CHARACTERIZATION OF PHYLLOSILICATES IN LIBYA MONTES AND THE SOUTHERN ISIDIS PLANITIA REGION USING CRISM AND HIRISE IMAGES.

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Introduction: The Libya Montes rim/terrace complex of the Isdis Basin possesses some of the densest concentrations of valley networks on Mars. This has led previous workers [1] to conclude that the area may consist of highly altered lithologies formed by possibly long-term aqueous processes. Phyllosilicate-rich surface units nested with olivine- and pyroxene-bearing materials have been identified using hyperspectral visible/near-infrared (VNIR) CRISM data. We are currently characterizing the phyllosilicate minerals in order to place some constraints on the possible aqueous processes that may have operated in this area. We are also exploring the possible relationships between these spectral units to determine if phyllosilicates are distinct from the olivine- and pyroxene- bearing lithologies and only present in the oldest terrains as suggested by previous analyses using OMEGA in neighboring regions [2] and from THEMIS and TES co-analysis of the olivine- and pyroxene- bearing lithologies within SW Isidis [3].

Libya Montes is situated near the Terra Tyrrhena and Nili Fossae regions where phyllosilicates were identified using hyperspectral VNIR data collected by the Observatoire pour la Mineralogie, l'Eau, les Glaces et l'Activité (OMEGA) on Mars Express [2,4]. CRISM mapping data show minor phyllosilicate abundances widespread throughout the Southern Highlands [5,6] which are dominated by low-Ca pyroxene bearing material [2,7]. Recent CRISM analyses have identified phyllosilicates in the Terra Tyrrhena region [8] just south of Libya Montes. CRISM and HiRISE images indicate that the Nili Fossae region consistes of olivine-rich sand dunes and mobile material covering layers of phyllosilicate-rich fractured terrain [6]. Thus, the identification of phyllosilicate-rich and olivine-rich materials in Libya Montes is consistent with observations for the region, and indicates that there may be a petrogenetic relationship between the Nili Fossae region and the southern Isidis Basin/Libya Montes region as suggested recently [2,9].

Image background: Targeted Mars Reconnaissance Orbiter (MRO) Compact Reconnasissance Imaging Spectrometer for Mars (CRISM) images collect 544 wavelengths from 0.36 to 3.9 µm in ~12 km swathes [5]. Images are processed for instrumental effects, converted to I/F and the atmosphere is removed using a ratio with a CRISM scene of Olympus Mons, scaled to the same column density of CO_2. In many cases ratios to spectrally bland regions in the scene are used as well to help resolve spectral features. Two targeted images are available to date: FRT00003B63_07 and HRS00047D8_07. Both are close to 3°N and 85°E.

MRO High Resolution Imaging Science Experiment (HiRISE) images can be collected with a spatial resolution of ~25 cm/pixel [10] and are acquired in a coordinated manner with CRISM observations.

Results: CRISM image FRT00003B63 exhibits multiple textures and small craters and is shown in Figures 1 and 2. Olivine is most abundant in the upper left portion of the image and is shown in red in Figure 2. Strong phyllosilicate signatures are not observed here. Ongoing work involves characterizing minor phyllosilicate abundances here.

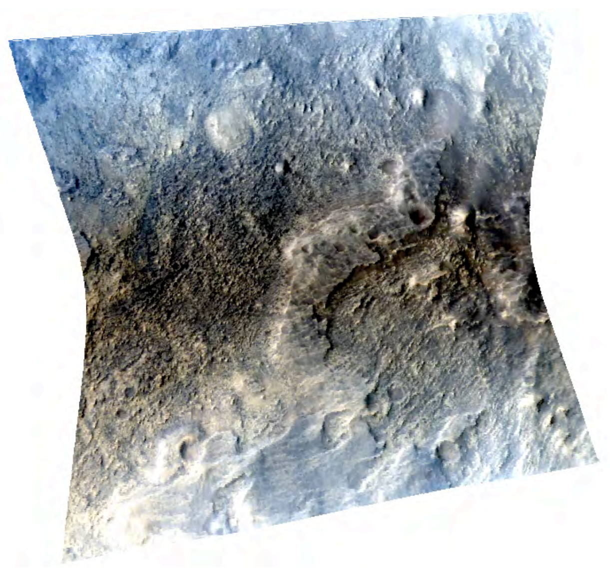

Figure 1 CRISM image FRT00003B63_07 of the Libya Montes region (red is 710 nm, green is 599 nm, and blue is 533 nm).

