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VNIR Spectral Change of Hydrated Sulfate Minerals at Different Low Temperatures. C. Carli¹, S. De Angelis¹, F. Tosi¹, P. Beck², B. Schmitt², O. Brissaud², S. Philippe², G. Piccioni¹, C. De Sanctis¹, and F. Capaccioni¹, ¹IAPS-INAF, via fosso del cavaliere 100, 00133, Rome, Italy, cristian.carli@iaps.inaf.it, ²IPAG, Université Grenoble Alpes / CNRS, Grenoble, France.

Introduction: Hydrated sulfate minerals have been identified on Mars surface from remote sensing data [e.g., 1] and in-situ rover data [e.g., 2], with strong implications for the climate history and evolution of the red planet. Hydrated minerals, including sulfate salts, have also been suggested as an important surface component to describe specific regions on some Galilean icy moons, like the disrupted and reddish terrains on Europa (e.g., [3]).

Spectral variations of hydrated minerals in the visible and near-infrared range (0.5-2.5 μm) were investigated in the past by several authors. Differences in spectra of hydrated salts were illustrated by [4], whereas [5,6,7] focused on the temperature (T) influence on the vibrational overtone of these phases.

Here we present reflectance spectra of magnesium sulfate hexahydrate (Hexahydrate, $\text{MgSO}_4 \cdot 6(\text{H}_2\text{O})$) and magnesium sulfate heptahydrate (Epsomite, $\text{MgSO}_4 \cdot 7(\text{H}_2\text{O})$), in the overall range between 0.5 and 4.0 μm . Sieved fraction of the samples were prepared in order to disentangle the effects of temperature and particle size. For each interval of particle size, a comprehensive set of spectra at different T were acquired, with absorption bands varying in shape, minima position and intensity. We also discuss the variations of spectral parameters with particle size, T and water content.

Methods:

Sample preparation. We used Hexahydrate and Epsomite (commercial samples with certified “purity level” > 99%). All samples were grounded and sieved in advance at <500 μm . Then we sieved both samples with size smaller than 150 μm , within ca. 25 μm steps, and we prepared for the measurements ca. 5 cm^3 for each sample at 20-50, 75-100, 125-150 μm size.

Reflectance measurements. All spectra were measured at the Institut de Planetologie et d’Astrophysique de Grenoble with a spectro-gonio-radiometer [8]. This bidirectional reflectance spectrometer works in the range 0.4–4.8 μm . Spectra were acquired from 0.5 to 4.0 μm using: incidence angle = 0°, emission angle = 20°, spectral sampling of 0.02 μm in the 0.5–1.2 μm and 3.0–4.0 μm ranges whereas a spectral sampling of 0.01 μm was used between 1.2 and 3.0 μm , where the temperature sensitive overtone vibrations are present. Spectralon® and Infragold® (Labsphere Inc.) were

used as references. Corrections were applied to take into account the standards spectral behavior.

The samples were placed into an environmental chamber with controlled pressure (P) and T. We worked with samples in the following condition: a P of few mbar to minimize the thermal gradient, and T at 93K, 103K, 113K, 123K, 138K, 153K, 178K, 203K, 228K, and 288K.

Data Analysis and Preliminary Results: For both Hexahydrate and Epsomite, we investigated spectral variability as a function of temperature, measuring one particle size at a time. Band parameters (e.g. position, depth, area) of diagnostic spectral features were computed for each spectrum (acquired at a given T), allowing a comparison in terms of band ratio among spectra acquired at different T, and spectra acquired at the same T but referred to different particle sizes. Finally, spectral differences existing between hexahydrate and epsomite, at fixed particle size and temperature, were pointed out. Here we report our preliminary results for:

Temperature Effect. In Fig. 1 we report the spectra of Hexahydrate 20-50 μm . Main spectral variations are observed for the ~1.5, and 1.9 μm absorptions as well as for weaker absorption features at 1.22, 1.75, and 2.22 μm .

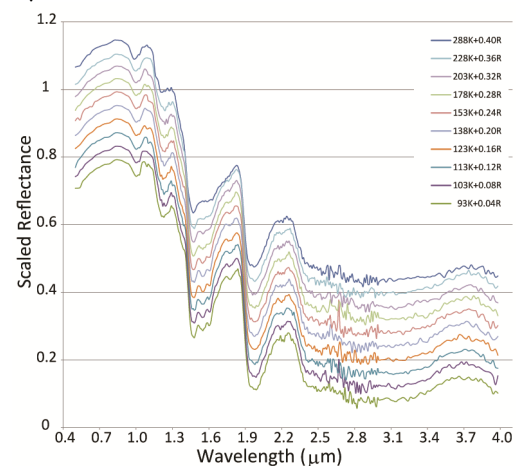


Fig.1- Scaled spectra of Hexahydrate 20-50 μm at different T. Spectra are offset for clarity.

Particle Size Effect. Fig. 2 shows spectra of hexahydrate at 123 K for the different grain sizes. Reflectance decreases with increasing grain size in the NIR, whereas only slight variations are observed in the ab-

sorptions, and in particular in the band depths. The major changes occur in the shape and intensity of the broad 3 μm absorption band.

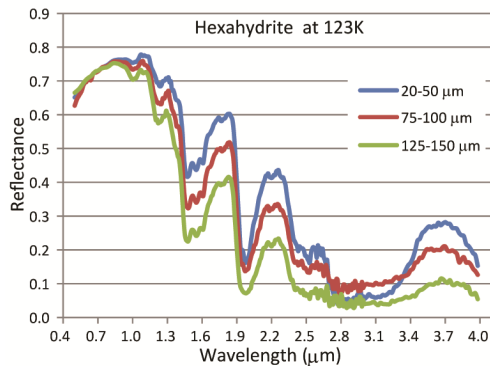


Fig.2- Hexahydrate reflectance spectra at 123K for the different sizes.

Composition Effect. In Epsomite, containing seven water structural molecules as opposed to the six molecules of Hexahydrate, a different T dependence for both ~ 1.5 and $1.9 \mu\text{m}$ absorptions is observed, as well as a different intensity for the $\sim 1.5 \mu\text{m}$ feature (Fig. 3).

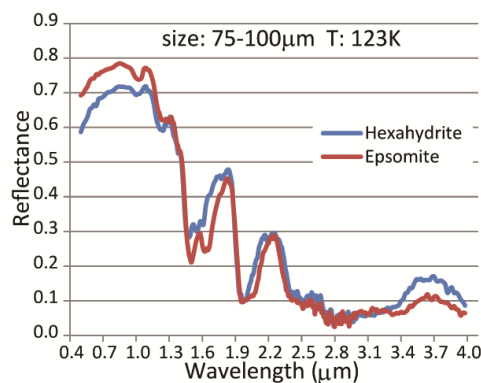


Fig.3- Reflectance spectra of Hexahydrate and Epsomite 75-100 μm , at 123K.

Implications: Variations in temperature, particle size and composition introduce different spectral changes in hydrated sulfate minerals, so an accurate investigation could permit to derive proper indicators useful to correctly interpret the analyzed material. Moreover we will report a detailed analysis of the absorption parameters (e.g. position, depth, width, band area) and investigate their relationship with T, size and water content, to understand how the recognized trends could be useful as, possibly independent, indicators for mapping hydrated sulfate minerals from the remote sensing data of Mars and icy satellites.

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