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How Does the Cryovolcanism Work on Titan? Some Clues from the Experimental Study of Methane Hydrates Behavior Under Pressure

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Presence of methane in Titan's dense atmosphere is known since the Voyager missions [1]. In-situ analyses from the Huygens probe showed amounts up to 5% near the surface. Such high amounts cannot maintain in the atmosphere without replenishment processes. Methane clathrate hydrates (MH) could trap methane inside Titan, and later release it during cryovolcanic events. Recent observation of a potential cryovolcano on the surface suggests occurrence of such events [2]. However, dissociation of MH in the deep interior is unlikely [3]. Therefore, two independent questions arise: i) what are the MH structures which can eventually go up to the surface through a volcanic vent? ii) is there any way to dissociate MH into gas + water during the ascent? For answering these questions, experimental studies on MH structures and dissociation processes are conducted. New high-pressure experiments are performed in the H2O-CH4 system within a cryostat equipped with an optical sapphire-anvil cell, which allows real-time observation of the sample and in-situ Raman spectroscopic measurements. Pressure and temperature are within the range [0-1.2 GPa, 240-320 K], relevant for the interior of Titan. The first objective is to describe the type of MH that can be observed on Titan's surface. The Raman signature of MH allowed observation of structure II (sII) MH [4] over a wide range of pressure, in addition to the common sI MH. It will be shown that sII crystallizes when amounts of methane are too high to allow crystallization of sI MH, the latter having higher water contents. This result suggests that sII MH could be generated in methane-rich zones of cryovolcanic vents, thus being the MH structure covering Titan's cryovolcanoes. The second objective is to investigate the possible dissociation processes of methane clathrates in Titan's interior. Dissociation cannot occur within Titan according to stability data on the simple H2O-CH4 system. However, ammonia is a MH inhibitor [5]. Nonetheless, this effect remains unexplored. Experimental studies are now in progress to constrain MH inhibition by ammonia. Preliminary results on the ternary system H2O-CH4-NH3 will be presented. References: [1] Tyler G. L. et al. (1981) Science 212, 201-206. [2] Sotin C. et al. (2005) Nature 435, 786-789. [3] Grasset O. and Pargamin J. (2005) Planet. Space Sci.53, 371-384. [4] Schicks J. M. and Ripmeester J. A. (2004) Angew. Chem. Int. Ed.43, 3310-3313. [5] Sloan E. D. (1998), Marcel Dekker: New York, p. 201.