TOPOGRAPHY OF MIDSIZE ICY SATELLITES 2: TETHYS AND THE EFFECTS OF ODYSSEUS.
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Introduction: Voyager reconnaissance, followed by global Cassini mapping have revealed the midsize icy satellites of Saturn to be dynamic and geologically complex worlds in their own right. Here we examine the case of Tethys [1], its famous large basin Odysseus and its tectonic features, as revealed by Cassini.

Mapping: Cassini imaging in 3-colors and in clear allow global mapping down to 250 meter resolution, with limited coverage (~20%) down to 100 m. Global topography has also now been obtained down to ~0.5 km resolution.

Geologic Features: *Odysseus.* The 410-km-wide Odysseus impact basin (Fig. 1) dominates Tethys geology. The basin has a general bowl-shape with a steep inner rim wall leading to a relatively flat floor 6-8 km below the rim, and a rimmed central pit ~4 km deep (Fig. 2). This morphology is different from other large basins in the Saturn system, which usually have prominent central peaks [2]. Despite its obvious depth, Odysseus lies somewhat below the extrapolation of the complex crater depth/diameter curve for Tethys [3], suggesting it has undergone some modest relaxation.

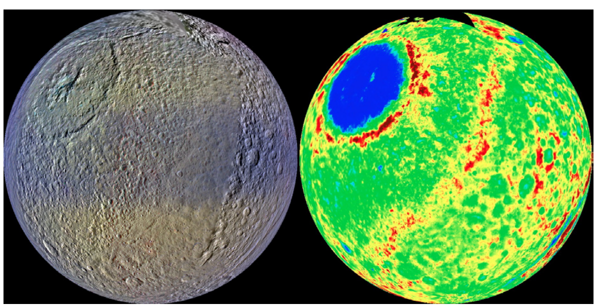

Figure 1. Orthographic views (left: color; right topography) of Tethys leading hemisphere, highlighting Odysseus and associated ridge. Ithaca Chasma is at extreme lower left.

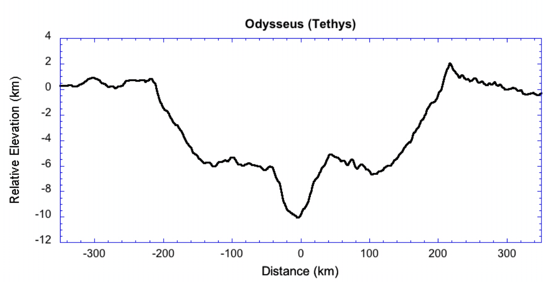

Figure 2. Averaged topographic profile across Odysseus.

Odysseus Ejecta. Surrounding the basin is a zone 380-450-km-wide that is heavily cratered in similar-sized craters, obliterates older large craters and bounded by a 2-3 km high sinuous ridge (Fig. 1). The ridge resembles the raised edge of some ejecta deposits on Ganymede and is in the right location to be the distal margin of a continuous ejecta deposit. It may also be a region of focused compressional deformation resulting from the excavation of Odysseus proper. Modeling is warranted. It is most curious that this ridge and the distinct zone of mantling are found only on the *eastern* side of Odysseus.

Ithaca Chasma. Our mapping confirms that Ithaca Chasma is broadly circumferential to Odysseus but extends along only 225° or so of circumference. Ithaca Chasma is several km deep along most of its length, except near its end points (Fig. 3).

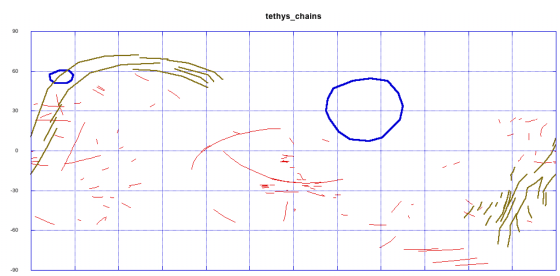

Figure 3. Global map of tectonic features (Odysseus in blue, Ithaca Chasma in brown).

One of the Cassini objects was to determine whether Odysseus and Ithaca are tectonically linked. Odysseus is not strictly concentric to Odysseus. Its distance from the rim varies from 450 to 920 km. While the further portions are indeed parallel to the rim of Odysseus, the trench then takes a bend and runs at ~45° to the rim. While Ithaca Chasma indeed does have a raised rim, that morphology only occurs along the zone that is parallel to the rim of Odysseus and furthest from it. Otherwise, no raised rim is present.

Global Tectonics. The highest resolution mosaics at ~10 m reveal narrow curvilinear fractures or graben across much of the surface of Tethys (Fig. 4). Some form bands of parallel E-W trending lineations. Others are random, which yet another set for odd broadly curving single lineations more than 400 km long. The origins of these features are unclear, although several mechanisms related to post-Odysseus deformation are possible. These include reorientation [4], global shape change during and after basin formation, and global fracturing during excavation and collapse.

