DETECTION AND CONTEXT OF HYDRATED MINERALOGY IN THE TYRRHENA TERRA AND LIBYA MONTES REGIONS USING HRSC, OMEGA AND CRISM.

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Introduction: The discovery of phyllosilicates on Mars [1] has had major implications on the perceived geologic and climatologic evolution of Mars [7]. Not only do phyllosilicates represent a 'wet' period on Mars, they might also represent a potentially favorable environment for life. The phyllosilicates have so far exclusively been found in or close to ancient Noachian highland terrain. Those phyllosilicate deposits studied (e.g. [2]) show a clear association between hydrated mineralogy and heavily eroded and crater-saturated outcrops.

Phyllosilicates on Earth are associated with a wide variety of geological processes (volcanism, metamorphism, hydrothermal alteration, sedimentation). The occurrence of phyllosilicates on Mars may be equally diverse in nature. To be able to place constraints on the early Martian environment, the processes by which these phyllosilicates formed need to be reconstructed. To derive this information from individual phyllosilicate deposits, it is necessary to interpret their internal compositional gradient in relation to the geological context and relative time relationships.

Methods and data products: HRSC data products (both image at 12 m/pixel and stereo-derived DTMs) are used for examining geologic cross-cutting relationships, geomorphologic landforms and visual determination of unit boundaries. Odyssey THEMIS nighttime TIR images are analyzed for spatial variations in thermal inertia. Where available, HRSC is supplemented by higher-resolution visible observations of CTX or MOC.

Hyperspectral analysis is conducted using data from both OMEGA and CRISM hyperspectral instruments. Whereas CRISM provides a higher spatial and spectral resolution, OMEGA allows for quicker detection of sites of interest due to its larger per-scene spatial coverage. In order to batch-process large amounts of OMEGA data, an IDL/ENVI tool was developed on top of the existing SOFT04, distributed by PSA. Atmospheric correction assumes that atmospheric contributions are multiplicative, and follow a power-law distribution with altitude [3]. The ratio of two spectra taken at base and summit of Olympus Mons provides the atmospheric spectrum. To quickly assess the mineralogy of a large region, CRISM multispectral summary products [4] are applied to both OMEGA and CRISM datasets. Hydrated mineral deposits are located on the basis of the absorption feature in the 1.9um region, in combination with features in the 2.2um and/or 2.3um region.

In order to analyze local mineralogy, a linear spectral unmixing algorithm provided by IDL/ENVI is applied. A possible tool for reconstruction of hydrothermal processes is the white mica alteration index (Eq 1, [5]):

$$\frac{D_{AlOH}}{D_{AlOH} + D_{FeOH}}$$

Eq 1. *White mica alteration index*

Where: D_{AlOH} = depth of AlOH absorption feature of white mica and D_{FeOH} = depth of FeOH absorption feature of chlorite.

This parameter represents the abundance of white mica relative to chlorite. It has been found to vary systematically along hydrothermal fluid pathways as a function of temperature and local chemistry. Such a variation is an important clue to the presence of a hydrothermal system, and might provide details on its inner workings.

Results: The methods described have lead to positive identification of phyllosilicates in Libya Montes and Tyrrhena Terra. As seen in figure 1, phyllosilicates are generally associated with very rough morphology and seem to be located underneath a smooth dark unit. Another common type of phyllosilicate deposits has been found excavated [6] in the ejecta of craters.

Spectrally ambiguous identification of hydrated mineralogy has been performed in Tyrrhena Terra (figure 2). The variation in the hyperspectral data is only slight, but visual inspection yields an old crater-saturated unit underlying a similarly old darker unit. The hydration band at 1.9µm and high-calcium pyroxene are anticorrelated in this scene, strengthening the interpretatation that the hydration signature observed is related to surface composition.

Discussion: The phyllosilicates identified so-far are correlated with extremely rough morphology and mostly light toned units in ancient terrain. Hydration has not been identified in stratigraphically younger units. This supports the idea that processes through which phyllosilicates formed, likely ended early in martian history [7].

