EPSC Abstracts
Vol. 13, EPSC-DPS2019-782-1, 2019
EPSC-DPS Joint Meeting 2019

EPSC
EPSC-DPS Joint Meeting 2019
15–20 September 2019 | Geneva, Switzerland

Temperature-dependent VNIR spectroscopy of magnesium chlorides

F. Tosi (1), S. De Angelis (1), C. Carli (1), P. Beck (2), O. Brissaud (2), G. Piccioni (1), B. Schmitt (2).

(1) INAF-IAPS, Via del Fosso del Cavaliere 100, I-00133 Rome, Italy, federico.tosi@inaf.it. (2) Univ. Grenoble Alpes, CNRS, IPAG, 38000 Grenoble, France.

Abstract

In the framework of the EuroPlanet 2020 Research Infrastructure (RI) programme, we took advantage of the CSS distributed planetary simulation facility at IPAG-Grenoble to perform a series of laboratory measurements aimed to acquire VIS-NIR spectra of anhydrous magnesium chloride and magnesium chloride hexahydrate, in three different grain sizes and in a broad range of cryogenic temperatures, representative of real planetary surfaces. These measurements are key to correctly interpret data acquired by spectrometers carried onboard ongoing and future interplanetary space missions aimed at various planetary bodies, particularly the Jovian icy satellites (JUICE, Europa Clipper) and Mars (ExoMars 2020, Mars 2020).

1. Introduction

The surfaces of the icy Galilean satellites Europa, Ganymede and Callisto, dominated by water ice, also show substantial amounts of non-water-ice compounds both at regional scale and at local scale. These satellites will be the subject of close exploration by the ESA JUICE mission and the NASA Europa Clipper mission, which will focus on Ganymede and Europa, respectively.

Among non-water-ice compounds thought to exist on the surfaces of the Jovian icy satellites, hydrated salt minerals have been proposed to exist as a by-product of endogenic processes. Europa and Ganymede's non-ice material was first suggested to result from a complex mixture of sulfate hydrates and other materials [1]. However, in recent years, the traditional hypothesis of the presence of sulfate salts on the surface of Europa has been recently challenged as Mg-bearing chlorinated species (chloride, chlorate, and perchlorate) have been found to provide improved spectral fits in the NIR range [2]. The derived global distribution of Mg-chlorinated salts (and particularly Mg-chloride) is correlated with large-scale geomorphologic units such as chaos and darker areas, thus suggesting an endogenous origin [2].

Chlorides are of particular interest because of their potential to preserve a biological signature through chemical sedimentation. In this regard, hygroscopic salts have been detected in soils in the northern latitudes of Mars, and widespread chloride-bearing evaporitic deposits have been detected in the southern highlands [3, 4, 5]. The key similarity between the formation of chlorides on the Earth and Mars is the presence of water.

2. Laboratory measurements

Following the fifth call of the Europlanet Transnational Access (TA) 2020 Research Infrastructure programme, our proposal was selected in February 2019. We focused on two magnesium chlorides, namely anhydrous magnesium chloride ($MgCl_2$) and magnesium chloride hexahydrate ($MgCl_2 \cdot 6H_2O$). Visible to near-infrared spectral profiles of these compounds were obtained in May 2019 taking advantage of the Cold Surfaces Spectroscopy (CSS) facility at the Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), where such compounds can be measured under cryogenic conditions representative of real planetary surfaces.

Anhydrous magnesium chloride was sieved so as to separate it in three different grain size ranges: 36-50 µm, 75-100 µm, and 125-150 µm. These grain sizes were chosen to: (1) be indicative of typical regoliths known or expected to exist on the surface of the icy satellites, and (2) avoid overlapping between ranges, therefore minimizing particles contamination among the dimensional classes. However, while sieving magnesium chloride hexahydrate, we found that the grains tended to stick together and form agglomerates, ultimately making it impossible to obtain fine grains. Therefore, and different from our original proposal, we had to adapt and measure magnesium chloride hexahydrate at overall larger grain sizes: 150-250 µm, 250-500 µm, and 500-800 µm.