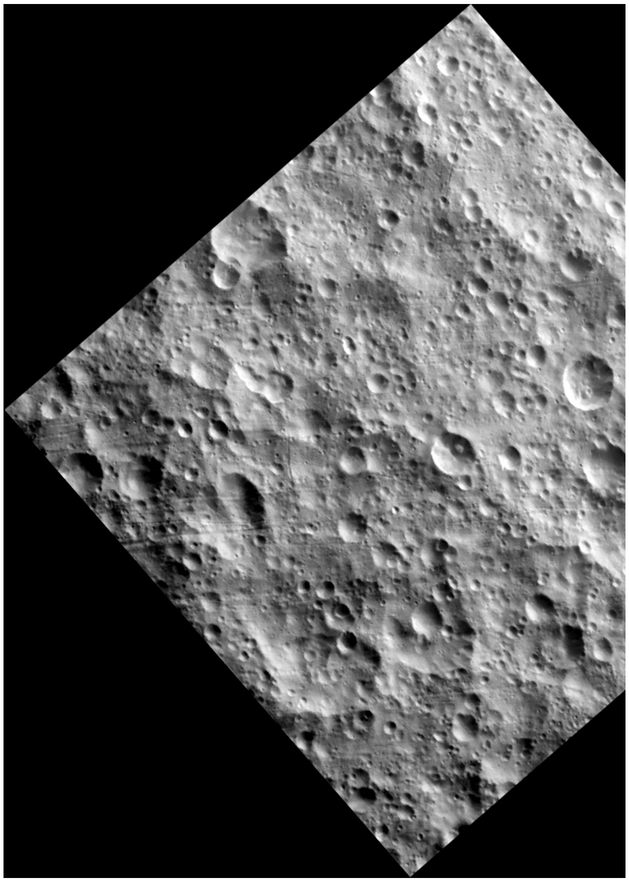

Figure 4. High-resolution (120-meter) Cassini view of Tethys showing parallel E-W lineations near the equator. Image from rev. 164. Image scale top-to-bottom is 175 km.

Discussion: Cassini mapping shows that the relationship between Odysseus and Ithaca Chasma is more complex than previously thought. To understand these geographic relationships better, we reproject the maps of Tethys so that Odysseus is centered at the paleopole, and all concentric features form straight horizontal lines (Fig. 5). This map confirms that the 2-3-km ridge and the most distant parts of Ithaca Chasma occur in the same quadrant wrt to the basin center. If Tethys was deformed during the impact, zones of compression and extension might be expected along certain zones outward from the basin. These can be tested in computer models, now that locations have been mapped. While the origin of the ridge remains uncertain (ejecta pile-up or distal compression), the extensional nature of Ithaca is clear. However, the change from raised rim in the 'parallel' section to flat-rimmed along the tangential section suggests that the mode of failure may have changed from simple extension to shear-extension, respectively.

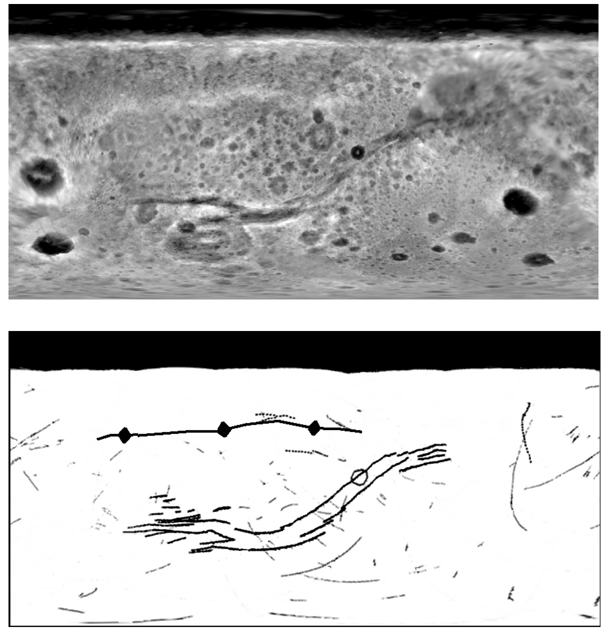

Figure 5. Reprojected global DTM (top) and sketch map of tectonic features (bottom) on Tethys. Odysseus is at top (black areas), Ithaca Chasma as dark lines, ridge as line with symbols.

A key objective was to determine the relative ages of Odysseus and Ithaca Chasma to confirm if they were similar in age. Crater counting is ongoing but the prevalence of secondaries from Odysseus across much of Tethys renders age dating of the floor of Ithaca Chasma relative to Odysseus problematic. The relationships of the smaller-scale global fractures now observed on Tethys (Fig. 4) are unclear but several mechanisms by which the basin may have formed have been identified. Despite remaining uncertainties, the spatial assocations of Odysseus, the ridge and Ithaca Chasma suggest that a direct link between all three features, in the form of extensional deformation and ejecta deposition (or compression) during impact remains a viable hypothesis. The circumferential graben on Vesta, associated with two large basisn formed there [5], adds further support for this hypothesis.

References: [1] Moore J. M. and J. A'hearn. (1983) *Pr. Lunar. Plan.Sci. 13,* A577. [2] White, O., P. Schenk, and A. Dombard. (2013) *Meteoritics & Planet. Sci., 32,* A74. [3] White, O., and P. Schenk, (2013) *DPS meeting 45*, #406.06 [4] Nimmo F. and I. Matsuyama (2007) *Geophys. Res. Lett10.1029GL030798*. [5] Buczkowski, D., et al., (2012) *Geophys. Res. Lett. 39*, L18205.