Europlanet TA Scientific Report

PROJECT LEADER

Project number: 20-EPN-042
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TA Facility visited: CSS (Cold Surfaces Spectroscopy) at IPAG

Project Title: **Reflectance spectroscopy of ammonium-bearing minerals: a tool to improve the knowledge of the surface of icy planetary bodies**

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

In the frame of the EUROPLANET2024 1st call, reflectance VIS-NIR spectra were collected. Ten different temperature steps were chosen to collect cryogenic data: 270-245-220-180-160-140-120-100-90-270up K. For the samples characterized by a low temperature phase transitions (mascagnite $(NH_4)_2SO_4$, sal-ammoniac NH_4Cl, ammonium phosphate $(NH_4)H_2PO_4$, tschermigite $(NH_4)Al(SO_4)_2 \cdot 12(H_2O)$ and ammonium nitrate NH_4NO_3), the measurement steps have been increased in the proximity of the expected temperature of mineral transformation. Cooling and heating experiments, using the same cooling/heating rate, were performed to break the phase transition *T*. In particular, mascagnite, sal-amoniac and ammonium phosphate monobasic samples showed clear and very interesting spectral bands variations during cooling, indicating that a phase transition occurred. Spectra were collected with three different grain size (150/125 – 125/80 – 80/32 µm) in the spectral range from 1 to 4.8 µm.
The collected data will help on the interpretation of VIR remote spectra from Europa, Pluto's moons, Enceladus and other icy celestial bodies surface where NH_4 minerals have been supposed to occur. Moreover, the study of ammonium bearing minerals and their behavior at very low temperature might give information on how the phase transition affects the bands position and shapes inside the reflectance spectra. Overtones and combinations of NH_4 bands are in the 1-3 µm range, whereas fundamental vibrational modes (v_1 and v_3) are present in the ~3 µm area.

Since the main aim of the research project is to study the reflectance evolution of anhydrous and hydrated ammonium bearing minerals with different anions at low temperatures, the following NH_4 minerals were selected:

- sal-ammoniac NH_4Cl**,**
- mascagnite $(NH_4)_2SO_4$,
- tscermigite $(NH_4)Al(SO_4)_2 \cdot 12(H_2O)$,
- larderellite $(NH_4)B_5O_7(OH)_2\,H_2O$,
- struvite $(NH_4)MgPO_4 \cdot 6(H_2O)$,
- ammonium bicarbonate $(NH_4)\,HCO_3$
- ammonium nitrate NH_4NO_3,
- ammonium carbonate $(NH_4)_2CO_3$,
- ammonium phosphate monobasic $(NH_4)H_2PO_4$

The minerals reflectance spectra were collected at temperatures like those assumed on the surface of the icy bodies. Spectra have a very high signal to noise ratio and do not present absorption bands due to water absorbed during the measurements. All of them show very clear absorption features typical of NH_4 groups. A first analysis of the collected data shows a clear identification of phase transitions in the samples of Sal-ammonia, mascagnite and ammonium phosphate monobasic with the presence of new peaks and/or their change of shape. Examples of the phase transition data collection are given in Figure 1.

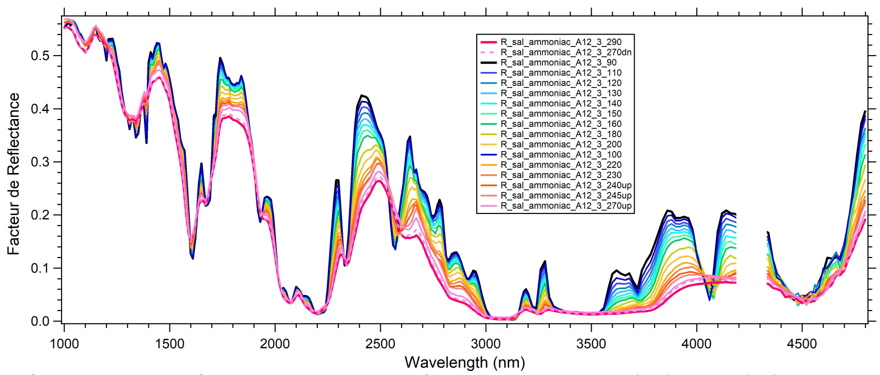

Figure 1 Reflectance spectra of sal-ammoniac collected from room temperature (R*T*) to 90K (L*T*). At ~2550 and ~4070 nm after 240K (red line) additional peaks are presents in relation to λ-transition (order-disorder type). The white area at ~4200 nm corresponds to the removal of atmospheric CO_2 features.

Figure 2 shows an example of how the different particle size and temperature influence the reflectance properties of the sample under examination.

Our (virtual) visit at IPAG-CSS (Grenoble) laboratory was very productive as we collected very accurate data for the whole set of the proposed samples and tested very low temperature phase transition for a few samples more than those proposed (tschermigite and ammonium phosphate monobasic). We investigated reflectance spectra from 290K to ~90K for all the samples with 80/32 µm granulometry. Instead, the other two granulometric size were analyzed at room temperature (~300K), always for all the samples. The quality of the lab is very high, and the researcher staff is highly qualified. Both scientific and lab support allowed us to optimize the time given for the experiments to cover as much sample analysis as possible. Even if Covid-19 does not allow us to perform face-to-face experiments we collected a very large quantity of high-quality data, in remote, thanks to the excellent professionalism of the lab staff (CSS laboratory).

