MOUNTAINS ON TITAN AS EVIDENCE OF GLOBAL TECTONISM AND EROSION.

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Introduction: Saturn's moon Titan as observed by the Cassini Radar instrument is replete with remarkably Earth-like landforms. These are likely a result of the paired processes of the release of internal heat in the form of volcanism/tectonism and the release of atmospheric energy and fluids, in the form of winds, rainfall, and surface erosion, as we see on Earth [1,2]. The landforms that reveal the integration of these processes most clearly are the mountains. These features protrude above the surface and are visible as radar bright-dark pairs, indicating illumination on the instrument-facing slope and corresponding shadows on the opposite slope [3,4]. We describe general morphologies of mountains, their heights and means of obtaining these through radar, and their distribution across Titan's surface.

Mountain morphologies and preliminary classifications: Mountains on Titan as classified and discussed here include all forms that protrude noticeably from the surface. We do not, however, include karstic or volcanic depressions, lake margins, or river valleys in otherwise flat terrain, all of which are major landforms but generally exhibit features depressed rather than raised above the local base level. The mountains on Titan that appear to have formed tectonically, perhaps through crustal compression [5], are different from blocks and ridges on other icy planetary bodies in that they do not appear to maintain their original, tectonic form as clearly as they do on, for example, Miranda or Iapetus. Rather, Titan's mountains, which are likely composed of mainly water ice [6,7] bear patterns of ancient, eroded mountains on Earth, such as serrated and isolated peaks, accompanying river valleys, and surrounding blankets of eroded materials. All of these features indicate that rainfall, most likely methane/ethane in composition, has had a significant effect on the morphology of the landform.

Mountains do not appear uniformly similar across Titan, however, and we have developed a preliminary classification scheme to better evaluate their similarities and differences: (1) radar-bright and isolated peaks in high contrast to surrounding terrain (typically radar-dark, and thus smooth), (2) radar-bright, high, elongated mountain ranges, (3) homogenous, nondescript radar-bright features with no or low slopes or peaks, (5) expansive, "crinkly-terrained" or hummocky, radar-bright regions that have been incised by fluvial erosion, and (6) platform-like, elevated features of varying radar brightness that are often incised by river valleys (in places with rounded heads [1]) and can have a regional slope, as evidenced by aligned drainages (Fig 1). This classification scheme will help us make comparisions and conclusions about processes on and within Titan, and will be refined by comparisions with similar features on Earth and other planets. We plan to eventually construct a geomorphologic map based on such a scheme.

Fig. 1. Several different types of mountains are seen in this image from the T39 flyby of the south polar region (12/07). Central left, high peaks and ridges (type 1,2), bottom portion, "crinkly" terrain (type 5), top right, plateau dissected by rounded drainages (type 6).

Mountain heights from radarclinometry: We use radarclinometry, or shape-from-shading, to determine slopes and heights of isolated mountain peaks across Titan, made possible by detailed knowledge about the operation of the Cassini Radar. We assume a model backscatter law for mountains to be $\sigma_0(i) \propto \cos$ (inc angle), which gives nearly constant backscatter across a range of incidence angles and agrees well with scatterometry results [4]. We then integrate slopes to obtain topography. The mean height of over 70 mountains measured in regions scattered across Titan is 864 m, with maximum heights of 2000 m [3]. Results will be discussed for heights of other mountains that we estimate to be 2000 m or slightly greater. Where suitable data needed to make direct comparisons are available, estimated mountain slopes and heights from 1-D and 2-D radarclinometry, altimetry, SAR-topo, and stereoanalysis agree, and the statistics gathered over broader areas are also consistent [8,9].

That mountains on Titan are fairly well eroded and are not excessively tall may at first indicate (1) all mountains formed at the same time, during a period of excessive tectonism, and have since been eroded to the same degree, (2) mountains formed at different times but in the relatively distant past, and have since been subjected to the same amount of erosion, perhaps due to climate change or (3) there is an optimal degree of erosion that all landforms approach. However, there are more subtle differences between landforms that indicate questions of variations in formation ages, erosion rates, and internal structure should be pursued.

