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Dissolution origin of Ontario Lacus on Titan: evidences from geomorphological mapping, terrestrial analogs (Namibia) and laboratory experiments

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1. Introduction

Ontario Lacus is the largest lake in the southern hemisphere of Titan, Saturn's major moon. It has been imaged at least twice by each imaging system of the Cassini spacecraft between 2004 and 2010. It was first observed as a dark elliptical feature, 75-km wide and 235-km long, by the ISS (Imaging Science Subsystem) instrument in July 2004 and June 2005 [1]. Hyperspectral cubes acquired by the VIMS (Visual and Infrared Mapping Spectrometer) instrument in December 2007 allowed the identification of liquid ethane on the floor of this depression [2] and the observation of concentric features along its eastern border [3]. A Cassini/RADAR altimetric profile acquired across Ontario Lacus in December 2008 showed that its surface is extremely smooth at 2.17 cm wavelength. It is basically a flat-floored closed depression lying in a shallow topographic basin surrounded by small mountain ranges [4]. In June and July 2009 and in January 2010, the RADAR acquired SAR images that allowed morphological interpretations of Ontario Lacus and its environment [5].
We compiled an interpretative geomorphological map of this region by merging all these datasets and by making comparisons with terrestrial landforms that closely resemble Titan's lakes: the Etosha pans in Namibia [6]. These terrestrial analogs develop through dissolution process under a semi-arid climate that is probably similar to Titan's climate [6,7]. On the basis of this analogy, we discuss the formation process of Ontario Lacus and other lakes on Titan.

2. Ontario Lacus and Etosha pans: flat-floored depressions partially covered by liquids

Surface channels can be seen in the southern part of Ontario Lacus. These channels, seen in infrared data, which document the composition of the few tens of microns below the surface, indicate that Ontario Lacus is not covered by a liquid layer in this part of the depression. Their presence in this non-uniformly dark area of the depression in the RADAR images confirms this hypothesis. We thus conclude that Ontario Lacus is a nearly flat-floored depression, covered by liquids only in those parts that display a uniformly dark signal on SAR images. These areas are therefore interpreted as regions where the depression floor lies slightly below the regional level of the "alkanofer". The floor would be exposed (and possibly dry or wet) over the rest of the depression (Fig. 1).
Similar landforms are encountered in arid/semi-arid places on Earth. In Namibia for example, the Etosha pans (Fig. 2) are partially liquid-covered, flat-floored and closed depressions that lie in a shallow topographic and sedimentary basin surrounded by small mountain ranges. Their climatic and topographic setting is therefore very similar to that of Ontario Lacus. In Namibia, the development of these depressions is controlled by evaporitic crystallization and dissolution, on geological timescales, of a soluble surface layer (calcretes) that covers the topographic and sedimentary basin.

3. Crystallization/dissolution of a surface layer as a formation process for Titan's lakes?

Geomorphological analogies between Namibian pans and Titan's lakes [6,7] may imply that a soluble layer covers those portions of Titan's surface where lakes are present. If the analogy with Namibia is correct, this surface layer would experience dissolution and evaporitic crystallization processes under the influence of repeated liquid precipitation-evaporation cycles under an arid/semi-arid context.

In our forthcoming work, we aim at constraining experimentally the evaporitic crystallization of a surface soluble layer and its dissolution during several precipitation/evaporation cycles of liquid hydrocarbons. These experiments will be done under simulated Titan conditions thanks to the Titan Module designed at the Arkansas Center for Space and Planetary Sciences [8]. This module allowed the first measurements of methane evaporation rates under Titan simulated conditions [9]. We will use simple hydrocarbons candidates for Titan's lakes composition [10], such as methane and ethane as liquids, and acetylene (predicted to be abundant on Titan's surface [11] and detected during the landing of the Huygens module in 2005 [12]) as a dissolved compound that could crystallize during evaporation.

References

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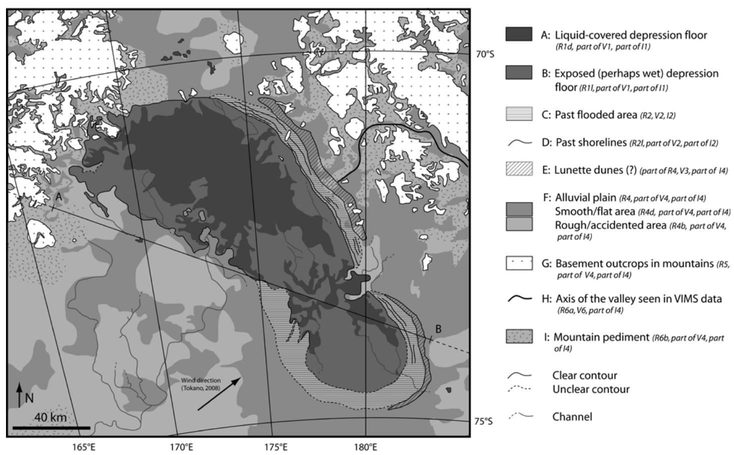

Figure 1: Geomorphological map of Ontario Lacus.

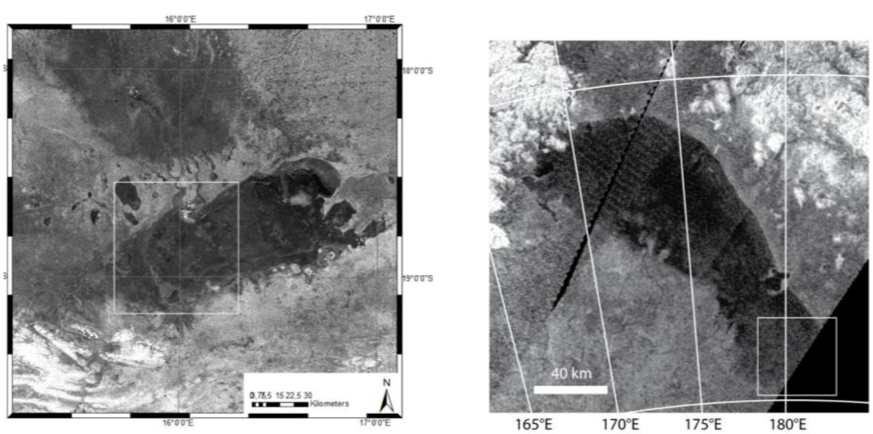

Figure 2: SAR images of the Etosha pans (Namibia, Envisat ASAR image provided by the European Space Agency ©ESA 2009, ESA®) and Ontario Lacus (Titan, image provided by NASA/JPL, PDS Imaging Node).