DIAPIRS & CANTALOUPES: LAYERING AND OVERTURN OF TRITON'S CRUST;

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It has recently been proposed that cantaloupe terrain formed as a result of instability and overturn (i.e., diapirism) of Triton's crust [1]. Morphologic evidence implicates compositional layering within Triton's crust as the driving mechanism for this overturn. Here, we review the morphologic evidence for this origin and evaluate some of the implications.

GEOLOGY

Cantaloupe terrain is comprised of well over 100 individual structural cells 25-40 km wide. Cells are elliptical to kidney-shaped in planform, and although closely spaced, they are interfering and do not crosscut each other. They most closely resemble the structural patterns observed in terrestrial diapirs such as salt domes (e.g., in the Great Kavir [2]), granitoid batholiths (e.g., in the Pilbara Block, W. Australia [e.g., 3]), and experimental centrifuge diapirs [2]. Diapirs are driven by density inversions in the crust resulting from either compositional or thermal induced density contrasts or both. Two geologic units have been identified in the structural cells; the rough central area or core (unit A), and the smoother annulus (unit B) surrounding the core. A third geologic unit, C, forms the matrix between the cells and may be the youngest unit. Unit C is comprised of numerous parallel ridges 20%-50% darker and 300-800 higher than the cell units. The first two units were stratigraphically lowest, having risen and pierced the overlying unit. All three units appear to be comprised of rheologically and compositionally distinct materials, indicating that compositional layering of the crust is the more likely cause of diapirism on Triton, although thermal convection may also be important.

STRATIGRAPHY

Evidence for diapirism on Triton opens a window into the crustal structure and stratigraphy. In simple systems, spacing between cells is related to the thickness of the overlying unit by a factor of ~2.6 [4]. Cell spacing averages 47 km, indicating a thickness of ~20 km for the denser overlying unit. Also, it is generally the case that the total thickness of all layers involved in the overturn is approximately on the order of the mean spacing of the diapirs, which implies a total thickness of 40-50 km. From a maximum formation time of ~2 b.y., we estimate a maximum crustal viscosity [4] of $<10^{22}$ Pa•s.

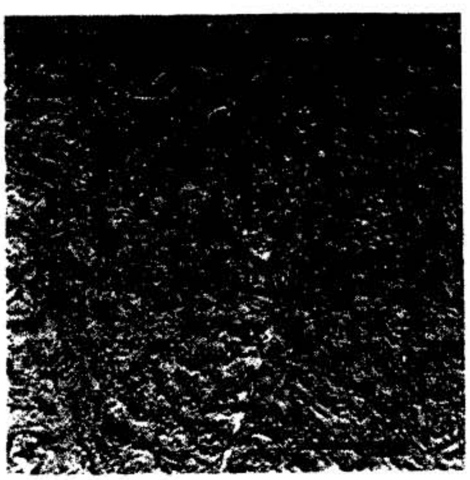
Many of the ridges in the matrix unit parallel cell margins; others form complex subparallel sigmoidal patterns reminiscent of fold belts on Earth. These are interpreted as forming from the buckling of relatively thin layer(s) of mechanically anisotropic material. As a first approximation, we use buckling theory [e.g., 4], where the wavelength of the folding is related to the thickness of the layer, to estimate the thickness of the surface unit. For a wavelength of ~3 km for the ridges, the estimated thickness of the buckled layer is 35-45 meters. The wavelength is also dependent on the viscosity contrast and usually decreases (by as much as a factor of 2) from the initiation wavelength as buckling progresses. Thus, we suggest that the thickness of the dark surface layer is probably between 35 and 100 meters. At this point, however, we stress that in our analyses we have assumed the crust was isothermal. The viscosities of most ices are highly temperature dependent [e.g., 5]. Hence our viscosity and thickness estimates should be considered approximate as more sophisticated analyses are being pursued.

In principal, the less dense cores of the diapirs should be elevated above the denser intercellular matrix. While crumpling could initially produce a thickened zone of accumulated material, equilibrium should eventually be restored. Our preferred interpretation is that the thin buckled surface unit is both more viscous and less dense relative to underlying portions of unit C. This encouraged buckling and discouraged downward drag on this thin surface unit. The bulk of the 20-km-thick overlying unit C would be denser than the cell units A & B, however. Complete piercing of the matrix by the cell units and of the outer unit B by unit A implies that these structures are mature or advanced diapiric structures. Spacing and widths of diapir cells in cantaloupe terrain increase northward, which may indicate a thickness change. Many cells in the northern portion of cantaloupe terrain have partially merged, suggesting they may form a diapiric canopy structure [2].

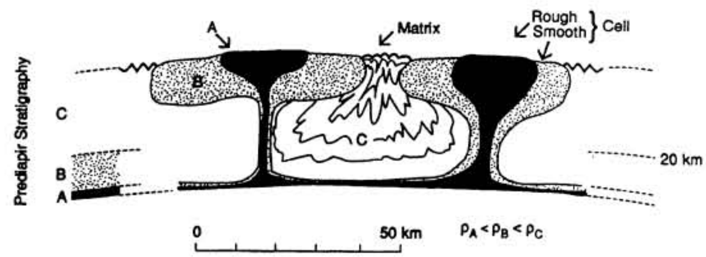
ORIGINS OF LAYERING

Diapirism appears to have been one of the first major events recorded in the crust that was regenerated following global melting [e.g., 6]. This overturn exposes compositional layering, including formation of a density inversion, in Triton's crust which may contain a record of the reconstruction of Triton's crust. At least three distinct layers have been identified to date. Although we are unable, as yet, to unambiguously identify the composition of these layers, they probably include layers composed of ice phases other than (and some denser than) water ice. The maximum crustal viscosity estimate ($<10^{22}$ Pa•s) is consistent with a bulk crustal composition dominated by H_2O, NH_3, or CO_2 [5, 7, 8] ices phases (or possibly simple hydrocarbons that may also be present [9]). Triton may have possessed a thick volatile rich atmosphere during the period of global melting [6, 10]. Among the consequences of this episode may have been the deposition or concentration of CO_2, NH_3, or simple organic compounds on the surface, either volcanically or through atmospheric condensation. Whatever the composition, the evidence of compositional layering in the crust is important evidence of the complexity of Triton's evolution.

[1] Schenk, P., & M.P.A. Jackson, *Geology*, in press, 1993. [2] Jackson, M.P.A., et al., *Geol. Soc. Am. Memoir 177*, 1990. [3] Hickman, A., in *Archean Geology*, Geol. Soc. Austr., p. 57, 1981. [4] Turcotte, D., & G. Schubert, *Geodynamics*, Wiley & Sons, 1982. [5] Kirby, S., et al., *J. Phys. C*, 48, 227, 1987. [6] McKinnon, W., EOS, 73, 190, 1992. [7] Durham, W., et al., pers. comm. [8] Clark, B., & R. Mullins, *Icarus*, 27, 215, 1976. [9] Shock, E., & W. McKinnon, *Icarus*, in press, 1993. [10] Lunine, J., & M. Nolan, *Icarus*, 100, 221, 1992.



Cantaloupe Terrain



Cross-section of Triton's crust