Study of brines at the conditions of Europa crust by Raman spectroscopy

Ercilla Herrero, Oscar[1]; Muñoz-Iglesias, Victoria[1]; Prieto-Ballesteros, Olga[1]

(1)Centro de Astrobiología CSIC-INTA. Carretera de Ajalvir km. 4, 28850 Torrejçon de Ardoz. Madrid. Spain (oercilla@cab.inta-csic.es)

Abstract

We have characterized aqueous solutions of Na_2CO_3, $MgSO_4$, NaCl and $MgCl_2$ by Raman. The results show that the solutions, observed at different temperatures (289 and 231 K), have unique and differentiable features between them.

Introduction

Several geophysical/geological evidences point that there is an aqueous ocean or liquid water reservoirs enriched in salts beneath the surface of Europa [1]. Since liquid water is one of the fundamental requirements for the life, as we know it, this Jupiter´s moon is one of the most interesting bodies in the Solar System for astrobiology.

Brines are under different conditions of pressure and temperature. During their ascent, the behavior of these fluids is comparable to a cryomagma, having internal dynamics and suffering different chemical changes (mineral precipitation, chemical differentiations, etc.), similar to the processes that terrestrial magmas can undergo but with different chemical composition [2 & 3].

Methodology

The experimental setup includes a thermostatically controlled high-pressure chamber connected to a hydraulic compressor [4]. For these runs the chamber is equipped with a larger sapphire window of 37 mm x 10 mm that allows the monitoring of the runs both, visually and spectroscopically. Pressure and temperature sensors connected to a Labview program record the thermodynamical path.

The Raman spectrometer HRi550 with a Nd:YAG solid state laser with a wavelength of 532 nm non polarized is used for spectroscopic measurements. Fiber optics connects the spectrometer to a cryogenic probe with a focal lens of 23.6 mm.

We prepared eutectic solutions of the binary systems water-Na_2CO_3, -NaCl, -$MgCl_2$ and -MgSO4. They were put into the high-pressure chamber where were undergone to variations in temperature and pressure simulating the conditions of Europa at different depths.

During the tests, pressure-temperature changes occurring on the samples were monitored, at the same time that they were texturally studied looking across a sapphire window and measuring in situ the Raman spectral signatures to determinate their behavior over the entire run.

Results

The four solutions studied show meaningful changes in the two extreme temperatures used in the tests: 289 and 231 K.

At 289 K ($\pm$ 1K) the spectra shows the water band between 3100 and 3500 cm^{-1}, with lightly variations depending on the salts (Fig.1, a). $MgCl_2$ shows the sharpest curve with a maximum intensity at 3431 cm^{-1}, very similar to what happens in the spectrum of NaCl, whose higher intensity appears at 3436 cm^{-1}. In the spectra of $MgSO_4$ and Na_2CO_3 the maximum intensities move to lower frequencies (3420 and 3412 cm^{-1} respectively) and they have a shoulder at 3256 cm^{-1} which is more evident in the Na_2CO_3 spectrum.

At 231 K ($\pm$ 2 K), the spectra (Fig.1, b) suffer strong changes at the water range (3100 to 3500 cm^{-1}), but still showing the characteristic high intensities for each salt. Both chlorides have close frequencies of their maximum intensities (3411 cm^{-1} for the $MgCl_2$ and

3427 cm^{-1} for the NaCl) and of one of the shoulders (3237 cm^{-1} for the $MgCl_2$ and 3260 cm^{-1} for the NaCl). However, the $MgCl_2$ have the other shoulder at 3151 cm^{-1} and the NaCl a peak at 3135 cm^{-1}. In addition, the $MgCl_2$ has two more peaks at 3463 and 3507 cm^{-1}.

$MgSO_4$ and Na_2CO_3 show remarkable Raman signatures at 3134 and 3143 cm^{-1} respectively (similar to the chlorides). $MgSO_4$ have a peak at 3431 cm^{-1}, while Na_2CO_3 have two peaks at 3259 and at 3363 cm^{-1}, both almost equal to those of the NaCl in position and morphology.

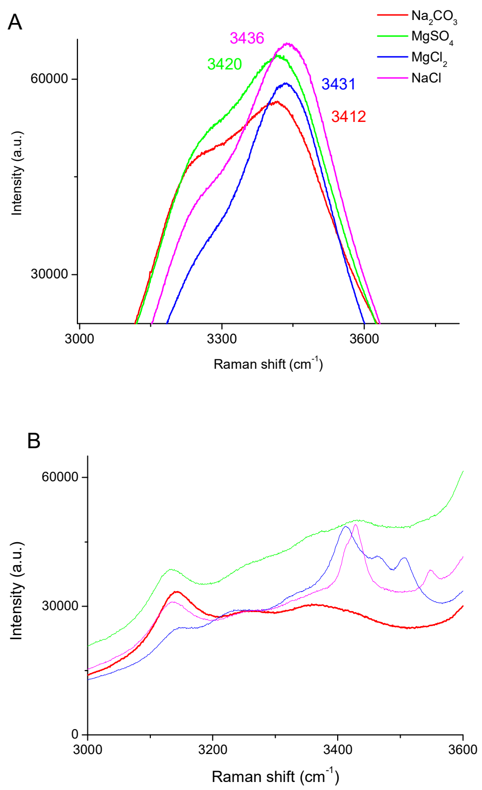

Figure 1: *Spectra of brine samples at 289 K (a) and 231 K (b)*

Conclusions

Changes in the temperature conditions (289 K and 231 K) produce characteristic Raman spectra of aqueous solutions with different dissolved salts.

We are studying all these solutions at the similar temperature range but at pressures up to 150 bar.

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