THE LUMPY SHAPE OF ENCELADUS AND IMPLICATIONS FOR THE INTERIOR.

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Introduction: The Voyager-Cassini discoveries at Enceladus [e.g., 1] have prompted a revolution in our understanding of small icy satellites. Key to this understanding is the state of the interior of these bodies. To what extent are they hydrostatic or homogenous (laterally or vertically). Our best information on these issues comes from density and gravity studies in combination with global topography. Limb profiles [2] have provided a few dozen linear tracks and give an excellent constraint on the gross shape of Enceladus. Here we report on regional areal mapping of the topography of Encaladus at kilometers scale or better, using stereo imaging and shape-from-shading. These data allow us to investigate regional variations in topography and correlate them with geology.

Topographic Mapping: Several large-scale stereo imaging opportunities exist with available Cassini data. The overlap between orbit 4 and 11 global mapping coverage and between orbit 4 approach image mosaics provides the best regional coverage, while several smaller mosaics at higher resolution provide supplemental coverage. These data sets overlap by 50% or more but provide digital elevation model (DEM) [3] mapping coverage of part of the south polar terrains, relict polar terrains located near the equator, and much of the older cratered terrains with vertical and horizontal resolutions of ~100 m and ~1000 m, respectively, over at least 50% of the surface. Shape-from-shading mapping [3] compliments these data (especially from orbit 3 mapping) and extend mapping to another 15% or so of the surface (albeit without reliable long-wavelength control.

Topographic data can be used to investigate geologic phenomenon at all length-scales, from individual structures such as faults and small craters to regional variations, including large tectonic features and geoid variations. Here we focus on regional scale variations.

Topography - Tectonic Features: Our data allow us to explore the topography of some of Enceladus' more prominent tectonic features. Several long fracture systems extend northward from the margin of the active south polar terrains [4]. One of these, along longitude 250°W is very well covered by our DEM. The trough is 1 km or deeper along its entire length, but the flanking rims are not always symmetric. With the east side being 200-300 m higher in some locations, the west side in others. Even when the trough system bifurcates, depths of 1 km persist. We note that no prominent consistently raised rim can be identified. The triangular shaped wedge of ridges at the origin of the fracture system (at the border with south polar terrains) stands ~500 m above surrounding terrains, consistent with a compressional origin [4].

A similar young fracture system occurs at ~10°N, 180°W. This system is bifurcated into several parallel en-echelon style troughs. These troughs are ~8 km at their widest and 1 km at their deepest. Distinctly bluish slopes are exposed on the steep flanks of these troughs, indicating a young age. In contrast to the north-south rift described earlier, this system sits atop a rise at least 750 m high. An older system just to the south consists of a prominent trough ~500 m deep and 10 km wide.

Topography - Regional Scale: Limb profiles demonstrate that Enceladus is relatively smooth but not perfectly so [2]. Hundreds of meters of relief are apparent but the profiles are too far apart to characterize the dimensions of these variations. In our view of Enceladus' topography on the sub-Saturnian hemisphere, we confirm that the south polar terrains are lower standing than equatorial terrains by 750 m or more. However, our global DEM also reveals the existence of additional depressions on the order of 150 km across, depressions that are not fully seen in the limb profiles. These are bowl-shaped depressions 1 to 1.5 km deep. Two are located within old cratered plains north of the equator. The most prominent of these broad depressions lies near 0°N, 150°W and is 1.5 km deep. This feature is especially interesting because it lies mostly within old cratered plains but also partly straddles a boundary with young ridged plains to the west (and in low-resolution imaging). None of these topographic features correlates with observable geologic features or terrains.

Interior: As discussed in Porco et al. [5], the global shape of Enceladus is not consistent with a hydrostatic and fully differentiated body. Several not entirely convincing hypotheses have been offered to either justify a lack of global relaxation from an early orbital position closer to Saturn or an undifferentiated interior. The shape evidence presented here suggests that Enceladus' surface has relaxed to an equipotential. We propose that it is the rocky core of Enceladus that is out of hydrostatic equilibrium, and that the 2nd-degree potential raised by excess core topography accounts for the excess elongation of Enceladus' tidal axis.

References: [1] Spencer, J., and 9 others, Science, 311, 1401-1405, 2006. [2] Thomas, P., and 12 others, Icarus, 190, 573-584, 2007. [3] Schenk, P., R. Wilson, and A. Davies, Icarus, 169, 98-110, 2004. [4] Helfenstein, P., and others, Icarus, in press, 2008. [5] Porco et al. (2006) Science 311, 1393-1401.