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Titan's evaporites structure and their formation time-scale

D. Cordier[1], Jason W. Barnes[2], T. Le Bahers[3], T. Cornet[4] and A. Ferreira[5]

[1]Institut UTINAM, CNRS/INSU, UMR 6213, 25030 Besançon Cedex, France (daniel.cordier@obs-besancon.fr), [2]Department of Physics, University of Idaho, Engineering-Physics Building, Moscow, ID 83844, USA, [3]Université de Lyon, Université Claude Bernard Lyon 1, ENS Lyon, Laboratoire de Chimie UMR 5182, 6 allée d'Italie, 69007 Lyon Cedex 07, France, [4]European Space Agency (ESA), European Space Astronomy Centre (ESAC), Villanueva de la Canada (Madrid), Spain, [5]Departamento de Engenharia Quimica, Universidade de Coimbra, Coimbra 3030-290, Portugal

Abstract

Hydrocarbons lakes have been discovered in polar regions of Titan (Stofan *et al.* 2007) [1]. Already, Stofan *et al.* (2007) noticed features suggesting the occurence of an evaporation process in the recent past. Barnes *et al.* (2009) [2] performed a detailed study of shoreline features of Ontario Lacus, they interpreted the 5-μm brigth annulus around this lakes as a dry, low-water ice content zone, possibly corresponding to a deposit of organic condensates. Barnes *et al.* (2011) [3] used a sample of several lakes and lakebeds located in a region south of the Ligeia Mare. They got a strong correlation between RADAR-empty lakes and 5-μm brigth units interpreted as low-water ice content areas.
On the theoretical side, Cordier *et al.* (2013) [4] elaborated a model for the chemical composition of the external layer of these possible organic evaporite deposits. This model was based on a simplified theory of dissolution (ideal solution and regular solution theory) and all computations were performed using a time-scale which did not enable any estimation for the depth of deposits layers.

On several crucial points, the model proposed in this paper has been improved compared to Cordier *et al.* (2013) [4]: (1) instead of the uncertain Regular Solution Theory (RST) the PC-SAFT[1] theory has been employed for the calculation of the activity coefficients, (2) the heat capacity terms in the equation

$$\begin{aligned}\ln \Gamma_i X_{i,\mathrm{sat}} = & - \frac{\Delta H_{i,\mathrm{m}}}{RT_{i,\mathrm{m}}}\left(\frac{T_{i,\mathrm{m}}}{T}-1\right) \\ & - \frac{1}{RT}\int_{T_m}^{T}\Delta c_p\,\mathrm{d}T \\ & + \frac{1}{R}\int_{T_m}^{T}\frac{\Delta c_p}{T}\,\mathrm{d}T\end{aligned}$$

[1]Perturbed Chain Statistical Associating Fluid Theory

are now estimated, (3) the molar volumes of the involved organic solutes are here computed thanks to a sophisticated *ab initio* technics based on the Density Functional Theory (DFT) and the Vienna ab-initio Software Package (VASP) 5.3 version. The PC-SAFT theory (Gross & Sadowski, 2001) [5] is widely used in the chemical engineering community, and has been successfully introduced in Titan's studies field by Tan *et al.* (2013) [8]. In our context of solids dissolution in cryogenic solvents (mainly methane and ethane) we have check the performance of PC-SAFT by comparing the outputs of this theory with recently obtained experimental results.

The present model allow us to compute the possible structure and composition of Titan's evaporites as a function of their depth. The features of "bathtub rings" are also discussed and the formation time-scale is estimated in the light of the methane and ethane measured evaporation rates (Luspay-Kuti *et al.*, 2012, Luspay-Kuti *et al.*, 2014) [6, 7].

References

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