Detecting Hydrated Minerals in Libya Montes, Mars using MRO CRISM Hyperspectral Data

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Introduction: Libya Montes is well known for evidence found there of fluvial, lacustrine, aeolian, volcanic, and hydrothermal process [1]. It is situated in the southern rim of the Isidis impact basin and is a site for investigating hydrated minerals. Identification of hydrated minerals has been a prime interest for understanding the Martian surface, and to address science questions and improve the understanding of geological process that have acted in the past. Hydrated minerals have been used as a proxy to understand extent of aqueous activity in Mars' distant past [1, 2]. The detection of these minerals has been based on the spectral response in the Visible - Near Infrared (VNIR) and Shortwave Infrared (SWIR) wavelength range of the electromagnetic spectrum. The present research aims towards the identification of hydrated minerals using Mars Reconnaissance Orbiter (MRO) Compact Reconnaissance Imaging Spectrometer for Mars (CRISM). We implemented CRISM spectral parameters/summary products described in [3, 4] to highlight the absorption features at 1.9, 2.2 and 2.3 µm.

Data and Methods:

CRISM hyperspectral datasets: MRO was launched in 2005. Its CRISM instrument measures the reflected energy of the Martian surface in the VNIR and SWIR (i.e. 365-3937 nm) with a spectral resolution of ~6.55 nm. It has two modes of data acquisition: a multispectral nadir-pointed survey mode with 72 spectral bands at a spatial resolution of 100-200 m/pixel and a hyperspectral targeted observation mode with 544 spectral bands at the spatial resolution of 18/36 m/pixel [5].

We processed two scenes of Full Resolution Targeted (FRT) CRISM hyperspectral data, FRT0000A819 and FRT00001647D, downloaded from PDS website: https://ode.rsl.wustl.edu/mars/index.aspx.

CRISM data pre-processing: The typical CRISM processing followed in this study includes the format conversion of PDS to CAT (CRISM Analysis Toolkit [5]), removal of noisy bands, photometric correction, and atmospheric correction using CAT 7.3.1 (http://pdsgeosciences.wustl.edu/missions/mro/crism.htm) with default parameters settings. The processed image will be referred to as the calibrated image hereafter.

CRISM spectral parameters derivation: Standard spectral parameters were formulated in [3 and 4] to highlight various minerals and other materials such as H_2O ice,rock dust, etc. These parameters have been developed using spectral characteristics such as absorption position, spectral depth, slope, reflection peaks and ratios of the minerals [3, 4]. The calibrated datasets have been used to derive spectral parameters/summary products such as BDI1000IR, OLINDEX, LCPINDEX, HCPINDEX, BD2290, and D2300 to highlight the main mineralogical composition and hydrated minerals in the region. A description of these indices is presented in Table 1. The regions that showed a positive response to the indices were targeted for further spectral analysis. We extracted the spectra from those pixels that contained deeper absorption band depths.

Table 1. Description of mineral indices [3]

Indices	Parameter/Target Minerals
BDI1000IR	Fe mineralogy
OLINDEX	Olivine Index
LCPINDEX	Low Ca Pyroxene index
HCPINDEX	High Ca Pyroxene index
BD2290	Mg, Fe-OH minerals, CO_2 ice
D2300	2.3 µm drop, hydrated minerals (mainly phyllosilicates such as mica, chlorite, talc and serpentine)

Results and Discussion:

The selected Libya Montes CRISM scenes displayed high values of the aforementioned indices (Table 1) and highlight the Fe-bearing and hydrated minerals in the regional bedrock. Fig. 1 illustrates the spatial distribution of olivine, low calcium pyroxene, and high calcium pyroxene derived from the OLINDEX, LCPINDEX, and HCPINDEX indices respectively. It can be noticed that the BD2290, D2300, BDI1000IR, and OLINDEX shows spatial overlap, indicating that the spectral response of Mg/Fe-OH bearing, and hydrated minerals mixed with olivine rich bearing rock.

These regions can be also considered for geomorphological context of the mineral mapping and better understood if minerals are hosted in rock or in dunes using MRO High Resolution Imaging Science Experiment (HiRISE) and Context Camera (CTX) images. These images can further assist in the identifying structure and layering characteristics usually associated with phyllosilicates and sulfates.

