Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN-029
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Home Institution: IAPS-INAF
TA Facility visited: *Cold Surfaces spectroscopy-CSS (FR)*

Project Title: "VIS-NIR reflectance analysis of analogue mixture representative of young Haulani crater on Ceres to assess the mineralogical composition of bright areas"

Scientific Report Summary.

(plain text, no figures, maximum 250 words, to be included in database and published)

In this project 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 arranging 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 50-100µm for two bright crater regions. The two initial mixtures have been acquired in the VIS-NIR spectral range (0.35-4.5µm) at low temperature, i.e. from 200K to 300K similar to Haulani by using Cold Spectroscopy Facility (CSS) (IPAG, France).

By comparing the spectral parameters (Band Center, Band Depth and FWHM of absorption bands at 2.7, 3.1, 3.4µm, spectral slope in the 1.2-1.9µm range and reflectance level at 2.1µm) with the obtained spectra of mixtures and VIR data, the best candidate to reproduce Haulani' bright areas is the mixture A3-8. That mixture exhibits values for the 2.7BD (Antigorite, Illite), 3.1BD (NH4-Montmorillonite), 3.4 BD (NaCO3) and the 3.1 µm FWHM very close to Haulani ROI3 and ROI4. In order to better reproduce Haulani areas some improvements may be performed in the next future, e.g., by changing the dark component with a mixture of graphite plus magnetite to better reproduce the spectral slope of Haulani or by adding hydrous natrite in low percentage to the mixture, e.g. 2-8% to assess the role of this component found in Haulani bright areas and how is the contribution to 2.7 µm spectral band.

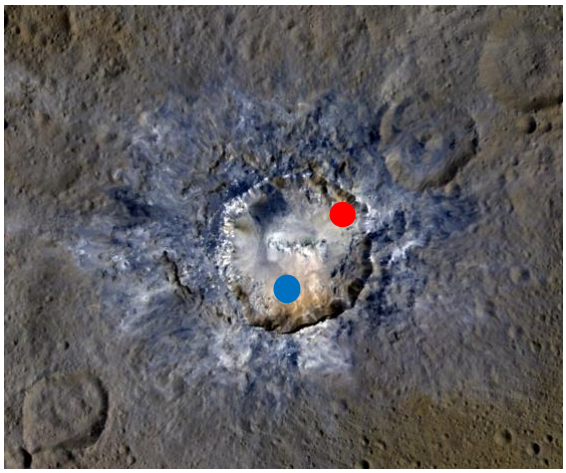
Full Scientific Report on the outcome of your TNA visit

The main objectives of this project is to study of different bright areas of Haulani crater, e.g. southern floor (ROI3) and north-east crater wall (ROI4) on Ceres in order to study the mineralogy composition of the sub-surface materials and comparing the results with Dawn VIR data. Firstly, the end-members have been identified based on previous studies (Tosi et al. 2018, 2019), i.e. Antigorite (Mg-phyllosilicate); NH_4-montmorillonite (ammoniated phyllosilicate); Sodium Carbonate anhydrous (Na-carbonate); Graphite (dark component), Illite (Phyllosilicates) and 2 analogue mixtures have been produced with grain size 50-100µm for two bright crater regions (*Figure 1*, Left: e.g. southern floor_3, north-east crater wall_2). The two initial mixtures have been acquired in the VIS-NIR spectral range (0.35-4.5 µm) at cold temperature, i.e., from 200K to 300K similar to Haulani crater (phase angle of 30°) with Cold Spectroscopy Facility (CSS) (IPAG, France) (*Figure 1*, Right). Finally, the analysis of spectral parameters of reflectance spectra (mainly relative to the absorption bands at 2.7, 3.1, 3.4 µm) and comparison with VIR data has been performed. The acquired spectra have been converted in radiance factor to be compared them with VIR spectral data.