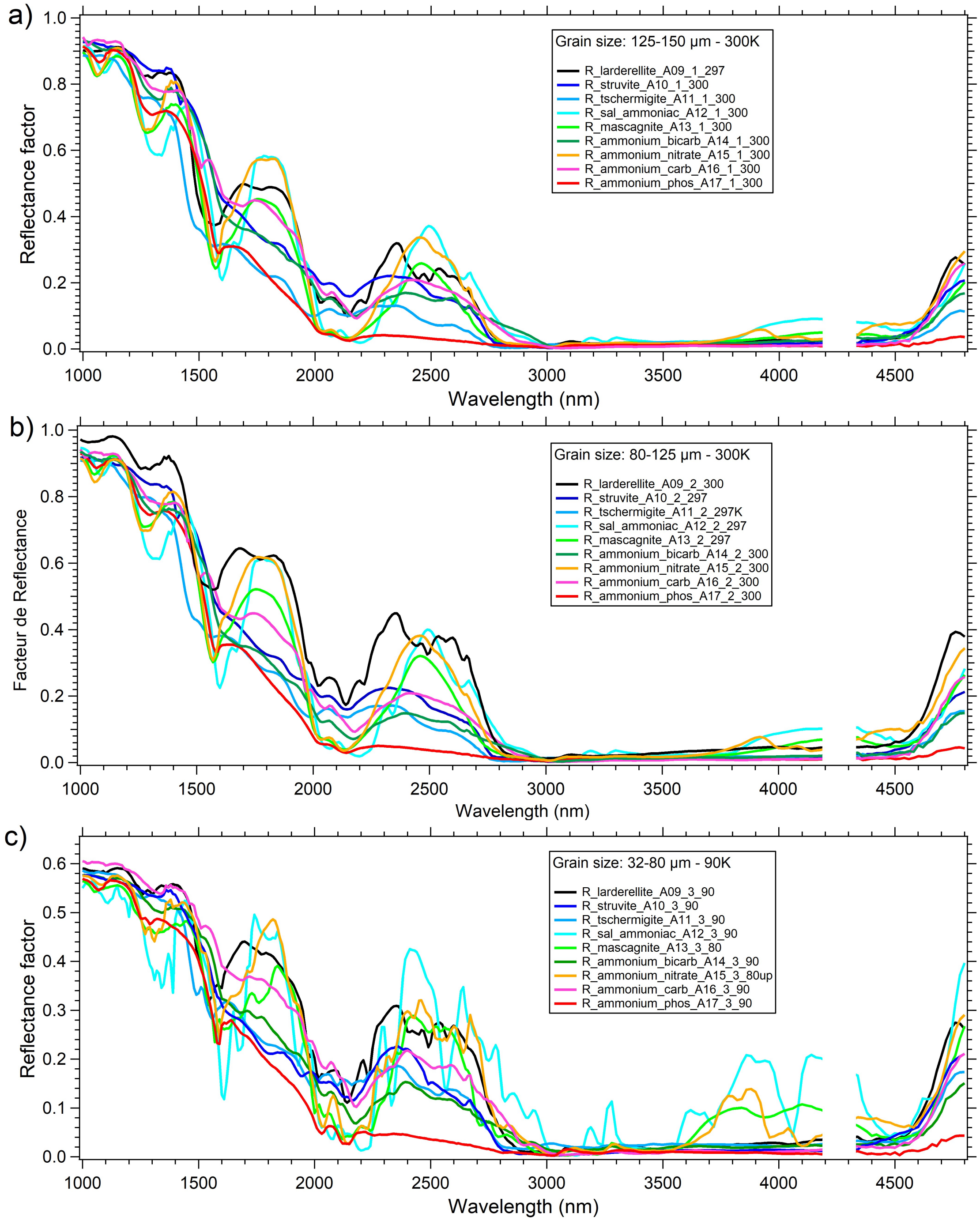

Figure2: a) reflectance spectra of the whole set of samples collected at 300K and grain size of 125/150 µm; b) reflectance spectra of the whole set of samples collected at 300K and grain size of 80/125µm; c) reflectance spectra of the whole set of samples collected at 90K and grain size of 32/80 µm. The white area at ~4200 nm corresponds to the removal of atmospheric CO_2 features.

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

- M. FASTELLI, P. COMODI, B. SCHMITT, P. BECK, O. POCH, A. ZUCCHINI. Ammonium salts reflectance spectra at cryogenic temperature and how distinguish them on the surface of icy planetary bodies. **Planned conference abstract** for *EPSC conference*, Helsinki, Finland, from September Sunday 19th – Friday 24th 2021.

- M. FASTELLI, P. COMODI, B. SCHMITT, P. BECK, O. POCH, A. ZUCCHINI. VIS-NIR analysis at low temperature and different grain size of ammonium bearing minerals. **Planned conference abstract** at EMC conference, Krakow, Poland 29th August – 2nd September 2021

- M. FASTELLI, P. COMODI, B. SCHMITT, P. BECK, O. POCH, A. ZUCCHINI. Reflectance spectroscopy of ammonium-bearing minerals: a tool to improve the knowledge of the icy planetary bodies surface. **paper in preparation to submitted to JGR journal.**

- 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:	09-11-2020	0	10	1	27-11-2020	Departed: Arrived:

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

Host Name	**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	**24/12/2020**

- Project Leader confirmation

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Project Leader Name	**Maximiliano Fastelli**
Project Leader Signature	
Date	**21/12/2020**