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Morphotectonic features on Titan and their possible origin

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Abstract

Spectro-imaging and radar measurements by the Cassini-Huygens mission suggest that some of the Saturnian satellites may be geologically active and could support tectonic processes. In particular Titan, Saturn's largest moon, possesses a complex and dynamic geology as witnessed by its varied surface morphology resulting from aeolian, fluvial, and possibly tectonic and endogenous cryovolcanic processes [eg. 1]. The Synthetic Aperture Radar (SAR) instrument on board Cassini spacecraft, indicates the possibility for morphotectonic features on Titan's surface such as mountains, ridges, faults and canyons [2,3]. The mechanisms that formed these morphotectonic structures are still unclear since ensuing processes, such as erosion may have modified or partially obscured them. Due to the limitations of the Cassini-Huygens in the acquisition of in situ measurements or samples relevant to geotectonics processes and the lack of high spatial resolution imaging, we do not have precise enough data of the morphology and topography of Titan. However we suggest that contractional tectonism followed by atmospheric modifications has resulted in the observed morphotectonic features. To test the possibility of morphotectonics on Titan, we provide in this work a comparative study between Cassini observations of the satellite versus terrestrial tectonic systems and infer suggestions for possible formation mechanisms [4].

1. Introduction

Morphotectonics correlate the relation of landscape morphology to tectonics [5] by studying the direct effect of the solid body's movements on landform evolution. Erosional processes that may influence the shape of the feature after its formation hamper their identification, also rendered difficult due to the lack of *in situ* data and sample acquisition. Thus, a comparative study between Titan and Earth since both display -at least in shape and structure- similar surficial expressions could shed some light to our understanding of Titan's surface morphology and tectonic processes.

2. Observations

The basic morphotectonic surficial features identified on Titan are mountains [e.g. 3;2], ridges [6], faults [7] as well as rectangular drainage patterns controlled most likely by tectonism which resemble the terrestrial ones in shape and structure but not in size.

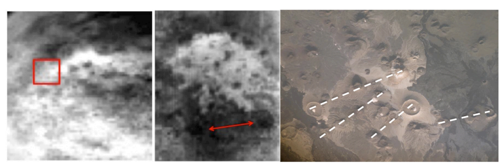

Figure 1: Area on Tui Regio (left) with possible tectonic influence; two dark patches on Hotei Regio (middle) interpreted as volcanic caldera ridges (NASA/JPL/University of Arizona); Harrat Khaybar (right), massive volcanic terrain in western Saudi Arabia, the dashed lines indicate the linear trend of the volcanic vents suggesting tectonic control (NASA).

Each of the major features observed has been accompanied by a proposed genesis mechanism with the most prevalent ones being those that suggest crustal shrinking either due to localized compression or folding or repeated episodes of extensional and compressional tectonism.

Table 1: Major cryovolcanic candidates and their association with tectonics.

Location	Name	Description	Tectonic-like features
20°S, 130°W	Tui Regio	Flow-like region	Trending dark linear marks on VIMS data [8]
26°S, 78°W	Hotei Regio	Volcanic-like terrain	Circular tectonic features [1]
15°S, 42°W	Sotra Facula	Volcanic-like terrain	Topographic elevation, mountain-like structures (unidentified)

3. Summary and Conclusions

The morphotectonic structures presented hereinabove seem to be the most important elevated as well as carved features seen on Titan. Most of the mountain features are concentrated in equatorial latitudes between 30°S and 30°N while possible cryovolcanic spots (Fig. 1) are located within the same zone (20°S-30°S) (Table 1) and are likely associated with surface stress field. Additionally, linear features are observed between the region 10°S-26°S. Thus, within the zone 30°S - 30°N around the equator, elevated as well as fractured crustal features are observed while this association indicates a morphotectonic pattern. Their shape, size and morphology as well as their location over specific zones, suggest that they are tectonic in origin. The triggering mechanism that leads to such dynamic movements is possibly to be Titan's tidal forces especially due to the concentration of morphotectonic structures around the equator and if their age is relatively young. We have argued here, that all these features are related to surface stress fields. In analogy with terrestrial morphotectonic structures, the shape, size and morphology of Titan's observed mountains, ridges, hills and linear features such as faults, major fractures and canyons probably originate through some form compressional and extensional tectonic activity. Titan's rigid crust and the probable existence of a subsurface ocean create an analogy with terrestrial, at least surficial, plate tectonics. From the detailed account of the landforms traced from the data of the Cassini mission and discussed hereabove, and even if the picture is still incomplete awaiting for more data, it appears that similarities do exist between surficial features observed on the Earth and on Titan [4].

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