DIFFERENTATION OF GAS-RICH BRINY CRYOMAGMAS IN ICY SATELLITES. SIMULATION EXPERIMENTS AT HIGH PRESSURE O. Prieto-Ballesteros[1], J. S. Kargel[2] J. A. Rodriguez-Manfredi[1], F. Gómez[1] and V. García Baonza[3], [1]Centro de Astrobiología, INTA-CSIC. Ctra. Ajalvir km.4, 28850 Torrejón de Ardoz. Madrid. Spain (prietobo@inta.es), [2]University of Arizona, Tucson, AZ, USA [3]Facultad de CC. Químicas. Universidad Complutense de Madrid, Spain,

Introduction: Evidences of cryomagmatism have been detected in some icy satellites such as Europa, Titan and Enceladus. A typical problem about cryomagmatism is that many aqueous cryomagmas have negative bouyancy relative to a pure water ice crust of an icy body. However, some geochemical models show that crusts of these satellites include other components making the crusts denser, and cryomagmas may contain ammonia or exsolvable gases, making them less dense and potentially causing positive buoyancy [1-3]. Segregated cryomagmatic liquids should have lower compositional or temperature-driven densities than the host materials in order to ascend in the crust. In the case of Europa, salt and sulfuric acid hydrates have been nominated as part of the composition of the surface and the crust suported by spectroscopic observations [4-6]. Although significant amounts of these solids can make the ice crust significantly denser, when dissolved they also make the liquid phase denser. Getting the right combination of low density liquid and high density crust and having it all make cosmochemical and petrological sense has been a long-standard challenge, albeit one with various proposed solutions.

We suggest that the formation of clathrate hydrates from an aqueous magmatic chamber enriched in gasses and dissolved ions will result in the differentiation of the cryomagmas into the icy satellites. Then, distilled aqueous cryomagmas, lacking a heavy load of dissolved salts and containing exsolvable gases, could ascend from the more dense residue, decompress, expand, and erupt explosively. We are testing this hypothesis making a set of experiments in a new high pressure simulation chamber.

The High Pressure Planetary Simulation Chamber (HPPSC): A new equipment for the simulation of different planetary environments at high pressure has been built at Centro de Astrobiolgia in Madrid (Spain). The equipment has two different chambers, one for physico-chemical studies which can reach pressures up to 10000 bar (called MINchamber), and other for biological experiments which has higher volume and can reachs up to 3000 bar (BIOchamber). Both can work in the temperature interval from 123 to 600 K. The heating/cooling system is an integrated circuit of liquid nitrogen and electrical resistance heaters.

Each chamber has four different ports to incorporate several sensors. They are used for making in situ analysis and to be able to monotor the processes ocurring during the changes of pressure and temperature. Currently, a Raman spectromete, and a video camera are installed on two ports using sapphire windows. Other sensors able to be incorporated for specific studies are those to measure magnetic susceptibility, electrical resistivity, and mass spectrometry.

The whole system can be controlled automatically, with data logging of the pressure, the temperature and other parameters while the experiment is running.

Testing hypothesis: clathration as a type of differentiation processes in aqueous cryomagmas. When an aqueous cryomagma with some gasses and salts is cooling, it should fractionally crystallize different minerals, including salt hydrates and clathrate hydrates of the gases. Clathrate hydrate formation should occur as soon as they reach the saturation concentration corresponding to the pressure of the dissociation curve. If the confining pressure is less than that and instead the saturation vapor pressure is attained first, then bubble exolution can occur. If that happens rapidly, and the cryomagma is free to expand (for instance, upon eruption), an explosive eruption may ensue.

On the other hand, sulfates compete with clathrates for the water in the aqueous cryomagma. But the evolution of the process will depend on which is the first hydrate which is formed in the interior of the planetary body. Formation of clathrate hydrates removes water from the original solution. So if the solution also contains salts, there will be a higher concentration in ions as soon as the clathrates are formed. Then, clathration could result in a cryomagmatic differentiation. The formation of clathrates would separate the crystals from the more concentrated brine magma by density. If the destruction of the clathrate layer occurred by any movement or fracturation, clean water ice or gas-enriched ice could ascend through the brine to higher levels. Crystallization of gas hydrates generally would cause expansion of the assemblage if water ice is a crystallizing phase, so that would cause tensional stresses on surrounding ice, and it might also drive fracturing, and then drive expulsion of the liquid.

References:

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