TITAN IMPACT CRATERS – CASSINI RADAR RESULTS AND INSIGHTS ON TARGET PROPERTIES

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Summary: As Cassini SAR imaging coverage of Titan approaches ~20%, a general picture of Titan's cratering style is emerging: craters are often modified by fluvial and Aeolian processes, so far there is no evidence of viscous relaxation. However, ejecta blankets and rounded rims suggest unusual target properties and atmosphere-ejecta interaction.

Introduction – Crater Density: If Titan were cratered to the same extent as some other Saturnian satellites, it would have >10,000 impact craters [1] with diameter 20km or more (above the atmospheric shielding threshold below which the differential density would decline). However, a striking result even from the earliest Cassini data was the lack of observable craters overall [2,3]. A survey [4] of the first ~10% of Titan's surface imaged by the Synthetic Aperture Radar (SAR) mode of the Cassini RADAR instrument finds that in fact the large-crater (>300km) population may be consistent with other Saturnian satellites (figure 1), but there is a striking dearth of medium-sized impacts (e.g. 30-100km diameter). Indeed, the slope of the cumulative size-frequency distribution is very shallow, much like the Earth, suggesting that similar processes may be responsible for the obliteration of the craters. A crater retention age of several hundred million years (roughly the same as Earth or Venus) appears to be indicated [3,4].

So far only 3 impact structures are securely-enough identified to have IAU-approved names (see figure 2) – we discuss these in turn.

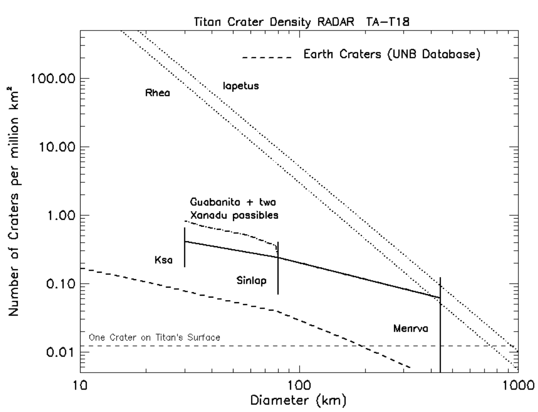

Fig.1 *Titan cumulative size-frequency plot (thick solid line with bars) for TA-T18, compared with Earth and Rhea/Iapetus. Some uncertainty (factor ~2) pertains to a number of structures which may or may not be of impact origin, but even taking these into accout, medium-sized craters are a factor of ~100-1000 depleted from what one would expect.*

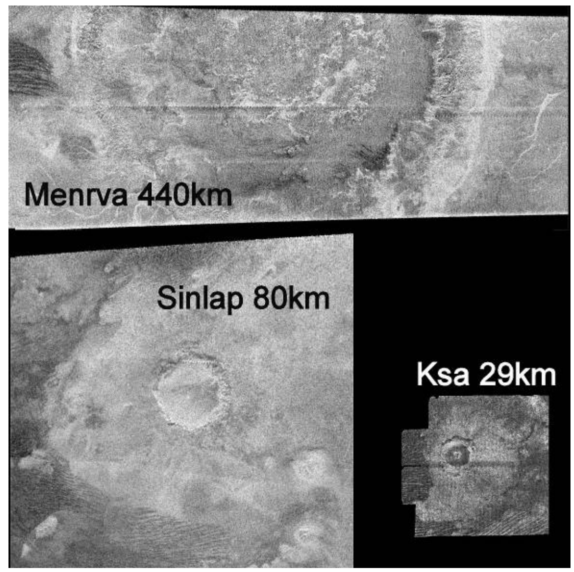

Fig.2 *Montage at same scale (128 pixels/degree) of the three confidently-identified and named impact structures, Menrva, Sinlap and Ksa. . North is up in each case – note the tendency of fluvial channels and Aeolian features to trend eastwards and the better-preserved Eastern rim of Menrva. Near-horizontal stripes across the whole images are radar imaging artifacts. Radar illumination is from above with approximate incidence angles of 21°, 14° and 34° respectively.Menrva – 440km across outer edge.*

Menrva: This impact basin is centered near 87° W, 19° N and had been noted as a dark annular feature in near-IR imaging. RADAR shows the crater morphology clearly. The outermost edge is 450km in diameter, although whether the structure is a true multiring basin is not yet clear. The steep inner wall is bright, exhibiting numerous radial grooves and chutes. The southern and western regions of the floor are relatively bland, suggesting it may have been flooded. The center of the basin appears elevated and is rough-textured, with bright material defining an inner ring about 100 km in diameter. Dark, thin linear streaks seem to seep from the basin's lower wall onto the basin floor. The western rim shows more signs of erosion than the eastern rim. Fluvial features appear to be associated with the basin, but small-scale features in the crater rim and in the central hills are preserved, suggesting that erosion has been rather limited since crater formation. The terrain surrounding the crater and ejecta also are indicative of local geologic processes, e.g., erosion, remobilization of ejecta, or aeolian redistribution. The Cassini RADAR team is presently exploring ways of measuring the topography of Menrva to constrain post-impact modification such as viscous relaxation.

