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Geomorphic Units on Titan: constraints on the origin of Undifferentiated Plains

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Abstract

We present the global distribution of the major classes of units and, where there are direct morphological contacts, describe how these classes of units relate to each other in terms of setting and emplacement history (Fig. 1). In particular, we focus on constraining the origin of the Undifferentiated Plains, which cover large expanses of Titan's surface (Fig. 2). We examined and evaluated different formation mechanisms, including (i) cryovolcanic origin, consisting of overlapping flows of low relief or (ii) sedimentary origins, resulting from fluvial/lacustrine or aeolian deposition, or accumulation of photolysis products created in the atmosphere. The results from our analysis suggest that a sedimentary origin is the most likely, with all the aforementioned processes possibly contributing.

1. Introduction

The Cassini-Huygens mission has revealed the surface of Titan in unprecedented detail. The Synthetic Aperture Radar (SAR) mode on the Cassini Titan Radar Mapper is able to penetrate clouds and haze to provide high resolution (~350 m spatial resolution at best) views of the surface geology. The instrument's other modes (altimetry, scatterometry, radiometry) also provide valuable data for interpreting the geology, as do other instruments on Cassini, in particular, the Imaging Science Subsystem (ISS) and the Visual and Infrared Mapping Spectrometer (VIMS). Continuing the initial work described in Lopes et al. [1] [1], we have established the major geomorphologic unit classes on Titan using data from flybys Ta through T92 (October 2004-July 2013) [2]. The major types of units are Hummocky/mountainous terrains, Undifferentiated Plains, Dunes, Labyrinth terrains and Lakes. The oldest classes of units are the Hummocky/mountainous terrains, which consist of mountain chains and isolated radar-bright terrains. The Labyrinth terrains consist of highly incised dissected plateaux with medium radar backscatter. The Undifferentiated Plains are younger than both Hummocky/mountainous and Labyrinth. Dunes and Lakes are the youngest major unit types on Titan; no contact is observed between the Dunes and Lakes but it is likely that both processes are still active. We have also identified individual features such as craters, channels, and candidate cryovolcanic features. Characterization and comparison of the properties of the unit classes and the individual features with data from radiometry, ISS, and VIMS provides information on their composition and possible provenance. We can use these correlations to also infer global distribution on regions not covered by SAR. This is particularly important as SAR data will not provide complete coverage of Titan by the end of the Cassini mission.

2. Undifferentiated Plains

We can place constraints on composition of the Undifferentiated Plains using results from VIMS, which senses the top few microns of the surface [e.g. 3;4], and radar radiometry, which has a greater penetration depth [e.g. 5].

The RADAR radiometer data indicate a strong compositional similarity in all high-emissivity terrains on Titan such as those of the Undifferentiated Plains, Labyrinth, and Dunes.

VIMS results show that Undifferentiated Plains and Labyrinth terrain albedo shape and values look very similar to one another, with very high values at all wavelengths. These albedo results show the similarity in composition between the Undifferentiated Plains and the Labyrinth terrains, in addition to the compositional similarity between the Dunes and interdune materials. The composition of the material of the first group (Plains-Labyrinth) appears, at least in the top few microns, to be very

different from the albedo-dark second group (Dunes-interdunes).

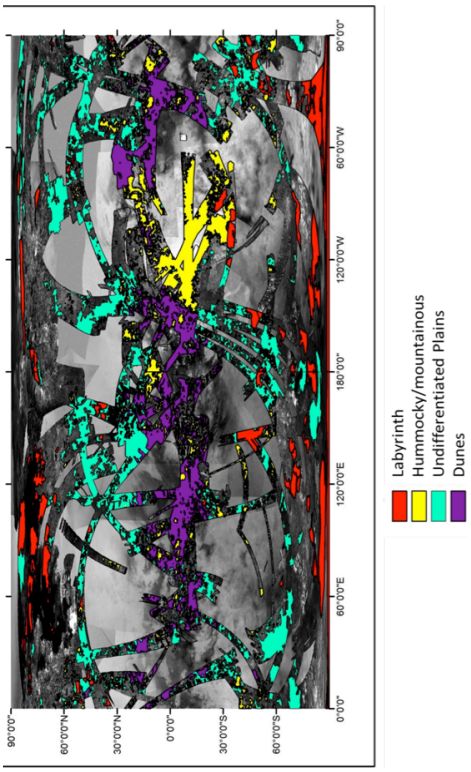

Figure 1: Global distribution of Undifferentiated Plains (green) compared to other major geomorphologic units on Titan (Dunes, Labyrinth, and Hummocky/mountainous). Map is at 1:1,500,000.

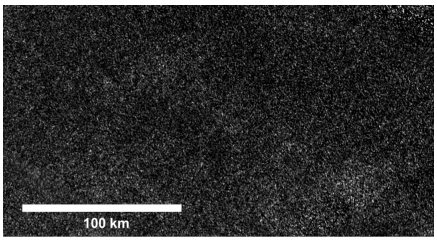

Figure 2: Example of Undifferentiated Plains ("blandlands") in Cassini SAR data. These plains appear relatively homogeneous and dark in the SAR data. This image shows an area of ~36,000 km^2 centered near (16.3ºN, 217ºW).

3. Summary and Conclusions

Our analysis, using both VIMS and RADAR SAR and radiometry data, shows that a sedimentary origin for the Undifferentiated Plains is more compatible with the data than a cryovolcanic origin. The Undifferentiated Plains and Labyrinth regions show strong similarities in the radiometry and VIMS data, implying commonalities in surface composition. Analysis of all the data sets shows differences between the composition of the Undifferentiated Plains and Dune/interdune areas, suggesting that the Undifferentiated Plains cannot be composed simply of unmodified wind-blown dune materials. We propose that deposition from fluvial erosion, as well as from aeolian materials [6] and photoplysis products, has played a significant part in the origin of the Undifferentiated Plains.

Acknowledgements

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