From first analysis, the Mixture A3-1 and A3-2 whose composition is reported in the figure caption in not well representative due to a too much dark components (up to 86% for A3_1) and missing of Na-carbonate bands for A3-2. Thus, the A3-2 has been modified (by producing the intermediate mixtures, i.e. A3-4 and A3-7) 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, the 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 H2O. The mixtures A3-8 and A3-9 were also pressed to test the effect of increasing density on the slope of the spectrum below 2.5µm.

The spectral results of A3-8 mixture (the most spectrally similar to ROI3 and ROI4) after heating and in vacuum at 200K is shown in *Figure 2* with a comparison with Haulani areas and calculated spectral parameters. The mixtures with a reflectance spectrum similar to the spectra of ROI3 and ROI4 have been analysed in detail, in particular the mixture A3-4, A3-7, A3-8 and A3-9. All these spectra have been characterized by means of absorption bands at about 2.7 µm (for the occurrence of phyllosilicates), at about 3.1 µm (due to the NH4-montmorilonite) and at about 3.4 µm (related to carbonates). The spectral analysis of mixtures and ROIs involved the following spectral parameters: the reflectance level at 2.1 µm, the spectral slope in the 1.2-1.9 µm range, in addition to the Band Center (BC), Band Depth (BD) and Full Width Half Maximum (FWHM) of the absorption bands at 2.7, 3.1 and 3.4 µm. By comparing the spectral descriptors of mixtures with the same ones of ROI3 and ROI4, the Mixture A3-8 shows the most similar spectrum. In particular, A3-8 exhibits values for the 2.7BD, 3.1BD and 3.4 BD that are the closest one to the ROI3 and ROI4, as can be observed in the left image of *Figure 2*. Furthermore, the width of the 3.1 µm band (3.1FWHM) of A3_8 has a value like 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.

In terms of reflectance level, the A3-9 mixture is spectrally similar to the ROI3 and ROI4 due to higher abundance of graphite which produces a strong weakening of the spectral bands, making this mixture not plausible to represent the Haulani's areas. ROI3 and ROI4 showed a positive spectral slope, i.e. increasing reflectance level at longer wavelengths, whereas the mixtures produced are characterized by a negative spectral slope, except for mixture A3-8, presenting the strongest spectral reddening. 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-members used) as can be noted in the right image of *Figure 2*, where the spectrum of A3-8 (green spectrum) is compared to the spectrum of ROI3 (blue spectrum) and ROI4 (red spectrum). In-depth analysis has to be performed in the next months to assess the mineralogical variation found in the Haulani bright areas in comparison with the obtained mixtures while the role of hydrous natrite could be assessed in a follow-up of the project to understand the evolution of dehydration process in Haulani. In that case, the dark components should be changed with a mixture of graphite plus magnetite or the percentage of carbon black should be increased in the A3-8 mixture to obtained a more reliable value of spectral slope.



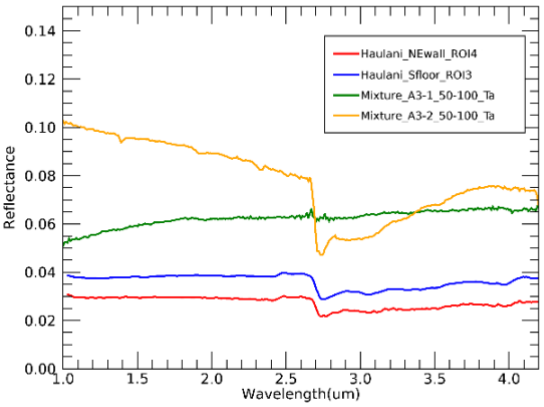
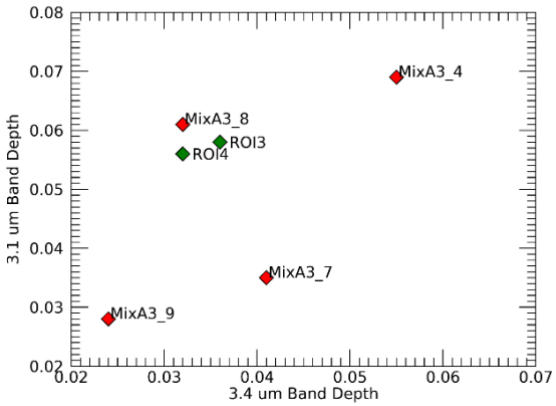


