

EFFECT OF THE SALTING-OUT ON THE HABITABILITY OF PLANETARY AQUEOUS ENVIRONMENTS. A. S. J. Méndez¹, V. Muñoz-Iglesias¹, F. Izquierdo-Ruiz^{1,2} and O. Prieto-Ballesteros¹, ¹Centro de Astrobiología (INTA-CSIC). Ctra. Ajalvir km. 4. 28850 Madrid. Spain. ²Dept. Química Física y Analítica, U. Oviedo, Julián Clavería, 8, 33006 Oviedo, Spain. (asanjose@cab.inta-csic.es)

Introduction: Salting-out is a phenomenon based on the electrolyte-nonelectrolyte interaction, in which under certain conditions the solvent has a preferential interaction with one of them, decreasing the solubility of the contrary. In the Earth, salting-out may occur naturally when an aqueous solution is enriched with a salt component (e.g. NaCl), causing other solutes to become less soluble and rejecting them, including those necessary for microorganisms. Moreover, salting-out could occur in the opposite way. One example of the salting-out global importance is observed when the terrestrial ocean freezes to sea ice in polar areas. The rejection of the salt produces the concentration of salt and density change, which affects to the global ocean dynamics, and therefore, to oceanic life. Similar effects happen when clathrate hydrates form.

Earth has large sedimentary deposits of natural gas clathrates, commonly made of CH₄, whose existence takes place in two geological environments: a) permafrost regions (where temperatures are very low); b) beneath the sea (in sediments at high pressures) [1]. In these places, the gas exhibits more favoured interactions with water molecules than salts in order to form clathrates, developing the salting-out effect.

Here we show the results of an experimental study simulating the salting-out phenomena in the chemical conditions of Europa and its consequences for the potential habitability of this icy moon.

Methodology: The salting-out experiment is performed in a thermostated high pressure chamber equipped with a sapphire window, which allows the monitoring of the runs by Raman spectroscopy. We evaluate the mineral transformations and record the pressure and temperature changes, which occur during clathrate formation and dissociation in the system H₂O-MgSO₄-CO₂. The initial composition of the aqueous solution is 17 wt% MgSO₄, saturated with CO₂. All relevant processes and phases that happen during the variation of pressure and temperature are monitored, photographed and filmed.

Figure 1 shows the phase diagram of the H₂O-CO₂ system, on which the stability fields of some sulfate hydrates are indicated. It is worth noting that some salt hydrated phases could coexist with clathrates and water ice Ih under given conditions at which salting-out takes place. The green dotted line is the pathway of the run. Raman spectroscopy confirm that significant salting out occurs during the steps number 13-23, which are associated with a drop in pressure due to massive clath-

rate formation. We observe that when clathrates form, the remanent aqueous solution becomes salt-riched. Later, precipitation of different salt hydrates occurs.

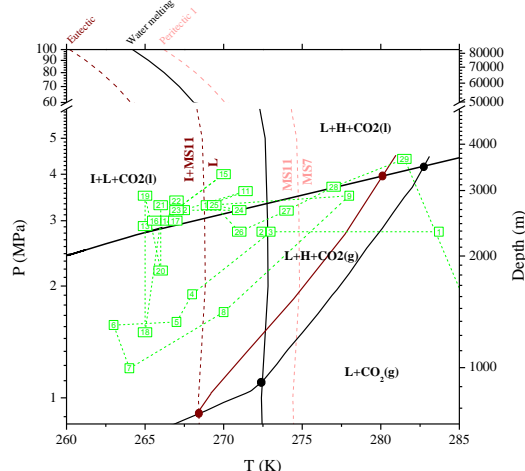


Figure 1. Phase diagram of the H₂O-CO₂ system.

Impact on Europa habitability: Suitable conditions for salting-out may occur in Europa's ocean. The chemical system selected here is an approach to the composition of Europa's fluids, determined mainly from data obtained by Galileo Near-Infrared Mapping Spectrometer (NIMS) and theoretical geochemical modeling. Water ice-Ih, magnesium sulfate salts (less inhibitor of clathrate formation than Cl⁻) and CO₂ are detected, and the last two are associated with structures related to resurfacing events [2, 3, 4, 5, 6]. The experimental model allow us to study the influence of salting-out, and then to make some predictions related to the implications on the geochemistry, ocean dynamics and habitability of Europa [7]. For example, whether there are other compounds in the system, such as soluble organic matter, its concentration would occur. Therefore this phenomena affects the availability of some nutrients in the aqueous solution.

References: [1] Jadhawar P. et al. In: Lombardi S. et al. (eds.), *Advances in the Geological Storage of Carbon Dioxide*, Springer (2006), pp. 111-126. [2] McCord T. B. et al. (1998) *JGR*, 103, 8603-8626 [3] McCord T. B. et al. (1998) *Science*, 280, 1242-1245. [4] McCord T. B. et al. (1999) *JGR*, 104, 11827-11851. [5] Dalton J. B. et al. (2005) *Icarus*, 177, 472-490. [6] Hansen G. B. and McCord T. B. (2008) *Geophys. Res. Lett.*, 35, L01202. [7] Muñoz-Iglesias V. et al. (2014) *Geochim. Cosmochim. Acta*, 125, 466-475.