CORRELATION BETWEEN PHYLLOSILICATES, OLIVINE AND LANDFORMS IN NILI FOSSAE REGION, MARS.
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Introduction: OMEGA-MeX data has provided a new spatial distribution of localized concentrations of olivine and phyllosilicates on Mars [1,2,3]. The largest and the highest concentration of olivine is in Nili Fossae [1,4]. Olivine was already identified by TES and THEMIS data that suggested olivine rich lava flows in this area of Nili Fossae [4]. Of specific interest is the presence of hydrated minerals in this very rich olivine-bearing region [2,3]. The identification of these hydrated minerals and their spatial distribution are examined using HRSC images and other visible datasets such as MOC.

Data processing: We combined OMEGA data from multiple orbits which covered Nili Fossae, North-East of Syrtis Major. Strong evidence of alteration in Nili Fossae comes from the identification of phyllosilicates, especially Fe-rich or Mg-rich smectites [3]. There is a large diversity in the position of the Fe-OH band in smectite minerals which goes from 2.29 to 2.32 µm. This implies that several types of clay minerals (from Fe to Mg- phyllosilicates) are likely present such as nontronite and chamosite. We use the maps from Poulet et al. [2005] and Poulet et al. [2006, this conference] to look at the geology of the phyllosilicate-rich regions. Pyroxene is also observed, mainly as HCP on Syrtis lava flows and LCP in some Noachian outcrops. Three HRSC orbits are used together with their DTM products and correlated with the OMEGA data in a GIS software.

Correlation between phyllosilicates and highlands bedrock: The region of Nili Fossae is a Noachian cratered terrain which experienced strong erosional processes as seen from dissected terrains with rough chaotic texture, isolated mesas and partially eroded craters. This rough eroded texture may explain the good spectral signatures obtained in this region. These superb exposures in this region allow us a detailed examination of bedrock compositional relationships.

OMEGA has identified clays in different areas of the studied region, especially on outcrops of the Noachian crust. In some locations, deep bands at 1.93 and 2.29 microns as well as the general spectral shape imply unambiguously the presence of Fe-rich clays such as nontronite. This area follows very well the contours of a peninsula of Noachian basement surrounded by the Syrtis lava flows. Along the basement, some hydrated pixels are also observed on the scarp bordering lava flows. Hydration band is never observed directly on the lava flows. Thus, in these examples, hydrated minerals such as clay minerals are always associated with Noachian basement, without any signatures on the Syrtis Major lava flows. Because the volcanic flows on Syrtis have been dated as Hesperian [5], this likely indicates that these minerals formed earlier. The presence of phyllosilicates indicates a weathering by different processes such as an early warm and wet climate, subsurface alteration due to hydrothermal systems in presence of strong geothermal gradients (for more details see Poulet et al., this conference).

Other evidence of the enrichment of the Noachian crust in phyllosilicates and hydrated silicate minerals comes from the ejecta of large impact craters. The 60 km diameter crater C1 is surrounded by ejecta stretching over tens of kilometers away from the crater (Fig. 1). While the ejecta is poorly visible at low resolution, examination at the full resolution of HRSC shows that clays are detected at the edge of the ejecta where erosion has likely dissected its surface. Analysis of MOC data within the ejecta blanket confirms the typical elongated patterns usually visible in ejecta at high resolution. Analysis of full resolution HRSC data of the ejecta blanket in the northern and eastern quadrants shows the same pattern. Southeast and east of the C1 crater, strong hydration bands may be also related to the ejecta of this crater. Here, the ejecta deposits are strongly eroded and their outer edge is difficult to identify. The presence of clays in ejecta can be due either (1) to the excavation of clays from the crust or (2) the formation of clays in ejecta by weathering due to hydrothermal processes caused by the presence of water in the impacted material (Newsom et al., 2001). We cannot discriminate between these two possibilities which are not excluding themselves, because water in the crust can be stored in clay minerals.

Relationships with the olivine-rich layers: Whereas most olivine signatures seem to be spatially unrelated with hydrated minerals [7], the region located close to the Syrtis Major lava flows exhibit mixtures of different materials. Indeed, this small region displays spectra that are consistent with olivine mixed with Fe-rich smectites. Many pixels on the RGB composite display turquoise (hydration band and olivine) and even yellow color (hydration, Fe-OH band and olivine) which suggest a mixture of olivine with Fe-rich smectites (Fig. 2). The question is to know if this mixture is the result of a spatial mixture due to the resolution (~600 m/pixel) or a consequence of the presence of partially weathered mafic materials. The fact that these mixed signatures occur on the same group of pixels argues in favor of the second case. This conclusion is important because it may indicate the presence of altered olivine-rich material. The alteration may be due to a warmer climate or to hydrothermal alteration at depth. Nevertheless, no serpentine (with typical 2.33-2.34 strong band) has been yet identified here suggesting that the alteration of mafic minerals occurred at relative low-T in the surface of near subsurface whereas relatively higher temperatures are required for of hydrothermal alteration of olivine to serpentine.