Each grain size was measured with the SHINE Spectro-Gonio-Radiometer facility [6] in the 0.5-4.7 µm spectral range (longer wavelengths, being very noisy, were discarded), with constant spectral sampling of 20 nm and spectral resolution decreasing with increasing wavelength. For each sample, the overall 80-295 K temperature range was acquired in 12 steps varying from 10 K to 25 K, imposed by time constraints. In particular, at the uppermost (room) temperature 295 K, we acquired the spectra both at the beginning (before cooling) and at the end of the ramp, to check for any macroscopic physical-chemical changes in the sample. Being extremely hygroscopic, the anhydrous magnesium chloride samples were put under vacuum for several days before being measured.

3. Preliminary results

Compared to previous laboratory measurements of magnesium chlorides obtained in the same temperature range [7], our spectra were acquired with a lower spectral resolution but in a broader spectral range. In magnesium chloride hexahydrate, the water-related absorption bands centered at approximately 1.20, 1.46 and 1.96 µm display an asymmetric shape and a fine structure that emerges with decreasing temperature. Longward of 2.5 µm, the most interesting observational evidence is the presence of additional absorption bands interspersed by three reflectance maxima, the strongest of which, peaking at about 3.70-3.85 µm, displays a clear dependence on temperature (see **Fig. 1**).
We analyze the spectral behavior of the diagnostic signatures of these two salt minerals as a function of both grain size and temperature, deriving trends related to specific spectral parameters such as band center, band depth, band area, and bandwidth.

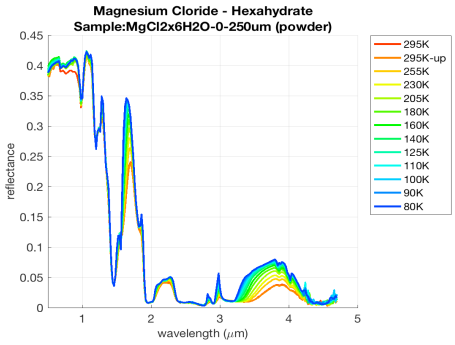

Figure 1. Reflectance spectra of magnesium chloride hexahydrate sieved to a relatively small grain size (150-250 µm). Different colors are indicative of the different temperatures at which the spectra were measured. By overlaying the spectra, one can evaluate the temperature dependence. Major variations are found in the right shoulder of the 1.46-µm band and in the position, strenght and shape of the 3.70-3.85-µm reflectance peak.

Acknowledgements

The set of measurements described in this work is the outcome of the research project: "*Characterization of Mg-chlorides at Cold Planetary Conditions*" (PI: Dr. Federico Tosi), selected and funded in February 2019 in the framework of the European Union's Horizon 2020 Research Infrastructure (RI) programme (http://www.europlanet-2020-ri.eu), under grant agreement No 654208. This work was partly supported by the Italian Space Agency (ASI), ASI-INAF 2018-25-HH.0.

References

[1] McCord, T.B., et al., 1999. Hydrated salt minerals on Europa's surface from the Galileo Near-Infrared Mapping Spectrometer (NIMS) investigation. J. Geophys. Res. 104 (E5), 11827-11852.

[2] Ligier, N., et al., 2016. VLT/SINFONI Observations of Europa: New insights into the surface composition. Astron. J. 151:163.

[3] Osterloo, M. M., et al., 2008. Chloride-bearing materials in the southern highlands of Mars. Science 319 (5870), 1651-1654.

[4] Osterloo, M. M., et al., 2010. Geologic context of proposed chloride-bearing materials on Mars. J. Geophys. Res. 115 (E10), E10012.

[5] Davila, A. F., et al., 2011. A large sedimnetary basin in the Terra Sirenum region of the southern highlands. Icarus 212, 579-589.

[6] Brissaud, O., et al., 2004. Spectrogonio Radiometer for the Study of the Bidirectional Reflectance and Polarization Functions of Planetary Surfaces. 1. Design and Tests. Applied Optics 43 (9), 1926-1937.

[7] Hanley, J., et al., 2014. Reflectance spectra of hydrated chlorine salts: The effect of temperature with implications for Europa. J. Geophys. Res: Planets 119 (11), 2370-2377.