VIS-NIR SPECTRAL CHARACTERIZATION OF LABORATORY ANALOGUE MIXTURES OF HAULANI: ASSESSMENT OF MINERALOGICAL COMPOSITION OF BRIGHT AREAS ON CERES

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Introduction: The VIR spectrometer on board of NASA's Dawn spacecraft provided important clues about the mineralogical composition of the Ceres regolith [1] and about bright spot regions, thought to be a possible result of cryovolcanism [2] [3] and post-impact hydrothermal activities [4]. In this framework, the study of bright areas is important to assess the mineralogical composition of the subsurface materials that could host water ice [5] [6].

In this project, different Haulani bright areas (Southern floor and North-east crater wall, hereafter named ROI3 and ROI4) (Figure 1) on Ceres are studied by producing different analogue mixtures and comparing them with Dawn VIR data. Based on previous studies [7] [8] the end-members are identified and the analogue mixtures are produced with grain size of 50-100 µm. The initial mixtures are acquired in the VIS-NIR spectral range (0.35-4.5 µm) at temperature similar to Haulani crater, i.e. from 200 K to 300 K, by using the Cold Spectroscopy Facility (CSS) at IPAG (France).

The main spectral descriptors of absorption bands, such as Band Center (BC), Band Depth (BD) and Full-Width-Half-Maximum (FWHM) are estimated for the spectral features at 2.7, 3.1, 3.4 µm present in the laboratory spectra, as well as spectral slope in the 1.2-1.9 µm range and reflectance level at 2.1 µm; the spectral parameters are then compared with those estimated in VIR spectra. Data analysis is extended to another interesting region hosting bright spots, the Central Peak of Haulani crater (ROI1) (Figure 1).

Project goals: the main goals of the project are: 1) the study of two different bright areas (ROI3 and ROI4) of Haulani crater in order to assess the mineralogy of the sub-surface materials; 2) the production of analogue mixtures of ROI3 and ROI4 areas by using terrestrial minerals with grain size between 50 and 100 µm and reflectance spectra acquisition (end-members and analogue mixtures) in the VIS-NIR spectral range 0.35-4.5 µm; 3) the analysis of analogue mixtures spectral parameters (BC, BD, FWHM of bands, reflectance level and spectral slopes; 4) comparison between the spectral parameters of analogue mixtures and the spectral descriptors of the VIR data corresponding to the selected areas.

Figure 1. Representative spectra of Haulani bright areas: southern floor (blue, ROI3) and North-East crater wall (red, ROI4) and one additional area still under study (orange rectangle, ROI1).

Analogue mixtures production and experimental procedure: By previous study [7] [8] the main end-members identified are: Antigorite (Mg-phyllosilicate); NH_4-montmorillonite (ammoniated phyllosilicate); Sodium Carbonate anhydrous (Na-carbonate); Graphite (dark component), Illite (Phyllosilicates). Two analogue mixtures are produced with grain size 50-100 µm for two bright areas of Haulani and the corresponding spectra are acquired in the VIS-NIR spectral range (0.35-4.5 µm) at cold temperature, i.e., from 200 K to 300 K (similar to the temperature of Haulani crater) and with a phase angle of 30° by using the Cold Spectroscopy Facility (CSS) at IPAG (France). Then, the spectral parameters relative to the absorption bands at 2.7, 3.1, 3.4 µm, are obtained and compared with VIR data. The acquired spectra are converted in radiance factor to compare them with VIR spectral data.

The first two mixtures named as A3-1 and A3-2 are not well representative of Haulani bright areas due to high dark components percentage (up to 86% for A3-1) and missing of Na-carbonate bands for A3-2. Thus, intermediate mixtures named as A3-4 and A3-7 are produced from A3-2 by reaching 9% for Na-carbonate, 32% of dark component (i.e. carbon black) and 25% of NH_4-Montmorillonite in the final A3-8 mixture. Then, the A3-8 mixture is modified by adding graphite and

NH_4-montmorillonite and obtaining the A3-9 mixture. In this case, the reflectance at 1.2 µm is closer to the VIR spectra of Haulani crater.

In order to remove the adsorbed H_2O each mixture is heated in a furnace at 120°C for 2 hours and then placed in the sample holder under vacuum (Figure 2). The mixture A3-8 is also pressed in order to test the spectral variations induced by the increase of the sample density. Then, the spectral results are compared with non-pressed A3-8 mixture.

Figure 2. *Left*: Sample holder with the pressed mixture A3-8 placed in vacuum after heating at 120°C for 2h. *Right*: Zoomed image of the pressed mixture in the sample holder.

Spectral analysis on ROI3, ROI4, ROI1 and main results: The spectral analysis mainly involved mixtures with a reflectance spectrum similar to ROI1, ROI3 and ROI4, in particular the mixture A3-4, A3-7, A3-8 and A3-9.

As a result, the mixtures A3-7 and A3-8 are the most spectrally similar to ROI1, while A3-8 is the most similar spectrum to ROI3 and ROI4.

In particular, the spectral similarities between A3-8 and the ROI3 and ROI4 lie in the BD of the absorption bands at 2.7 µm (ascribed to phyllosilicates), at 3.1 µm (due to NH_4-montmorillonite) and at 3.4 µm (carbonates). The differences in reflectance level could be due to opaque end-members used (Figure 3). In terms of reflectance level, the A3-9 mixture is spectrally similar to the ROI3 and ROI4 due to higher abundance of graphite: the percentage abundance of the opaque component (22%) however, results in a strong weakening of the spectral bands, making this mixture not plausible to represent the Haulani’s areas.

For the ROI1, the most representative mixtures are A3-7 and A3-8 for spectral similarities with the BD of the 3.1 um absorption band.

Further analysis and modification of existing mixtures will be performed in order to: 1) to clarify the nature of Ceres darkening agent in the regolith since it has not been identified with certainty. Thus, a putative dark component or a combination of two darkening agents (e.g. graphite plus magnetite or by varying the percentage of carbon black) can be used starting from A3-8 mixture in order to obtain a more reliable value of spectral slope; 2) to assess the contribution of hydrous Na-carbonate to the spectral bands of analogue mixtures: this mineral, suggested to compose the Haulani bright areas, can be added to the mixtures (e.g. 2-8%) and the contribution to the 2.7 µm spectral band can be assessed.

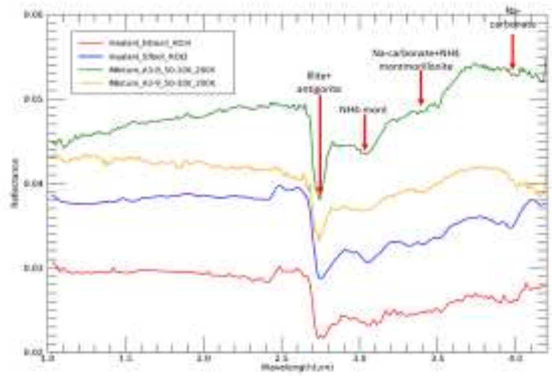

Figure 3. Reflectance spectra of ROI3 (green spectrum) and ROI4 (red spectrum) compared to the spectra of mixture A3-8 (green spectrum) and A3-9 (orange spectrum).

References:

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