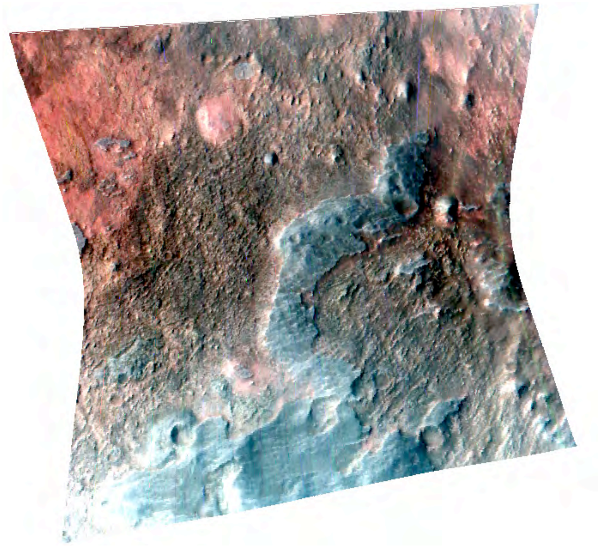

Figure 2 CRISM image FRT00003B63_07 (red is 2500 nm, green is 1500 nm, and blue is 1200 nm).

Coordinated HiRISE image PSP_002756_1830 and CRISM image HRS00047D8 captured a 13.2 km diameter crater named Hashir at the transitional boundary between Isidis Planitia and Libya Montes. It contains layered materials that infilled the crater interior and have been subsequently eroded back to reveal the buried central uplift of the crater. What appears to be a lag deposit lies in the lowest portions of the crater interior. These morphologic features possess spectra that are consistent with pyroxene, phyllosilicates, and olivine, respectively. The HiRISE image is shown in Figure 3, the visible CRISM data are shown in Figures 4-6, and an infrared CRISM image is shown in Figure 7. The layered capping materials shown in Figure 3 have been suggested to be remnant eroded lavas that infiltrated the Libya Montes and Isidis Basin from Syrtis Major.