Figure 1. *Left*. Representative spectra of two bright areas: southern floor (blue) and North-East crater wall (red). The composition of mixture A3-1 is: NaCO3 (3.1%), Graphite (86.4%), Antigorite (4.2%), NH4-Mont. (2.9%), Illite (3.4%) while the A3-2 is: NaCO3 (10%), Graphite (18%), Antigorite (36%), NH4-Mont. (28%), Illite (8%). *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).



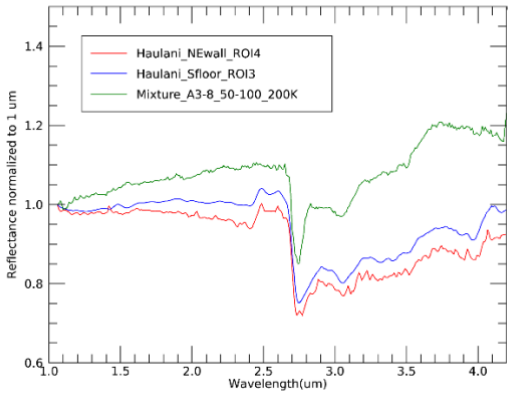


Figure 2. *Left*. Scatterplot of 3.1 µm Band Depth vs 3.4 µm Band Depth for some of the mixtures (red diamond) produced during the on-line visit (A3-4, A3-7, A3-8, A3-9) compared with the areas of interest of Haulani, i.e. ROI3 and ROI4 (green diamonds). *Right*. Comparison between the reflectance spectra of the Haulani southern floor, i.e. ROI3 (blue spectrum) and Haulani North-East crater wall, i.e. ROI4 (red spectrum) with the spectrum of the most representative mixture of ROIs, the A3-8 mixture (green spectrum).

- Give details of any publications arising/planned (include conference abstracts etc.)

- **Abstract EPSC2021 (planned).** *Title*: VIS-NIR reflectance analysis of analogue mixtures representative of different bright areas of Haulani crater on Ceres to assess the mineralogical composition.
- **Scientific Paper (planned).** *Title*: VIS-NIR reflectance analysis of analogue mixtures representative of different bright areas of Haulani crater on Ceres to assess the mineralogical composition.

- Host confirmation

Please can hosts fill in/check this table confirming the breakdown of time for this TA project:

Dates for travel to accommodation for TA visit (if physical visit by applicant)	Start Date of TA project at facility	Number of lab/field days spent on TA Visit pre-analytical preparation	Number of days in lab/field site for TA Visit	Number of days spent in lab for TA Visit data analysis	End Date of TA project at facility	Dates for travel home (if physical visit by applicant)
Departed: (virtual visit) Arrived: (virtual visit)	15-03-21	0	8	2	26-03-21	Departed: (virtual visit) Arrived: (virtual visit)

The host is required to approve the report agreeing it is an accurate account of the research performed.

Host Name	**Dr. Bernard Schmitt**
Host Signature 	The two managers of the CSS facility, Bernard Schmitt (CNRS/IPAG, Grenoble), and Pierre Beck (UGA/IPAG, Grenoble), approve the report and agree that it is an accurate account of the research performed during the virtual visit of the Cold Surface Spectroscopy facility (TA2/DPSF/CSS).
Date	**03/05/2021**

- Project Leader confirmation

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Project Leader Name	**Dr. Fabrizio Dirri**
Project Leader Signature	
Date	**29/04/2021**