Mountain distributions and global tectonism: A survey of mountain distributions across Titan can yield information about global or regional tectonism. Based on Cassini Radar coverage (currently approximately 25% of the surface biased slightly toward equatorial and northern hemispherical latitudes), mountains may have a slight concentration at equatorial regions [10], although there are steep mountains in the north polar lakes region. A survey of orientations of mountain ridge crests, long axes of ranges, radar-bright materials with associated mountains, and connections of adjacent peaks reveals that many of these features are oriented roughly W-E (Figure 2). If tectonism is responsible for these morphologies [5], then compressional or extensional forces may have acted perpendicular to Titan's equator and latitudinal lines, for yet unknown reasons.

References: [1] Stofan E.R. et al. (2008) *LPS XXXIX*, this volume. [2] Lunine J.I. et al., *Icarus*, in press. [3] Kirk R.L. et al. (2005) *LPS XXXVI*, 2227. [4] Radebaugh J. et al. (2007) *Icarus*. [5] Mitri G. et al. (2008) *LPS XXXIX*, this volume. [6] Lunine J.I. and Stevenson D.J. (1987) *Icarus*. [7] Soderblom L. et al. (2007) *PSSS*. [8] Kirk R.L. and Radebaugh J. (2007) *ISPRS WG IV/7*, abstracts. [9] Styles B. et al. (2007) *EOS, Fall Suppl*. [10] Lopes R.M. et al. (2007) *OPS Workshop*, Abstracts.

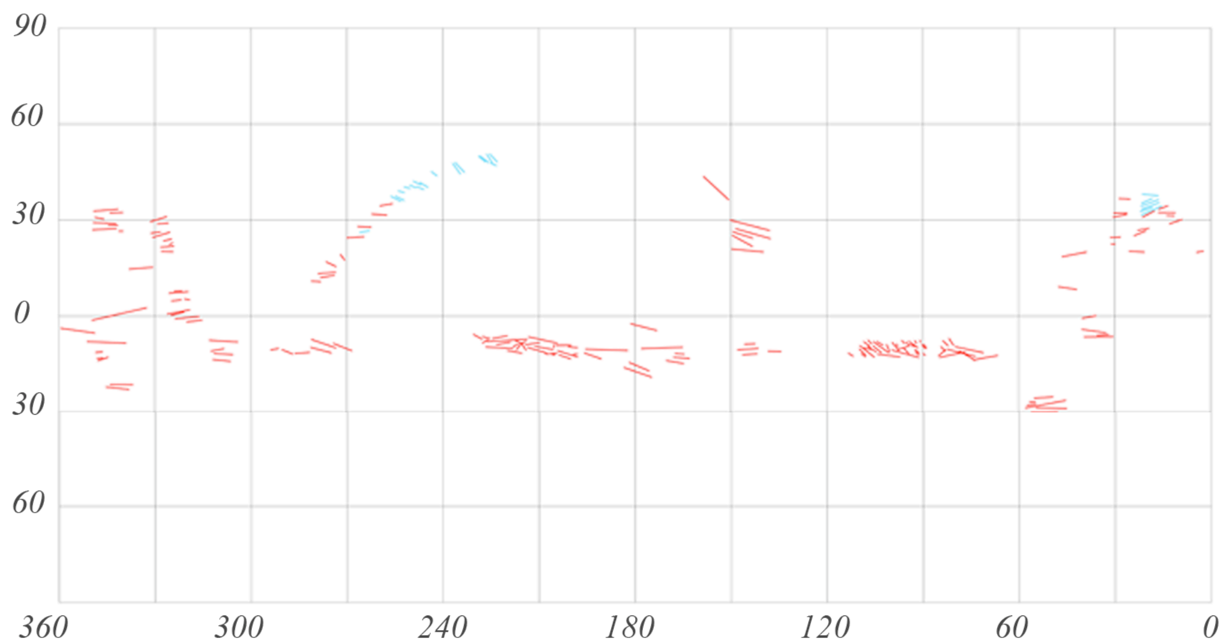

Figure 2. Lineations associated with Cassini Radar mountain features, such as peak traces, long axes of mountain ranges, peak chains (blue traces), and orientations of other radar-bright materials containing mountains.