The deposit in Tyrrhena Terra shows a particularly interesting anticorrelation between stratigraphic level and degree of hydration. Although data quality limits further interpretation, the fact that hydration is irrespective of stratigraphic level might imply cross-cutting processes like hydrothermalism. The observed gradient in hydration is however also supportive of the idea, that a long-lasting process slowly subsided.

OMEGA and CRISM data are subject to significant levels of noise. This introduces a probability for false-positives in the case of spectral parameters (see [4]). This probability can be minimized by taking into account a minimum detection threshold and performing cross-sensor validation.

Dust cover and noise levels will introduce inaccuracies in quantitative analyses of the spectra. Noise causes variations in band depth, whereas dust has a smoothing effect on the entire spectrum. The white mica index parameter has thus far only been applied to ground-based analysis.

The integration of THEMIS observations will likely shed additional light on the nature of the deposits in Tyrrhena Terra. Additionally, the BD530-parameter will be used to quickly assess dust cover and thus spectral quality of the scene [8]. Future work will first focus on integrating various datasets to provide unambiguous identification of phyllosilicates and their geological setting. Second, there will be efforts to quantitatively analyze individual spectra according the methods outlined.

References:

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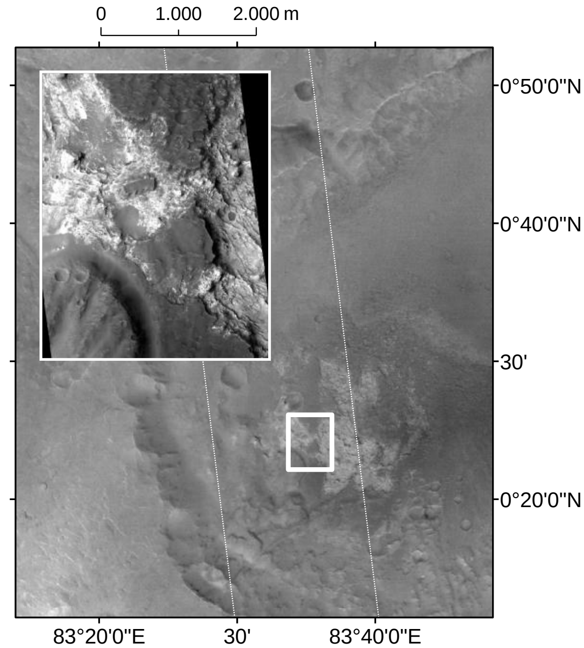

Figure 1: HRSC visual image showing light-toned hydrated deposit in Libya Montes. Inset: MOC closeup. Dotted: CRISM MSP-observation footprint.

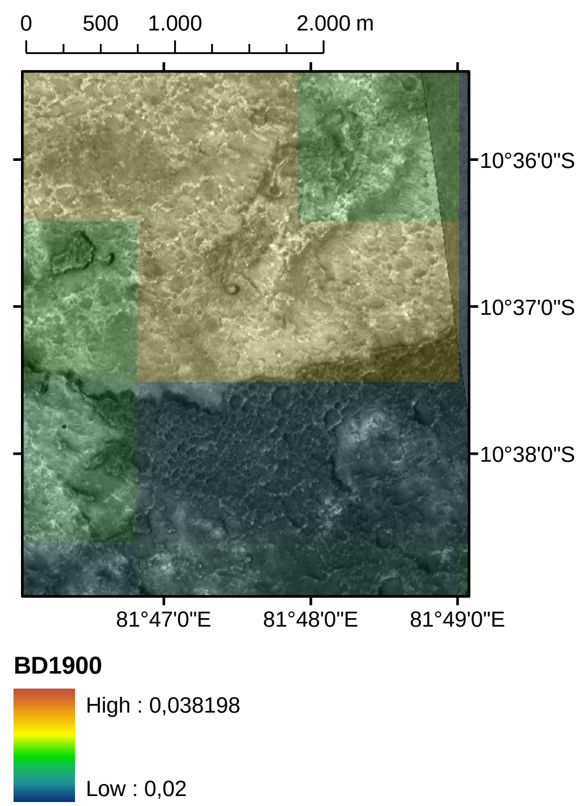

Figure 2: Potentially hydrated mineralogy in Tyrrhena Terra. MOC observation s1403090 overlain with lower-resolution OMEGA-based BD1900 parameter.