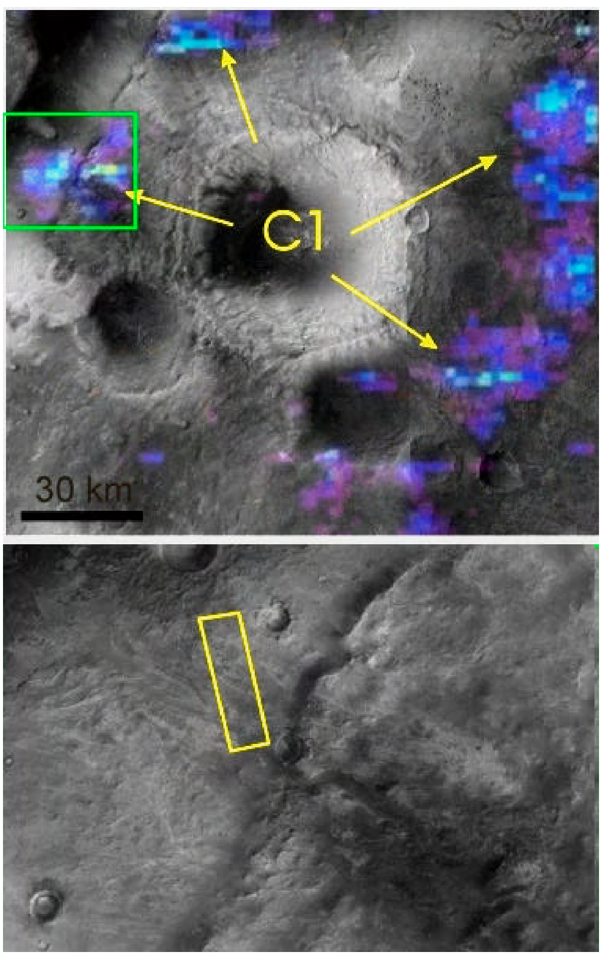

Fig. 1: (top) OMEGA 1.93 micron band plot over HRSC image 1347. Phyllosilicates surround a 50 km large impact crater. These locations correspond to ejecta of the crater as shown in the close-up (bottom). In yellows is the location of a MOC image close-up showing outcrops are eroded material.

Conclusion: Nili Fossae is a region of unique spectral diversity combining observations of phyllosilicates, olivine together with both types of pyroxene. Phyllosilicates are present in the ancient crust as outcrops exhumed by erosion and as ejecta of large impacts. This shows the occurrence of a strong weathering at the Noachian epoch. Olivine is sometimes correlated with phyllosilicates and may indicate a weathering state more than a spatial combination of phyllosilicates with olivine. This association shows that the olivine was possibly formed at a time the process of weathering was still active.

References: [1] Mustard J. et al. (2005), *Science*. [2] Bibring J.-P. et al. (2005) *Science*. [3] Poulet et al., 2005, *Nature*, 2005. [4] Hamilton et al. 2005, *Geology*, 2005 [5] Hiesinger and Head, *JGR*, 2004. [6] Newsom, H. E., Hagerty, J. J. & Thorsos, I. E. *Astrobiology* 1, 71–88 (2001). [7] Mustard et al., this conference.

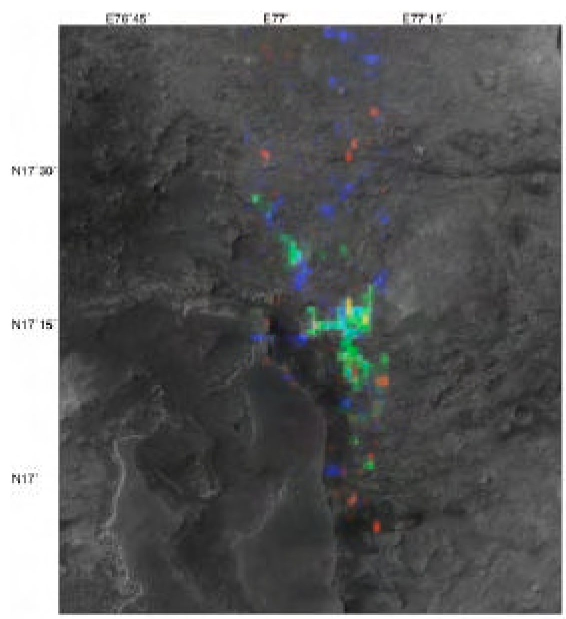

Figure 2: RGB map of phyllosilicates and olivine region over HRSC image 988. Red= 2.3 micron band (Fe/Mg-OH bound), Blue=1.93 micron band (hydration). Green=olivine detection. In the center of the olivine zone, pixels in turquoise and yellow show the association of olivine together with phyllosilicates.