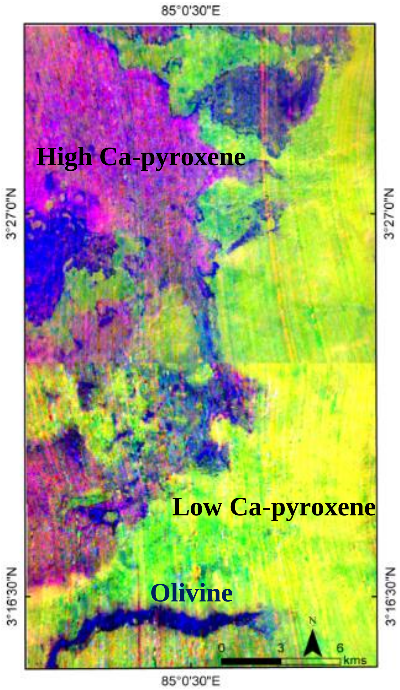

Figure 1. Displaying the HCPINDEX, LCPINDEX and OLINDEX indices in RGB color space to highlight the high Ca pyroxene (magenta), low calcium pyroxene (yellow/light green), and olivine (blue) in the area.

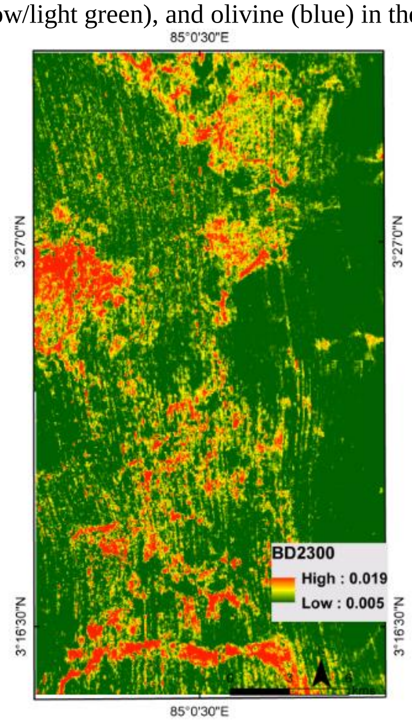

Figure 2. Highlighting the area bearing the hydrated minerals (Fe/Mg smectite) using D2300. The red color indicates the hydrated minerals whereas green represents backgound.

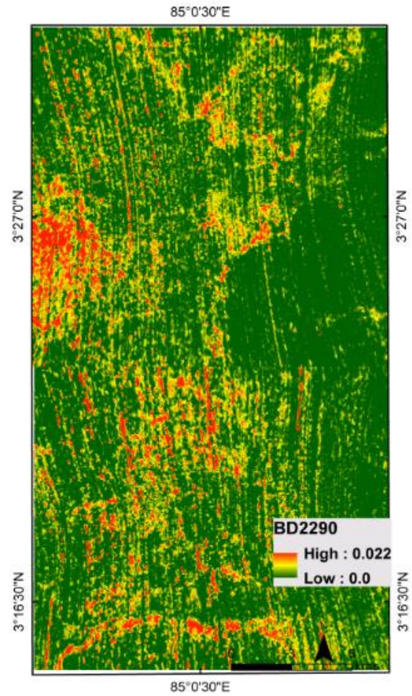

Figure 3. Highlighting the area bearing the Mg/Fe-OH minerals using BD2290. The red color indicates the minerals whereas green represents backgound.

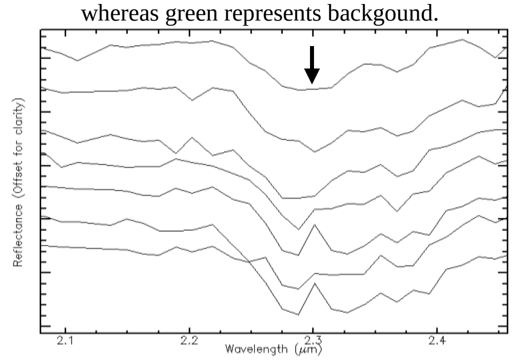

Figure 4. The spectral profile of Mg/Fe-OH minerals derived from the pixels contains higher spectral depth using BD2290 and D2300.The arrow points the band minimum ~2.3 µm.

Conclusion: Aqueous alteration in Libya Montes is indicated by spectral summary products (Fig. 2 to 4) of Mg/Fe-OH minerals using MRO CRISM hyperspectral data. Most of these minerals shows association with olivine bearing rocks (Fig.1). The highlighted areas of minerals can be further investigated using HiRISE and CTX to understand the morphological characteristics of the area and to place their formation into a geologic context.

References: [1] Tirsch, D., et al. (2018) *Icarus*, *314*, 12-34. [2] Mancarella, F., et al. (2018) *Planet. & Space Sci. 152*, 165-175. [3] Pelkey, S. M., et al. (2007) *Journ. of Geophy. Res.: Planets*, *112*(E8). [4] Viviano-Beck, C. E., et al. (2014) *Journ. of Geophy. Res.: Planets*, *119*(6), 1403-1431. [5] Murchie, S. L., et al. (2009). *Journ. of Geophys. Res.: Planets*, *114*(E2).