Sinlap : The 80-km crater, at 16° W, 11° N shows no evidence of a raised rim. It appears to be flat-floored – craters on Ganymede of this diameter [5] have domed floors due to viscous relaxation, and central pits, perhaps indicating that their transient cavity came close to a subsurface layer of lower viscosity. There is no indication of such features, nor of a central peak or peak ring, yet the overall impression suggests it was formed by impact. The floor seems flat, similar to some lava-flooded craters on the moon and Mars or to craters with lacustrine deposits on Mars. Making the assumption that the crater wall has the same height and slope around its perimeter, we calculate [6] a slope of 16 +/- 5 deg and a crater depth of 1300 ± 200 m for a depth/diameter ratio of 0.016 ± 0.03. This shallowness may be due to the crater being significantly modified by infilling. The crater is asymmetrically surrounded by a blanket of SAR-bright material biased toward the eastern side : the inner part of this blanket has some radial striation. In places it extends more than two crater radii beyond the rim. While the parabolic shape of the ejecta blanket is similar in shape to the extensive dark, diffuse, parabolic haloes seen around venusian impact craters, we do not detect a similar deposit in this limited view of the crater.

Ksa : The T17 flyby in August 2006 showed a 29km diameter crater named Ksa not far from Menrva. Again, this structure shows the recurring pattern of 'intrusion' of aeolian material from the West. There is a central structure suggestive of a peak ring, and a well-defined but smooth rim. A large and sharp-edged ejecta blanket is reminiscent of the fluidized ejecta around many Martian craters, suggesting a significant influence of the atmosphere in constraining the ejecta plume expansion, and the possibility of surface volatiles.

Suspiciously-Circular Features and other potential impact structures : A number of circular or near-circular features form bright rings in both radar and optical data – many of these may have an impact origin (e.g. figure 3). The dark floors suggest infilling, perhaps by aeolian sediment – in the case of Guabonito, duneforms are evident.

The large leading-face bright region Xanadu appears geologically distinct and has a number of likely (but highly degraded) impact structures. Further study of these, and their implications for the age of Xanadu, are under way.

Radar imaging has revealed polar lakes and seas of liquid hydrocarbons[7], suggesting we may find submarine impact structures [8] (e.g. figure 4).

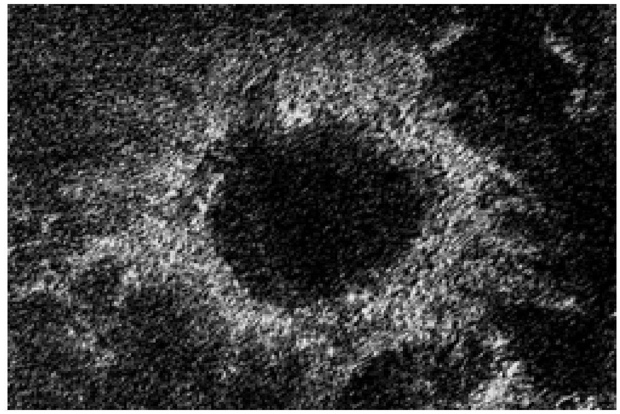

***Fig 3**. Unnamed feature, possibly an oblique impact structure observed on T16 – inner part is 65km across, a typical size for 'suspiciously circular features' on Titan.*

***Fig.4** Unnamed 9km diameter feature, possibly a submerged or previously-submerged crater rim observed on T29. Note nearby river channels.*

Conclusions : Titan's craters are quite distinctive, sometimes having a 'soft' appearance and in many ways are more comparable with craters on the terrestrial planets than on other icy satellites. To generate these morphologies presents a new challenge to modelers and may inform our understanding of Titan's crustal properties. The steep walls of Sinlap contrast with the rounded rims and ejecta patterns seen elsewhere, suggesting possible regional variation in surface properties.

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