CRISM OBSERVATIONS OF HYDRATED CRATERS DEPOSITS IN TERRA TYRRHENA, MARS

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Introduction: Terra Tyrrhena is an expanse of heavily cratered and dissected Noachian terrain [1] south of the Isidis basin and north of the Hellas basin. Phyllosilicates in this region were first identified using visible/near-infrared spectra collected by the OMEGA instrument on the Mars Express mission [2,3,4]. Focusing on higher resolution recently acquired observations from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard the Mars Reconnaissance Orbiter (MRO), we are able to refine our understanding of the hydrated mineral detections observed in this ancient martian terrain.

Datasets: OMEGA is a visible and near-infrared imaging spectrometer that covers wavelengths from 0.35 – 5.1 µm with spectral sampling of 7-20 nm and spatial resolution of ~300 m – 5 km [5]. To date, OMEGA has obtained near global coverage of Mars.

CRISM is a hyperspectral imager covering the visible to near-infrared wavelengths of 0.362 – 3.92 µm at 6.55 nm/channel [6]. CRISM has two primary modes of operation, mapping mode and targeted mode [6]. In the mapping mode, data are collected at a subset of 72 wavelengths covering key mineralogic absorptions. Mapping mode data are spatially binned resulting in resolutions of 100 or 200 m per pixel. In the targeted mode, a region of interest is mapped at full spectral resolution (544 channels) and full or half spatial resolution (~18 or ~36 m/pix).

Standard processing approaches have been used to convert both OMEGA and CRISM data to I/F. Simple corrections for photometric and atmospheric effects were then applied to both datasets. Division by the cosine of the incidence angle corrects for variations in observing geometry, while the effects of atmospheric gas absorptions are removed via division by a scaled atmospheric transmission spectrum, an approach used with success by the OMEGA instrument [7]. Transmission spectra are empirically derived from observations made across Olympus Mons by each instrument.

Observations: Using OMEGA data acquired from January 2004 through August 2006, we created maps of spectral indices to assist in locating mineralogically interesting areas [8]. Figure 1 shows a map of D2300, a parameter designed to detect the decrease in reflectance in the 2.3 µm area due to metal-OH absorptions typical of those seen in phyllosilicates (values have been stretched to display only the most robust detections). The highest values are located around and within select craters in the area. Higher spatial resolution CRISM mapping data in the same area (Fig. 2) show the phyllosilicate-rich material to be constrained to lobate crater ejecta.

CRISM has also acquired a targeted observation (east of the area in Fig. 1) covering a portion of another crater with lobate ejecta (Fig. 3). Again mapping spectral parameters, we see mineralogically rich areas in exposed portions of the crater wall and rim as well as in smaller areas on the crater floor and ejecta (Fig. 3b). At this resolution, CRISM displays multiple, spatially distinct mineral signatures indicating the presence of both phyllosilicate-rich and mafic material in different locations along the crater wall and rim. These initial results indicate that CRISM data will allow for the use of mineralogy as a stratigraphic probe.

Discussion: Figure 2 clearly shows that the phyllosilicate-rich material is confined to the lobate crater ejecta. Since it is unlikely that the ejecta material would be any more susceptible to post-impact alteration than the surrounding material, it is unlikely that the alteration of the ejecta material occurred in place. Thus, the correlation with ejecta morphology indicates that the phyllosilicate-rich material existed prior to the impact event and was excavated in the process of crater formation. As seen in other areas of the planet [2,3], this result indicates that the phyllosilicate signature is from Noachian basement material and supports the hypothesis of an era of non-acidic surface or sub-surface aqueous alteration early in Mars' history [3].

Investigating similar mineral detections in a different location at a higher spatial resolution (Fig. 3), we see evidence for phyllosilicate-rich material in exposed areas of a crater wall and rim. In addition, smaller areas of mafic, low-calcium-pyroxene rich material can be seen above the altered material (Fig. 3b). Further investigation needs to be made into the exact geologic and stratigraphic relationship between these two areas, however, the presence of an unaltered mafic layer overlying altered material would contribute significantly to our understanding of the type and timing of the alteration process. Provided that clear geologic and mineralogic relationships can be determined, we hope to be able to distinguish between mechanisms of phyllosilicate formation.

Future Work: The significance of the relationship between hydrated mineral detections and lobate ejecta is not entirely clear. While OMEGA observed hydrated mineral signatures on a number of lobate ejecta deposits [4], there were far more instances of lobate ejecta that did not exhibit enrichment in hydrated minerals [7]. Determining the significance of the correlation between hydrated minerals and lobate ejecta as well as the stratigraphic and regional context of the hydrated mineral detections will be the primary focus of this work. CRISM will continue to acquire both mapping and targeted observations throughout Terra Tyrrhena. In addition, the co-alignment of MRO instruments allows for simultaneous CRISM and HiRISE (High Resolution Imagine Science Experiment) coverage providing geologic context for mineral detections down to a spatial scale of ~25 cm per pixel [9].

