CASSINI/VIMS OBSERVATIONS OF CRYO-VOLCANIC FEATURES ON TITAN. L. LeCorre[1], S. Le Mouélic[1], C. Sotin[2], J.W. Barnes[3], R.H. Brown[4], K. Baines[2], B. Buratti[2], R. Clark[5], P. Nicholson[6]. [1] Laboratoire de Planétologie et Géodynamique, Université de Nantes et CNRS, 2 rue Houssiniere, 44322, Nantes, France, [2] JPL-Caltech, Pasadena, USA, [3] NASA Ames Research Center, USA, [4] Lunar and Planetary Lab and Stewart Observatory, University of Arizona, Tucson, USA, [5] USGS, Denver, USA, [6] Cornell University, USA. [Email: Lucille.LeCorre@univ-nantes.fr].

Introduction: After more than 3 years in the Saturnian system, the Cassini spacecraft has performed more than 40 Titan flybys. The Visual and Inrared Mapping Spectrometer (VIMS) can observe Titan's surface in 7 infrared windows, which allows us to map surface features at different wavelengths in the near infrared. Although most of the observations are taken at spatial resolution of more than 5 km/pixel, some dedicated flybys have allowed us to image specific targets at resolution down to a few hundred meters, similar to radar resolution. Both modes reveal surface features that can be interpreted as cryo-volcanic features.

The global cycle of methane on Titan is still being worked out. Cassini-Huygens has revealed the presence of rivers and lakes with methane being the primary candidate for the liquid phase. The lakes found on Titan [1] may explain the present amount of methane in the atmosphere [2]. However, the river channels suggest that more liquids fell on Titan's surface and that Titan's atmosphere was richer in methane than it is at present time. Episodic releases of methane by cryovolcanic processes may explain time to time enrichments in methane. After describing the features that could be associated with cryovolcanism, this study investigates the amount of methane that could be released in Titan's atmosphere during these events.

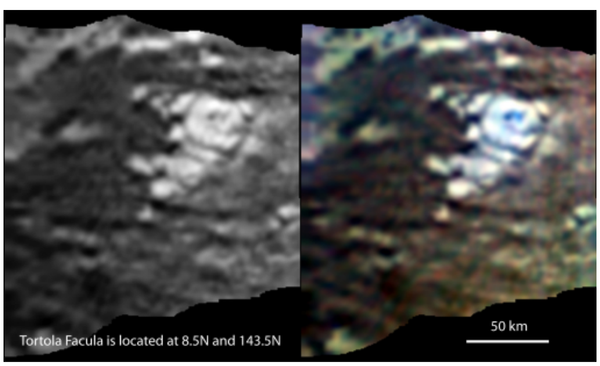
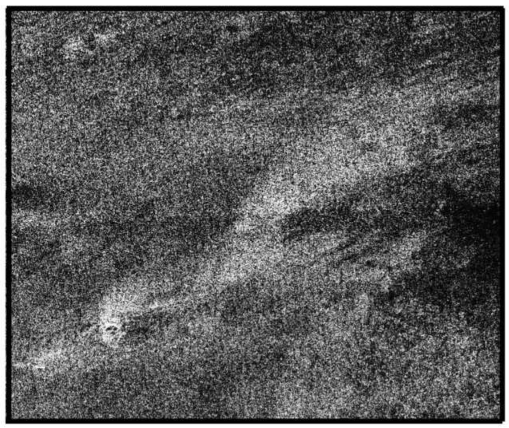


Figure 1: Tortola Facula is a 30 km circular feature with elongated structures to the West. The image on the left is obtained at 2 μm. The false color image on the right uses the following colors: red=2.75 μm; green=2.0 μm; blue=1.6 μm

VIMS observations: Several morphologic features have been tentatively related to cry-volcanic features. The first one is a circular feature observed during Titan's first flyby in October 2004 (Figure 1). This dome-shaped feature has been interpreted as a cryo-volcanic feature based on geomorphology [3]. So far, no similar features have been found although several circular features are intriguing. It raises the question of the timing for these features to be altered. Also, it must be pointed out that observations with a resolution of less than 5 km per pixel are required in order to map this kind of feature. So, far only a few percents of the surface have been mapped with such a resolution.



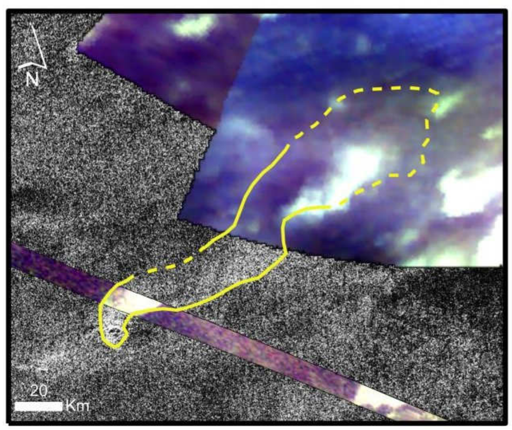


Figure 2: Flow channel observed during T20 with VIMS and radar. At the top, only radar and at the bottom, addition of VIMS data and annotations (RGB: 1.59/1.27 μm, 2.03/1.27 μm, and 1.27/1.08 μm).