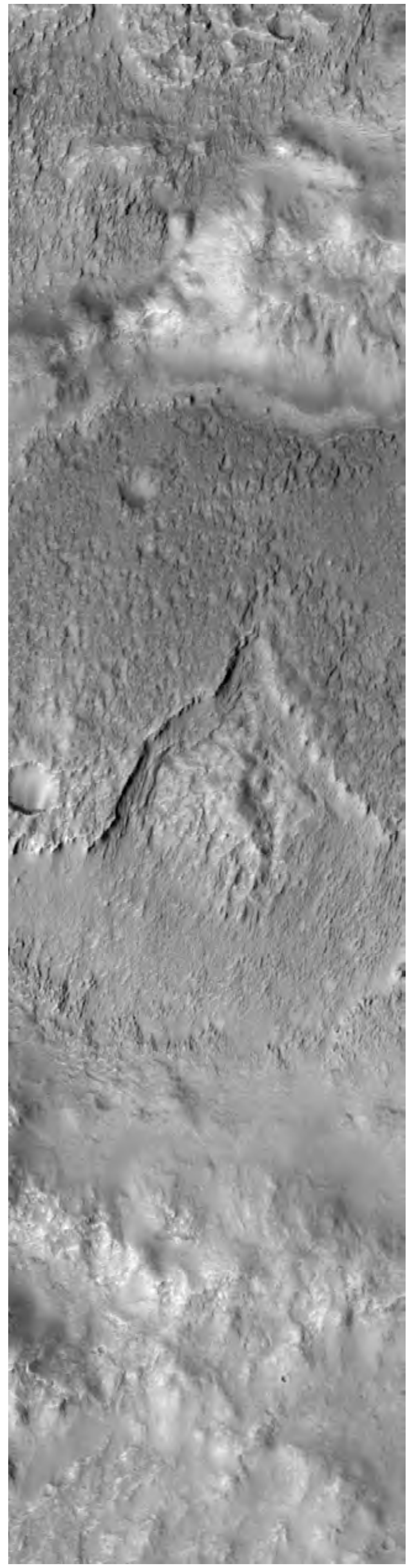

Figure 3 (right) HiRISE image PSP_002756_1830 of the infilled crater Hashir (D ~13.2 km) just within the Libya Montes region.

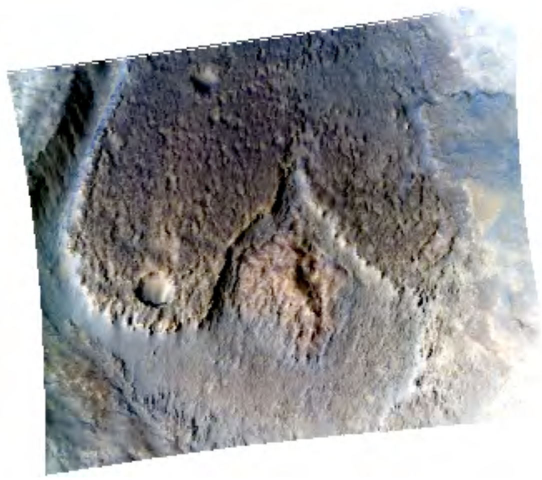

Figure 4 CRISM image HRS000047D8_07 of Libya Montes region (red is 710 nm, green is 599 nm, blue is 533 nm).

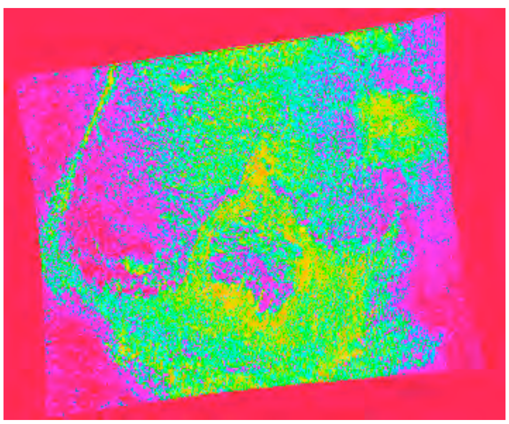

Figure 5 BDI1000VIS parameter map for CRISM image HRS000047D8_07. The ferrous iron band near 1000 nm is mapped here such that high abundancies are shown in green and the highest abundances are shown in orange.

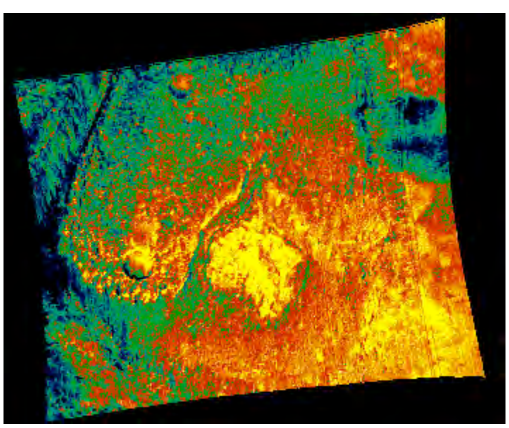

Figure 6 RBR parameter map (670 nm/440 nm) for CRISM image HRS000047D8_07. The areas having brighter reflectance are mapped in orange to yellow.