References: [1] Greeley R. and Guest J. E. (1987) *USGS I-Map 1802-B*, 1:15M scale. [2] Bibring, J.-P., et al. (2006) *Science*, **312**, 400-404. [3] Poulet, F., et al., (2006) *LPSC XXXVII*, 1698. [4] Costard, F., et al. (2006) *LPSC XXXVII*, 1288. [5] Bibring, J.-P., et al. (2004) ESA-SP, 1204. [6] Murchie, S., et al. (2007) *JGR*, in press. [7] Bibring, J.-P., et al. (2005) *Science*, **307**, 1576-1581. [8] Pelkey, S.M., et al. (2007) *JGR*, in press. [10] McEwen, A. et al. (2007) *JGR*, in press.

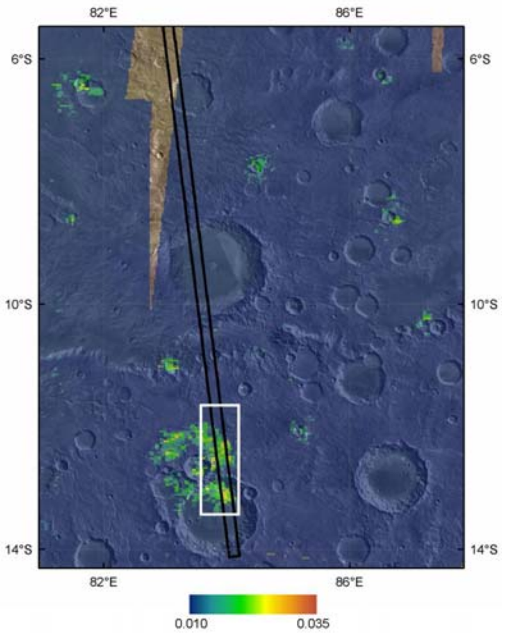

Figure 1: D2300 spectral index as derived from OMEGA data overlain on a MDIM2 mosaic. Areas with the highest values are concentrated around and within select craters and indicate the likely presence of phyllosilicate-rich material. The outline of a CRISM mapping observation is shown in black; the white box indicates the area shown in Figure 2.

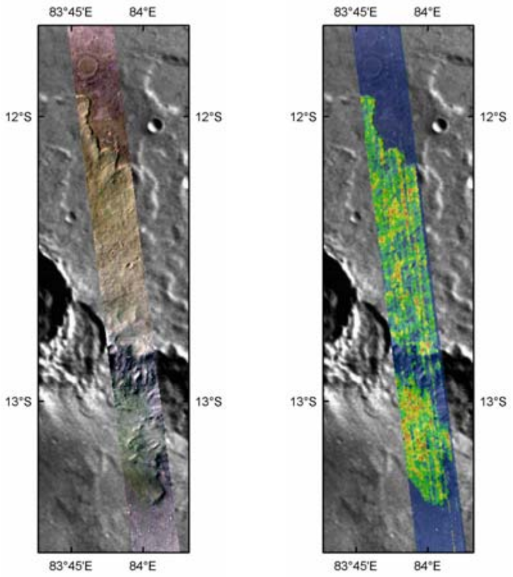

Figure 2: (left) False color stretch of 3 infrared bands from CRISM observation MSP0000312F_05 (~100 m/pix) overlain on a MDIM2 mosaic. The mapping strip covers a portion of lobate ejecta associated with the crater on the western edge of the scene. **(right)** Left panel overlain with a map of the D2300 spectral parameter derived from this observation (same scale as Fig. 1). Areas with enhanced absorption near 2.3 µm, typical of phyllosilicates, are well-constrained to crater ejecta.

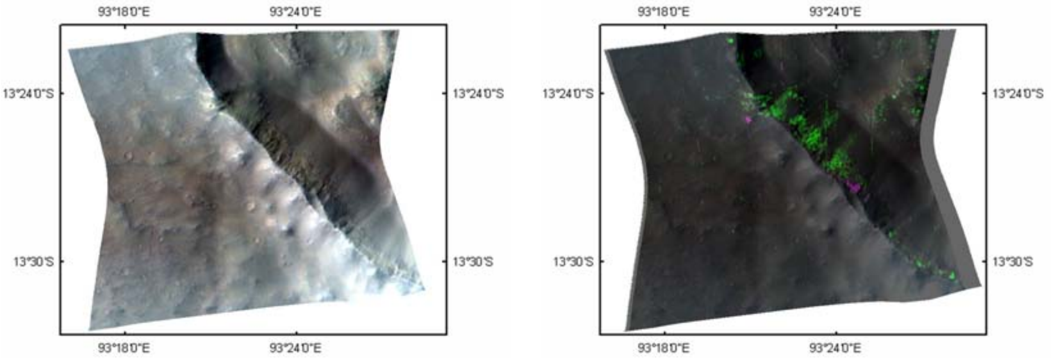

Figure 3: (left) False color stretch of 3 infrared bands from CRISM observation FRT000035DB_07 (~18 m/pix). The targeted observation covers a portion of the ejecta, wall, and floor of a crater with a lobate ejecta blanket. **(right)** Left panel overlain with a map of spectral parameters derived from this observation, green indicates phyllosilicate-rich material, purple indicates materials rich in low-calcium-pyroxene.