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Mountain Building on Titan

G. Mitri (1), M. Bland (2), R. M. Lopes (1), and A. P. Showman (2)

(1) Jet Propulsion Laboratory, California Institute of Technology, (2) Lunar and Planetary Laboratory, University of Arizona (Giuseppe.Mitri@jpl.nasa.gov)

Cassini remote sensing observations on Titan yield evidence of features of relatively high topography interpreted as mountains [Radebaugh J. et al. (2007) Icarus, 192, 77-91]. The mean topographic height observed with the Cassini Radar instrument during T3 (February 2005) and T8 (October 2005) is 864 m and the topography ranges between 123 m to 1930 m. Both isolated blocks and linear chains of mountains 200 - 300 km long are observed on Titan's surface. During the T20 flyby, the VIMS instrument observed large mountain chains (150 km long and 30 km wide) south of Titan's equator [Sotin C. et al. (2007) LPS XXXVIII, Abstract 2444].

Four scenarios for orogenesis on Titan have been proposed [Radebaugh J. et al. (2007) Icarus, 192, 77-91]: (i) compressional crustal deformation; (ii) horsts; (iii) secondary impact ejecta; and, (iv) mesas. The presence of mountain chains suggests that the dominant mountain building process is compressional crustal deformation. Successive denudation-accumulation controlled by erosion and weathering can modify the morphology of mountains though time. Here we investigate whether the compression crustal deformation can produce topography on Titan.

Present radiogenic and tidal heat flux from the rocky interior is actually $\sim$ 0.007 W m^{-2}. During Titan's early history, the heat flux was higher [Tobie G. et al. (2005) Icarus 175, 496-502] leading to the assumption that Titan has experienced a cooling over time. We demonstrate that Titan's secular cooling produces global radial contraction of the satellite. Consequently, crustal compressional deformations of the ice-I shell can occur.

We simulate the two dimensional compressional crustal deformation in a state of

plane strain of Titan's ice-I shell using the Tekton (version 2.3) finite-element code. The model considers elastic-viscous-plastic and composite rheologies of the water ice [Bland M. T. and Showman A. P. Icarus 189 (2007) 439-456]. We show that compressional crustal deformation as a consequence of Titan's radial contraction produces a topographic height of the order of hundreds m to several km, depending on the strain, strain rate and temperature gradients. For example, for an initial two-dimensional domain of 100 km per 25 km, strain of 0.158, strain rate of 5×10^{-15} s^{-1}, and a temperature gradient in the ice-I shell of 10 km K^{-1}, we simulate a topography of 2.6 km and a wavelength of $\sim$ 50 km. This topography encompasses the observed topography on Titan.