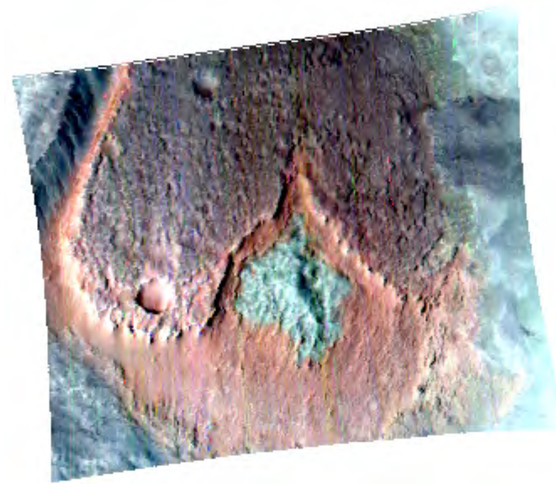

Figure 7 CRISM image HRS000047D8_07 of Libya Montes region (red is 2500 nm, green is 1500 nm, and blue is 1200 nm).

The image shown in Figure 7 displays distinct regions for phyllosilicates, olivine and pyroxene using near-infrared (NIR) wavelengths. Phyllosilicates are observed in the buried central uplift of the crater (shown in blue) and are surrounded by an olivine-bearing layer in the lowest portion of the crater interior (shown in red). The upper layer of infilling material is either spectrally bland or contains a weak pyroxene feature. For example, pyroxene signatures are observed in the dark grey patch in the upper right of the image and the brown flat layered capping unit is spectrally neutral in the infrared. These observations are consistent with the visible region data in that the strong mafic band in Figure 5 is observed where the olivine and pyroxene are observed in the infrared. Also the bright region in the center of Figure 6 corresponds to the phyllosilicate spectra in the infrared.

Spectral Analyses: Spectra were averaged over 4 by 4 pixels and extracted from the atmospherically corrected image. Spectra of the brown flat terrain were used to ratio the phyllosilicate and olivine spectra in order to enhance the mineral features and remove instrument noise.

Phyllosilicates are identified in the NIR image by an OH combination band near 2.3 µm, a water band near 1.9 µm and an OH stretching overtone near 1.4 µm. Olivine is identified in the NIR spectra by a strong absorption band near 1.2 µm and a steep slope from 1.4 to 1.8 µm. Pyroxene is characterized in the NIR spectra by a broad 2-µm band.

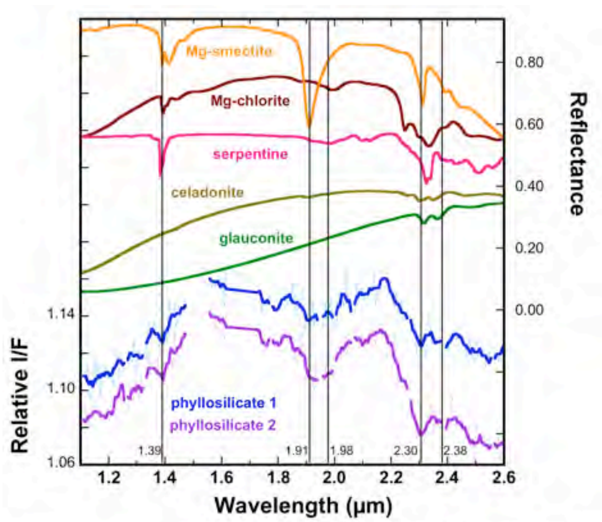

Figure 8 Spectra of the phyllosilicate-rich region compared with lab spectra of several Mg-rich phyllosilicates (serpentine offset by -0.1, celadonite offset by -0.2).

