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Clathrate crystallization from saline cryomagmas in planetary conditions

M. V. Muñoz-Iglesias and O. Prieto-Ballesteros . Centro de Astrobiología. INTA-CSIC. Torrejón de Ardoz, 28850 Madrid. Spain (mugnoziv@inta.es)

Abstract

Gas clathrates have not been detected directly in any planet of the solar system yet, apart from the Earth. However, their presence has been proposed in many planetary environments since the ingredients and formation conditions may be reached. Oceans inside icy satellites are environments where gas clathrates may occur [1]. Here, we investigate the formation and the stability of gas clathrates under Europa aqueous ocean conditions. We assume that the Europan ocean is not pure liquid water, but salty, considering that: a) hydrated salts , which seems to have an endogenic origin, have been detected [2], and b) the evidences of an induced magnetic field [3]. Experiments have been conducted from different compositions of brines and gas clathrates, starting with CO_2 clathrates from $MgSO_4$ brines.

1. Introduction

In this study, the environment of a potential ocean in Europa satellite is simulated. Thermodynamical conditions and presence of gases allow the existence of clathrates below the icy shell, forming part of the mineralogy of the satellite. On the other hand, dissociation of clathrates can be an explanation of both, the presence of the detected gases in the surface and, of some geological features. Phase diagram of the system H_2O-CO_2-$MgSO_4$ is being completed experimentally in the region where Clathrate-Liquid Water-CO_2(gas) are in equilibrium to the region of Clathrate-Liquid Water-CO_2(liquid) in the presence of $MgSO_4$ at several concentrations.

2. Experimental Apparatus, Materials and Procedure

The experimental equipment consists of a stainless steel high pressure chamber. It has room for 2 cc of sample, and has a control temperature system and four ports for making different in situ analysis. Experiments have been performed at isobaric, isochoric and static conditions. A picture of the equipment is shown in figure 1.

Clathrate formation has been performed from aqueous solution of $MgSO_4$ (5%, 10%, 17% in weight) at six different pressures: 18, 20, 25, 30, 50 and 65 bar. Cooling at pressures below 40 bar, clathrate has been formed in the CO_2 gas zone, while experiments above this pressure has been done in presence of CO_2 liquid.

Sudden changes in the pressure imply the formation or dissociation of the clathrate. When clathrate forms, pressure decrease because CO_2 molecules are compressed in the cavities of the crystal structure, while an increasing in pressure occurs during the dissociation [4] and [5].

Fig. 1. Outlook of the experimental equipment

3. Results

It is known that salts act as inhibitors in clathrate formation. In the presence of $MgSO_4$, theoretical models predict a decrease in the dissociation temperature of 2ºC, 1ºC and 0.5ºC depending on the concentration of the brine (17%, 10% and 5% in weight respectively) [1].

4. Conclusions

CO_2-Clathrates in presence of aqueous solution of $MgSO_4$ at different concentrations have been formed and dissociated, obtaining the equilibrium lines in good accordance with the already proposed theoretical models for low pressures. Different clathrate behavior has been found at pressures above 60 bar, requiring a more profound study. Similar experiments with other salts detected by Galileo's Near Infrared Mapping Spectrometer [6] will be carried out since characterization of the clathrate properties will help to detect them in planetary conditions, and understand their role in the activity of the icy moons.

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