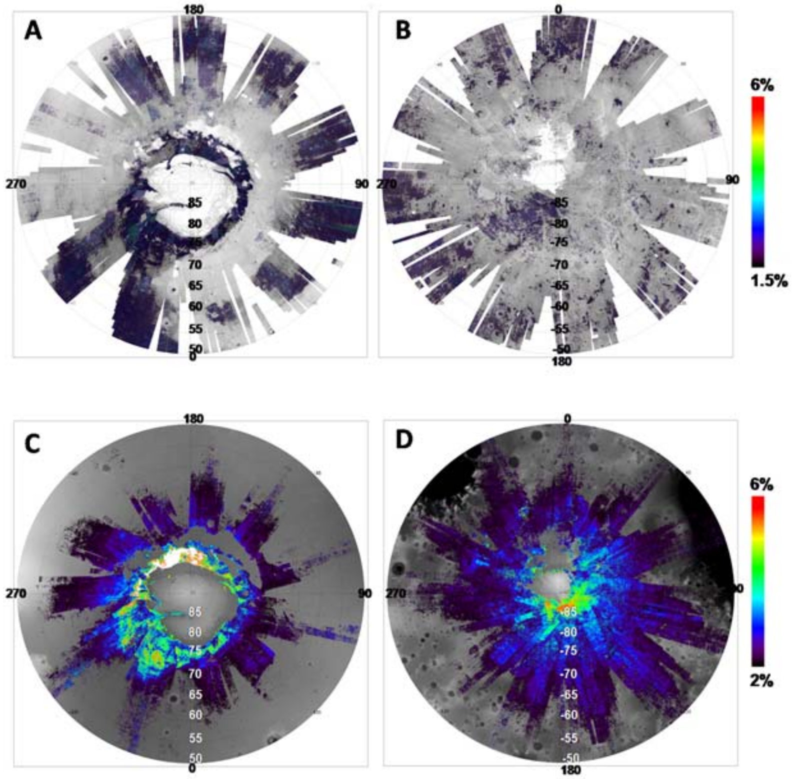

Figure 1. Polar spectral parameter maps (North pole at left, and South pole at right): (A, B) pyroxene over OMEGA albedo map at 1.08 µm, (C, D) hydrated minerals identified with the 1.9 µm band criterion over MOLA map. Pixels with values below the detection limit and pixels that exhibit the presence of water or CO_2 ices are not plotted.

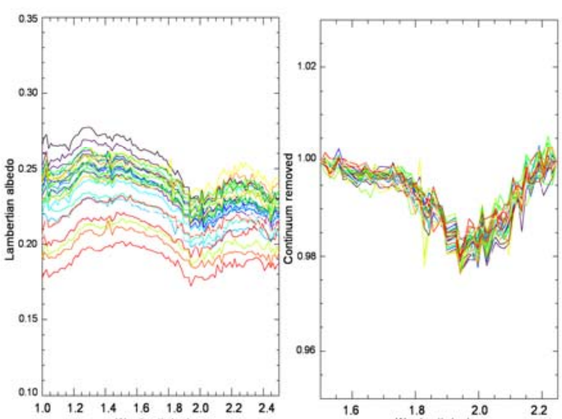

Figure 2. Spectral variations seen in the southern regions. (left) The albedo spectra are extracted from a terrain located at 85°S, 180°E. The band depth of the 1.9 µm signature varies from 2% to 5% depending on the values of Ls ranging in the [265°,287°] interval. (right) Same as left but with the continuum removed.

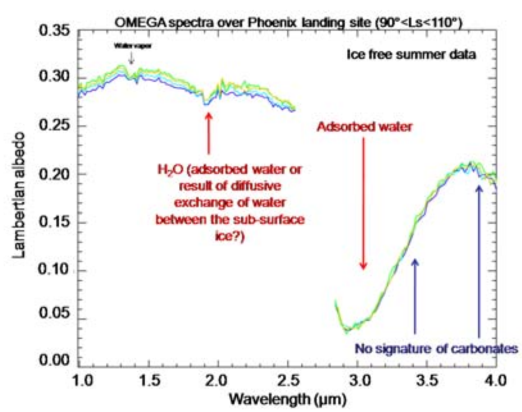

Figure 3. Spectra over the Phoenix landing site taken during the ice-free summer. Positions of different signatures are indicated by arrows.