EXPERIMENTAL SIMULATION OF CRYOMAGMATIC PROCESSES. WATER ICE, CLATHRATES AND SALTS. [1]V. Muñoz-Iglesias, [1]O. Prieto-Ballesteros, [2]I. López. [1]Centro de Astrobiología (INTA-CSIC). Ctra. Ajalvir km. 4, 28850 Madrid, Spain. E-mail: vmunoz@cab.inta-csic.es, prietobo@cab.inta-csic.es, [2]Escuela Superior de Ciencias Experimentales (URJC). C/Tulipán, s/n, 28933 Móstoles, Madrid, Spain. E-mail: ivan.lopez@urjc.es

Introduction: Several evidences indicate that the icy crust of Europa has a renewal mechanism (undergone tectonic and volcanic resurfacing processes) that keep the surface clean of impact craters and with a varied and characteristic geological signature. Extensional deformations and disruption of the surface appear in the form of faults, ridges, *lenticulae* and chaos terrains, and most of them are related to reddish non-icy materials that could be outcrops. Recent works have found signs of potential subduction zones [1,2]. Additionally, thermal activity may exist from the ocean bottom and arrive to the upper layers as hot plumes.

Sulfates and chlorides have been proposed as candidates to form the reddish materials [3,4]. CO_2 has been also observed linked to them [5] and may resolve the problem of the negative buoyancy of a salty cryomagma through a H_2O ice-rich shell [6].

In this work, independently of the original heat source, we simulate the stabilization of several cryomagmas at pressures up to 3.5 MPa and temperatures down to 267 K, followed by a thermal perturbation and a later re-crystallization. As cryomagma, we select one formed by H_2O-CO_2 and other similar but with the addition of $MgSO_4$. For each run, we change different parameters, like the initial CO_2 concentration at the cryomagma or the maximum temperature reached during the heating step, to observe the variety of processes and structures that could occur at the chosen chemical system.

Experimental setup: A temperature-controlled high-pressure cell is coupled to a Raman spectrometer HRi550. The cell is placed vertically and completely filled with the aim to study the pressure changes due to the intrinsic sample volume variations during the crystallization/melting and gas dissolution or clathrate-trapping/exsolution processes. Also the exo/endothermic character of the reactions is observed in the temperature changes. Previous experiments were done with the chamber at horizontal position, which are used in combination with the vertical to describe better the system evolution [7].

Results and Discussion: In general trends, when the cryomagma is cooled, it is observed and measured the formation of CO_2-clathrate, and later of water ice I_h, at the top (Fig. 1). The final decrease in the sulfate concentration at the remaining aqueous solution at lower temperatures indicates the precipitation of sulfates at the bottom. Nevertheless, small differences in the ratio between the compounds of the original cryomagma composition imply particular variations in each run that results in different events. As an example, we show in Figure 2 the Raman spectrum (red line) and the picture taken at 277 K and 2.9 MPa, during the heating step of a cryomagma composed by the ternary system. While at first sight we can see a dark solution with tiny crystals immersed, the spectrum revealed a solution richer in CO_2 dissolved but poorer in sulfate than before sulfate precipitation (black line). In this run, during the first cooling, the amount of CO_2 was not sufficient to stabilize clathrates and, then, the precipitation of sulfates promoted the concentration of the CO_2 at the solution.

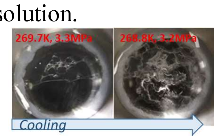

Figure 1. CO_2-clathrate growth at the top of the cell.

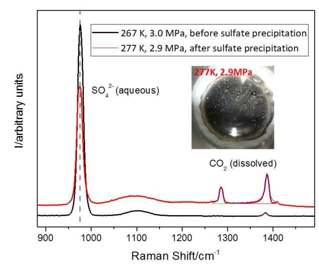

Figure 2. Raman spectra of a 15 wt% $MgSO_4$ aqueous solution with CO_2 dissolved.

Conclusions: The analysis of surface features at the chamber shows several morphologies that could be related to those observed on Europa: e.g. pseudo-circular *lenticulae*. This experimental cryomagmatic study could help constrain the mechanisms occurring under the surface and the structure of the outer part of the Europa's icy crust.

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