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Cryovolcanism on Titan: a re-assessment in light of new data from Cassini RADAR and VIMS

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Abstract

Several surface features on Titan have been interpreted as cryovolcanic in origin, however, alternative explanations have been proposed and the existence of cryovolcanism on Titan is still debatable. Here we re-examine candidate cryovolcanic features using a combination of Cassini data sets from RADAR and VIMS to re-examine these features. We find that Sotra Facula is the strongest candidate for a cryovolcanic origin, the interpretation being strongly supported by new topographic data. We find that some features previously interpreted as cryovolcanic are erosional or fluvial in origin and that the nature of other candidate cryovolcanic features is still uncertain.

1. Introduction

Results from the Cassini mission have shown that Titan is a complex world in which interior, surface and atmospheric processes interact, much as they do on Earth, to create and modify geologic features. Among the surface features identified on Titan are candidate cryovolcanic features [e.g., 1, 2]. Alternate, exogenic interpretations [3] have been suggested, particularly as new data have shown that Ganesa Macula, observed in Synthetic Aperture Radar data and interpreted as a volcanic dome or shield [2] does not have the topographic characteristics of either [4, 5]. These new data have motivated the re-examination of putative cryovolcanic features on Titan. Here we use data from the Cassini RADAR, including SAR imaging and topographic data, RADAR radiometry, and data from the Visible and Infrared Mapping Spectrometer (VIMS) to re-examine several putative cryovolcanic features on Titan in terms of likely processes of origin (fluvial, cryovolcanic, or other). We present new evidence that the region known as Sotra Facula contains several cryovolcanic centers, including a tall peak and deep pit, which we consider the best example of a cryovolcanic edifice so far found on Titan.

2. Data

The SAR Titan data, as of late 2010, comprise a rich dataset that covers 48 % of Titan's surface (excluding overlap), well distributed in both latitude and longitude. SAR images are combined with other data, where available, to re-examine candidate cryovolcanic features in light of these other data – specifically, topographic data from the SARTopo [6] and radar stereogrammetry [7]; VIMS data, and radiometry obtained by the RADAR.

3. Results

We find that the region known as Sotra Facula (15S, 40W) is the strongest candidate for a cryovolcanic origin (Fig. 1). Sotra Facula was observed in SAR mode in the T25 and T28 flybys. The initial interpretation [5] was of a cryovolcanic edifice consisting of a partial depression ~30 km in diameter, adjacent to a relatively steep-sided mountain or dome ~40 km across. Lopes et al. [5] also described a bright-edged lobate unit interpreted as a flow ~ 180 km long, extending to the north of the edifice. RADAR stereogrammetry [7] obtained from the crossover swaths T25 and T28, allowed detailed analysis of the whole region, showing that the mountain at the southern end is ~1km high and the adjacent depression is ~1.5 km deep and oval in shape rather than circular (therefore unlikely to be of impact origin). A second major peak, also ~1 km high, is found in a larger are of flow-like textures to the north of Sotra Facula itself, and separated from it by a 200 km wide band of dunes.The flows are generally subdued in elevation, with thicknesses for the most part no greater than 100 m, but the flow area

contains apreviously unsuspected high terrain in the form of a 40 by 70 km ovoid with outer rim up to 0.8 km high and interior depressed below the surrounding terrain. The three areas of highest elevations are aligned in a NNE trend, to which the long axis of the middle ovoid is roughly parallel.

The topography, combined with SAR imaging and VIMS data, strongly suggests that the Sotra Facula region is an area of multiple cryovolcanic features: two volcanic mountains, a deep non-circular depression associated with the southernmost Mons, a flow that appears to come out of this Mons, other non-circular depressions between the two Montes, and a series of flows surrounding the northern Mons. Of particular interest is the fact that the area is totally devoid of fluvial channels, making a fluvial origin for the flows unlikely. Moreover, the dune field that lies in between the two Montes indicates that this is a dry region. The fact that the depressions are not circular makes an impact origin unlikely for these features, and there is no evidence of any impact ejecta blanket surrounding the depressions. Furthermore, the occurrence of Titan's deepest known depression and several lesser depressions in such close proximity to some of the most substantial mountains on Titan make it unlikely that impacts—so rare elsewhere on Titan— could explain these features.

The region known as Hotei Regio is a second strong candidate for a site of cryovolcanism on Titan. It was proposed as a cryovolcanic region [8, 9, 10] on the basis of morphology (numerous overlapping flows) and possible brightness changes in the infrared [8]. However, an alternative origin was proposed by Moore and Pappalardo [3] who argued that the presence of many radar-bright valleys, likely fluvial in origin, suggest that the flows were formed by fluvial and sedimentary activity. Topographic data from RADAR stereogrammetry) revealed that the flows are topographically high, with heights of ~200 m above the base level at which the channels are found. This is more consistent with a cryovolcanic than fluvial origin, as it implies a complex rheology, such as what might be expected for ammonia-water-methanol mixtures [11].

The combined datasets have shown that other areas initially proposed to be cryovolcanic most likely have other origins: Tortola Facula, Ganesa Macula, and Winia Fluctus. The origin of several other features proposed as candidate cryovolcanic features remains uncertain. These include the flows at Tui Regio, Western Xanadu, and Rohe and Ara Flucti. Analysis of data sets available for these features is ongoing. Our results so far indicate that cryovolcanism was not ubiquitous on Titan, though it is possible that features may not have yet been identified due to the relatively low resolution of the datasets.

References

[1] Sotin, C. and 24 colleagues: Release of Volatiles from a Possible Cryovolcano from Near-Infrared Imaging of Titan. Nature, 435, 786-789, 2005.

[2] Lopes, R.M.C. and 43 colleagues: Cryovolcanic Features on Titan's Surface as Revealed by the Cassini Titan Radar Mapper. Icarus, 186, 395-412, 2007.

[3] Moore, J.M. and R.T. Pappalardo: Titan: An Exogenic World? Icarus, 212, 790-806, 2011.

[4] Kirk , R.L., and 16 colleagues: Three-Dimensional Views of Titan's Diverse Surface Features from Cassini RADAR Stereogrammetry, Lunar Planet. Sci., XL, Abstract #1413, Lunar and Planetary Institute, 2009.

[5] Lopes, R.M.C. and 24 colleagues: Distribution and Interplay of Geologic Processes on Titan from Cassini RADAR Data. Icarus, 205, 540-588, 2010.

[6] Stiles, B.W. and 19 colleagues: Determining Titan Surface Topography from Cassini SAR data. Icarus. 202(2), 584-598, 2009

[7] Kirk, R.L. and 17 colleagues: High resolution topographic models of Titan's surface derived by radar stereogrammetry with a rigorous sensor model, Icarus, in revision, 2011.

[8] Nelson, R.M. and 28 colleagues: Saturn's Titan: Surface change, ammonia, and implications for atmospheric and tectonic activity. Icarus, 199, 429-441, 2009.

[9] Wall, S.D. and 15 colleagues: Cassini RADAR Images at Hotei Arcus and Western Xanadu, Titan: Evidence for recent cryovolcanic activity. Geophys. Res. Lett., 36, L04203, 2009.

[10] Soderblom, L.A. and 12 colleagues: The geology of Hotei Regio, Titan: Correlation of Cassini VIMS and RADAR, *Icarus*, *204*, 610–618, 2009

[11] Kargel, J.S., Croft, S., Lunine, J., Lewis, J., 1991. Rheological Properties of Ammonia-water liquids and Crystal Slurries: Planetological Implications. Icarus 89, 93-112, 1991.