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VIS-NIR reflectance analysis of analogue mixtures representative of Haulani crater on Ceres to assess the mineralogical composition of bright areas

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Introduction

The VIR spectrometer on board the NASA's Dawn spacecraft allowed providing important clues the mineralogical composition of the Ceres regolith (De Sanctis et al., 2015) and of the bright areas widespread across its surface (Palomba et al., 2019; Carrozzo et al., 2018). Some bright spots are thought to be the result of phenomena like cryovolcanism (Ruesch et al., 2016; Russell et al., 2016) and post-impact hydrothermal activities (Bowling et al., 2016). The study of Ceres bright areas is important to understand in more detail the mineralogical composition of the subsurface materials that could host water ice (Prettyman et al., 2017; Schmidt et al., 2017) or have been under aqueous alteration (De Sanctis et al., 2016).

In this study different bright areas of Haulani crater (e.g. Southern floor, i.e. ROI3 and North-east crater wall, i.e. ROI4) on Ceres have been studied by creating different analogue mixtures and comparing them with Dawn VIR data. The end-members have been identified based on previous studies (Tosi et al. 2018, 2019) and the analogue mixtures have been produced with grain size 50-100 µm for two bright crater regions. The spectra of two initial analogue mixtures have been acquired in the VIS-NIR spectral range (0.35-4.5 µm) at low temperature, i.e. from 200 K to 300 K similar to Haulani by using the Cold Spectroscopy Facility (CSS; https://cold-spectro.sshade.eu) (IPAG, France).

Scientific goals and method

The main scientific objectives of this study are: 1) the study of two different bright areas of Haulani crater (hereafter called ROI3 and ROI4, Figure 1) on Ceres in order to study the mineralogy of the sub-surface materials starting from results inferred by Dawn VIR; 2) the identification of the end-members of mineral mixtures of bright areas and production of endmembers and analogue mixtures with grain size 50-100 µm; 3) the acquisition of reflectance spectra of end-members and analogue mixtures in the VIS-NIR spectral range (0.35-4.5 µm); 4) the analysis of appropriate spectral parameters of reflectance spectra and comparison with those obtained by VIR data.

In particular, spectral parameters of mixtures will be estimated, focusing on Band Center (BC), Band Depth (BD), Full Width Half at Maximum (FWHM) of bands, reflectance level and spectral slopes (estimated between 1.2 and 1.9 μm). The spectral parameters of analogue mixtures have been compared with the VIR data corresponding to the selected area in order to constrain their mineralogical composition.

Data analysis and conclusion

Two analogue mixtures (50-100 μm), here called A3-1 and A3-2 have been produced by using the end-members Antigorite (Mg-phyllosilicate); NH_4-montmorillonite (ammoniated phyllosilicate); anhydrous Sodium Carbonate (Na-carbonate); Graphite (dark component), Illite (Phyllosilicates) to simulate the two bright crater regions (*Figure 1*, i.e. southern floor and red spot or ROI3, i.e. north-east inner crater wall or ROI4). Reflectance spectra of the two mixtures have been acquired in the VIS-NIR spectral range (0.35-4.5 μm) at cold temperature, i.e., from 200 K to 300 K (phase angle of 30°) with the SHINE spectro-gonio-radiometer equipped with the CARBONIR simulation chamber (sample in inner cell filled with few mbar of pure N_2 gas) at the Cold Spectroscopy Facility (CSS) in IPAG, France (*Figure 1*, Right). Finally, the analysis of spectral parameters of the reflectance spectra (mainly relative to the absorption bands at 2.7, 3.1, 3.4 μm) and the comparison with VIR data have been performed. The acquired spectra have been finally converted in radiance factor.

A first analysis shows that the Mixture A3-1 and A3-2 are not well representative due to the high amount of dark components (up to 86 % for A3-1) and missing Na-carbonate bands (for A3-2). Thus, the A3-2 has been modified (by producing the intermediate mixture) and by reaching 9 % for Na-carbonate, 32 % of dark component (i.e. carbon black) and 25 % of NH4-Montmorillonite in the final mixture named as A3-8. Finally, graphite and NH4-montmorillonite have been added to the A3-8 mixture, obtaining the last mixture A3-9. Thanks to carbon black the reflectance level compared with Haulani spectra is more similar. The analysed mixture were heated in the furnace in air at 120°C for 2 hours before each measurement and then placed in the sample holder under vacuum to remove the adsorbed H_2O.

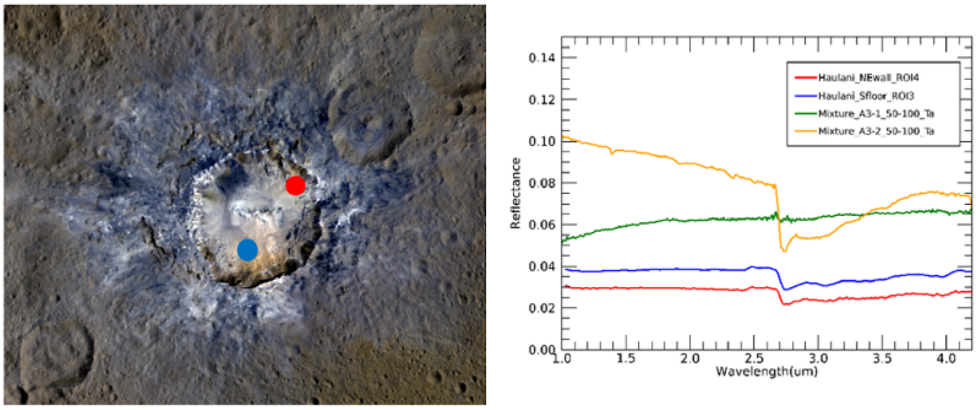

Figure 1. *Left*. Representative spectra of two bright areas: southern floor, called ROI3 (blue) and North-East crater wall, called ROI4 (red). *Right*. Reflectance spectra of ROI3 (green spectrum) and ROI4 (red spectrum) compared to the spectra of mixture A3-1 (green spectrum) and A3-2 (orange spectrum).

The mixtures with a reflectance spectrum similar to the spectra of ROI3 and ROI4 have been analysed in detail. By the spectral analysis, the Mixture A3-8 shows the most representative reflectance spectrum for the Haulani's areas of interest (even if the difference in the reflectance level is probably due to opaque end-member composition) and exhibits BD values for the 2.7, 3.1 and 3.4 μm bands that are the closest one to the ROI3 and ROI4. The width of the 3.1 μm band (3.1FWHM) of A3-8 has a value similar to the ROI4 (about 0.15). In particular, the 2.7 BD is about

13% lower than ROI3 and ROI4, the 3.1BD is 5-9% higher while the 3.4BD has the same value of ROI4 and 11% lower than ROI3. A more in-depth analysis of the data is in progress.

Besides, in order to better reproduce Haulani areas some improvements may be performed, e.g., by adding a low amount of hydrous natrite , e.g. 2-8%, to assess the role of this component found in Haulani bright areas and how it contributes to the 2.7 μm spectral band.

References

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