The second kind of features is lava flows that seem to come from a volcanic construct. Such a feature was imaged by the radar instrument during the T3 flyby [4]. There is a very good correlation with the high-resolution VIMS T20 observations, which suggests that this radar bright area is a vent. The composition of the material that would have come out from this feature is still being worked out. The correlation between bright radar, which is suggestive of rough material at a 2 cm wavelength, and bright VIMS at 2 μm is not often encountered on Titan. For example, the detailed radar-VIMS study of Sinlap crater [5] does not show such a correlation, which is indicative of a different process.

One must note that the two features described above are quite small. On the other hand, other areas like Thui region [6] and Hotei region [7] are much larger. These areas are very bright at 5 μm and have been interpreted as resulting from cryovolcanic activity [6,7]

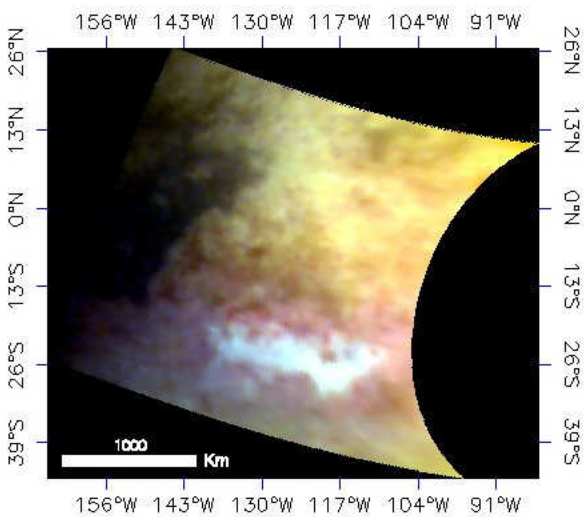


Figure 3: Tui region appears in white in this color composite image using red as 1.55 μm, green as 2.69 μm, blue as 5μm. Data cube from T12 flyby at a distance of 75 000 km from Titan. The Tui region covers about 4,18 10^5 km².

Implications for the amount of methane released in the atmosphere: In this section, we calculate the amount of methane that could be released by the different cryovolcanic features that have been described above. These values can be compared with the amount of methane in Titan's atmosphere which is on the order of 2 10^{17} kg. Following [8], we assume that methane can be released from the interior by methane clathrate destabilization in Titan's crust. Such a process would happen in the upper kilometers (on the order of 2 to 5 kilometers) and is triggered by upwelling hot plumes that form at the ice/ocean interface [9]. In order to get a maximum amount, we assume that ice is saturated in methane (ratio 1:6).

A small feature like Tortola Facula (Fig. 1) could release the volatiles destabilized by a single plume. The thickness of the thermal boundary layer can be considered as the typical diameter of an ascending plume [10], which is a few kilometers in diameter. We also assume that the destabilized area above the plume has the size of the plume. Within a cylinder 2 km in diameter cylinder and 5 km high, there is about 10^{13} kg of methane. This amount is quite small compared to the amount of methane in the atmosphere. If we imagine that every plume can destabilize such a large amount of methane, then this number turns to be on the order of 3 10^{17} kg, which is on the order of the methane in present day Titan's atmosphere. However, it must be pointed out that we haven't seen other features like Tortola Facula in the few percents of Titan's surface that has been images with sufficient resolution. Another possibility that needs to be refined is that methane would come from the deep interior and would be incorporated in the convective cells. In that case, there would be a constant rate of methane supplied in the upwelling plumes. It must be noted that no active zone have been found on Titan.

An area like Tui region potentially produces much more methane. Taking also a thickness of 5 km below this area, we find that the total amount of methane is on the order of 4 10^{17} kg, which is on the order of the amount of methane in the atmosphere. It seems that such an area could provide the methane that exists in the atmosphere.

The VIMS observations suggest that different cryovolcanic processes could exist on Titan. The crude calculations suggest that the large 'hot' features can explain a replenishment of methane. However, a more complete study must take into account other sources and sinks of methane like those due to chemical reactions in the atmosphere and interactions between surface, lakes and atmospheres.

References: [1] Stofan et al. (2007) *Nature*, 445, 61-64. [2] Mitri G. et al. (2007) *Icarus*, 186, 385-394. [3] Sotin C. et al. (2007) *Nature*, 435, 786-789. [4] Lopes R.M. et al. (2006) *Icarus*, 186, 395 – 412. [5] LeMouelic S. et al. (2008), *JGR*, in press. [6] Barnes J.W. (2007) *GRL*, 33, 16204-16207. [7] Barnes J.W. (2005) *Science*, 310, 92-95. [8] Tobie G. et al. (2006) *Nature*. , 440, 61-64. [9] Choukroun et al. (2008) LPSC XXXIX. [10] Deschamps F. and Sotin C. (2001) JGR, 106, 5107-5121.