**Exploring the inner structure of Titan’s dunes from Cassini Radar observations**

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**INTRODUCTION**

- Images taken by the Cassini Synthetic Aperture Radar (SAR) and Visual and Infrared Mapping Spectrometer (VIMS) and Imaging Science Subsystem (ISS) have depicted extensive linear dunes in Titan’s equatorial regions [1,2] (Figure 1).
- Although the geomorphology of the dunes has been studied from Cassini SAR images, it has not been possible to investigate their internal structure in detail as yet. The single polarization (HH), Ku-band (2.17 cm), Cassini SAR data available for Titan [3] solely does not provide enough information to examine the shallow layering and, consequently, formation history of the dunes on Titan.
- The purpose of this study is to qualitatively assess the internal structure, relative age and formation history of the dunes on Titan.

**METHODOLOGY AND HYPOTHESIS**

- GPR surveys of terrestrial linear dunes, combined with trench digging on site, have provided an insight to the aeolian layering within these features [4].
- The GPR data collected by our team provide evidence for difference in the internal layering between older (and consequently larger) and younger (and consequently smaller) dunes. GPR radargrams of individual dunes in the Siwa (left) and Qattaniya (right) dune fields in Egypt are shown in Figure 2. Both dunes are observed to be layered in the first 4 m of the subsurface; however, the larger dune in the Siwa dune field is much more finely layered than the smaller dune in the Qattaniya dune field, which consists of coarser internal layers.

**TERRESTRIAL ANALOG SITES**

- For comparisons with Titan’s dunes, we focus on three sites having linear dune fields in the Egyptian desert: 1) Great Sand Sea in central-southwestern Egypt (~28°N, 26°37′E), 2) Siwa dunes in north-western Egypt (~25°54′N, 26°17′E) and 3) Qattaniya dunes in north-eastern Egypt, west of Cairo (~30°18′N, 30°24′E) (Figure 4).

**RADAR CHARACTERIZATION OF TITAN’S AND EARTH’S DUNES**

- For studying the dunes on Titan, we have used backscatter data from the Cassini Radar instrument, which is a Ku-band (13.7 GHz, 2.17 cm wavelength), linearly polarized device [3]. More than 50% of Titan’s topography has been imaged by the SAR. The resolution of the SAR dataset varies from ~350 m to ~1500 m.
- For our SAR characterization of the analog sites in Egypt, we used C-band (5.6 cm wavelength) backscatter data from the Spaceborne Imaging Radar (SIR)-C, in Multi Look Complex (MLC) format in both quad polarizations (HH, HV, VH and VV) and dual polarizations (HHVV) polarization modes, with a range resolution of 50 m and azimuth resolution of 50 m (~2 m) [5]. We have also utilized elevation data with a resolution of 1 arc-second (~30 m) from the Shuttle Radar Topography Mission (SRTM) [6].

**DIELECTRIC PROPERTIES OF TITAN’S DUNES**

- To successfully demonstrate that the Cassini Ku-band backscatter data can provide information about sub-surface layering in the dunes on Titan, we first needed to quantify the depth to which the Cassini Ku-band microwaves can penetrate through Titan’s surface.
- Based on analysis of the Cassini VIMS data, Titan’s dunes consist of water ice and organics (tholins), with lesser water ice than the rest of Titan [7]. Assuming the water ice fraction for the dunes varies between 10-40%, the tholin fraction between 40-70% and the air between 20-30%, we calculated the effective dielectric constant using the Maxwell Garnet dielectric mixing law for multiphase mixtures with spherical inclusions [8]. The loss tangent and penetration depth were then calculated using Eq. 1 and 3.

**VARIATION OF RADAR BACKSCATTER WITH ELEVATION ACROSS DUNES**

- We used the ENVI software for processing all of the radar imaging datasets used in this study. For each site, we stacked layers of the SIR-C band backscatter data, SRTM elevation data and SRTM C-band backscatter data (example shown in Figure 7).

**CONCLUSIONS**

- The backscatter-height dependence exhibited by Titan’s dunes is similar to the sub-surface structure of the terrestrial dunes, the Qattaniya dunes, indicating coarser layering and a relatively younger age for the dunes on Titan.
- Our results indicate coarse layering in the top 3 meters of Titan’s dunes, which could be the result of deposition by multiple massive dust storms in the past on Titan, which would be capable of depositing meters of organic dust. Such storms in the past would indicate fast paleo-winds regimes from large dust gradients on Titan.

**REFERENCES**


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