

STABILITY OF HYDRATE SULPHATE MAGNESIUM UNDER THE SURFACE CONDITIONS OF EUROPA

M. Fernández-Sampedro¹, V. Muñoz-Iglesias¹, E. Mateo-Marti¹, O. Prieto-Ballesteros¹

(¹) Centro de Astrobiología INTA-CISC, España. (fernandezsm@cab.inta-csic.es)

Abstract

Spectroscopic data from Galileo spacecraft show that hydrated magnesium sulphate is present on the surface of Europa. We have studied epsomite ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$) under simulated Europa surface conditions (vacuum, temperature and UV irradiation) in order to understand its stability on the Europa's surface using Raman spectroscopy. Our results indicate that at temperatures ranging from 100 to 200 K, the hydrate state is stable, however from 200 K the epsomite dehydrates. UV irradiation for periods up to 68 h does not produce significant changes.

1. Introduction

Two missions will be launched to the Jupiter's system in the next decade: JUICE by ESA (European Space Agency) and Europa Clipper by NASA (National Aeronautics and Space Agency). Both of them will explore Europa potential habitability.

The components of Europa's surface is mainly water ice and hydrated non-ice material. Spectroscopy results from NIMS (Near Infrared Mapping Spectrograph) on the Galileo spacecraft suggest that the non-ice fraction is form of hydrated magnesium sulphate [1, 2]. These materials are affected by extreme conditions dominating the surface: charged particles within the Jovian's magnetosphere, temperature between 86-132 K, ultra high vacuum (UHV) conditions at the exosphere, and solar and particle irradiation [3, 4]. We investigate the stability of $\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$ (epsomite), under the conditions of Europa's surface, which is relevant for data analysis of future missions to Europa.

2. Methodology

Laboratory simulations were carried out in the Planetary Atmosphere and Surfaces Chamber (PASC) at CAB (Centro de Astrobiología) [5]. Deuterium lamp performed ultraviolet (UV) irradiation with a dose emission of 2.3 W/m^2 . Salt samples were characterized by *in situ* Raman spectroscopy. The analysis allows distinguishing the different hydrated states using the peak position of symmetric stretching vibration mode of SO_4 [6].

3. Results and discussion

Each experimental run was performed on the same sample, without breaking vacuum.

In the first run, the epsomite was put into the chamber that was pumped down to 10^{-7} mbar for 3 h and the sample irradiated with UV during 24 h. The initial spectrum shows peak at 980 cm^{-1} indicating the presence of the pristine epsomite salt. The Raman spectra of epsomite exhibit changes in the hydration states after this time. With more exposure time to UHV, it emerges a peak at 1025 cm^{-1} and the peak at 980 cm^{-1} disappears. The peak at 1025 cm^{-1} indicate the presence of $\text{MgSO}_4 \cdot 3\text{H}_2\text{O}$ (Fig. 1). Under UV irradiation during 24 h more, no changes were observed.

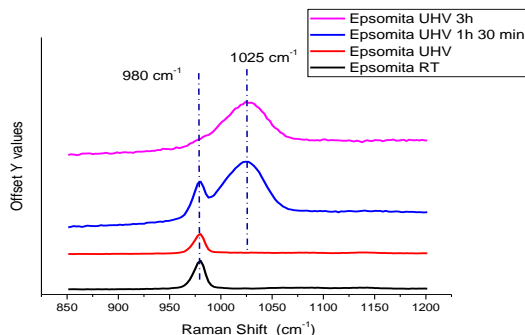


Figure.1. Raman spectrum of epsomite measured inside PASC at different conditions: the salt at room temperature (black spectrum); epsomite when ultra high vacuum is reached (red spectrum); after 1h 30 mins at of 10^{-7} mbar (blue spectrum); after 3h under 10^{-7} mbar (pink spectrum).

In the second run, epsomite was cooled down to 100, 150 and 200 K) while exposed to 10^{-7} mbar and UV radiation. The reference spectrum was obtained inside PASC before lowering the conditions of pressure and temperature and start the UV irradiation (Epsomita RT in Fig. 2). The sample was initially cooled to 100 K and the chamber pumped down to 10^{-7} mbar. The Raman

spectra at these conditions shows a peak at 980 cm^{-1} that still belongs to epsomite. At this point, we switch on the UV lamp while heating the sample. At 200 K the peak at 1025 cm^{-1} appears and that at 980 cm^{-1} starts to disappear (Fig. 2), as in the first run. On the other hand, we were not see significant changes after 68 h of irradiation.

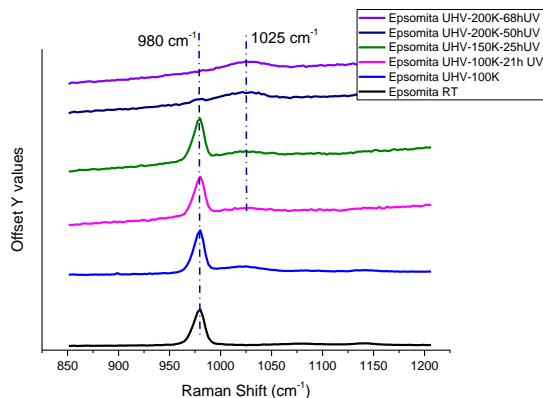


Figure.2. Evolution of the Raman spectra of epsomite measured inside PASC during run 2.

4. Conclusions

Laboratory studies help to better distinguish between different hydrate states of minerals and to understand the processes that modify the surface of this ice moon.

The experiments that we performed with epsomite at Europa's surface simulated conditions confirm that low temperature keeps the stability of the hydrated phase despite of the UHV environment. The UV doses employed did not affect the material stability as well. If thermal activity occur on Europa surface at present, local warming would promote changes in the hydrated minerals. During dehydration, the crystal structure is affected. The triggered structural defects may be responsible for the colour of the Europa salts.

5. References

- [1] McCord T.B., et al. (1998a) Salts on Europa's Surface Detected by Galileo's Near Infrared Mapping Spectrometer. *Science*, Vol. 280, Issue 5367, pp. 1242-1245
- [2] Shirley J.H.; et al. (2010) Europa's ridged plains and smooth low albedo plains: Distinctive compositions and compositional gradients at the leading side–trailing side boundary. *Icarus*, 210(1): 358-384
- [3] Thomas E. C., et al. (2017) Composition and evolution of Frozen Chloride Brines under the Surface conditions of Europa *ACS Earth and Space Chemistry*, 1, 14-23

[4] Hibbitts, C. et al. (2017) Irradiation salts and the color of the nonice material on Europa. LPSC (Lunar and Planetary Science) XLVIII, abstract 2456

[5] Mateo-Marti et al.(2006) *Measurement and Science Technology*,17, 2274-2280.

[6] Wang, A. et al (2006) Sulfates on Mars: A systematic Ramans pectroscopic study of hydration states of magnesium sulfates, *Geochimica et Cosmochimica Acta*, 70, 6.118-6.135

Acknowledgements: This work has been funded by the projects ESP2014-55811-C2-1-P y ESP2017-89053-C2-1P.