Two preliminary NIR phyllosilicate-region spectra from CRISM image HRS00047D8 are shown in Figure 8. They both exhibit H_2O combination bands near 1.9 µm that could either be due to water in a phyllosilicate mineral or water in an associated mineral. The primary band center appears to occur ~1.91-1.93 µm, but this band is broadened towards 1.98 µm, which could be due to the surface components or may have some atmospheric contribution. The OH combination band in the NIR spectra occurs near 2.30 µm, which is just in between where this band lies for Fe-bearing and Mg-bearing phyllosilicates. However, broadening of this band towards the long-wavelength edge and/or the presence of an additional band near 2.36-2.38 µm is most consistent with a Mg-bearing phyllosilicate. Phyllosilicates often have additional features near 2.4-2.5 µm as observed here in the CRISM spectra. The OH stretching overtone occurs near 1.39 µm, which is most consistent with Mg or Si bound to OH.

Some examples of lab spectra [from 11] are shown for comparison. A Mg-smectite such as hectorite or saponite could account for most of the features observed here. However, the multiple features in the range 2.25 to 2.4 µm in the clinochlore (Mg-chlorite), chrysotile (serpentine), celadonite (Al-Fe-Mg mica) and glauconite (Fe-Mg mica) are more consistent with the broader and/or multiple features observed in the CRISM spectra. Ongoing work will further characterize the phyllosilicate spectra in image HRS000047D8 and coordinate these observations with phyllosilicate spectra elsewhere in Libya Montes and the region.

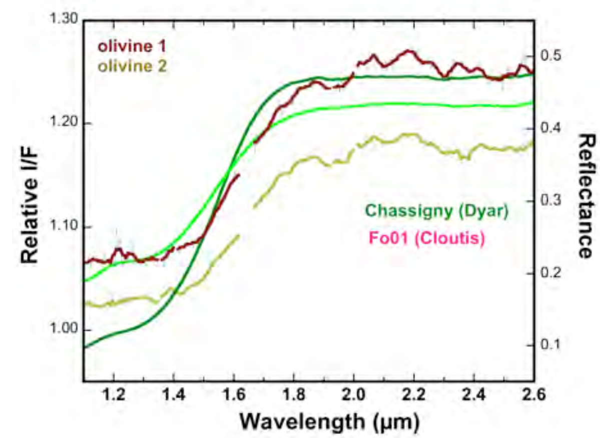

Figure 9 Spectra of the olivine-bearing region compared to lab reflectance spectra of a Martian meteorite (from D. Dyar) and an olivine mineral separate with Fo01 composition (from E. Cloutis).

Two examples of olivine spectra from CRISM image HRS00047D8 are shown in Figure 9. These were collected from opposite sides of the olivine-rich ring surrounding the phyllosilicate material. They are plotted for comparison with lab spectra of the Mg-rich olivine found in the Chassigny meteorite and a fayalite mineral separate.

Summary: Phyllosilicates were identified in the central uplift of Hashir crater surrounded by an olivine-rich deposit in CRISM image HRS000047D8. Olivine is also detected in HiRISE image PSP_002756_1830 in layers that appear to be *in situ* bedrock just below the cap unit. Olivine was also identified in CRISM image FRT0003B63. Both images are located within the transitional boundary between Libya Montes and Isidis Planitia. Coordinated CRISM-HiRISE investigations of the Libya Montes area are continuing as more images become available.

References: [1] Crumpler, L. S. and Tanaka, K. L. (2003) *JGR, 108*, 8080, DOI 10.1029/2002JE002040. [2] Bibring, J.-P., et al. (2006) *Science, 312,* 400-404. [3] Tornabene, L. L. et al. (2007) *JGR, submitted.* [4] Poulet, F. et al. (2005) *Nature, 438,* 632-627. [5] Murchie, S. L. et al. (2007) *Science, submitted.* [6] Mustard, J. F. et al. (2007) *7th Int'l Conf on Mars, submitted.* [7] Mustard, J. F. et al. (2005) *Science, 307,* 1594-1597. [8] Pelkey, S. M. et al. (2007) *LPS XXXVIII,* Abstract #1994. [9] Mustard, J. F. et al. (2006) *LPS XXXVII,* Abstract #1683. [10] McEwen, A. S. et al. (2007) *JGR, in press.* [11] Bishop, J. L. et al. (2007) *Clay Minerals, submitted.*