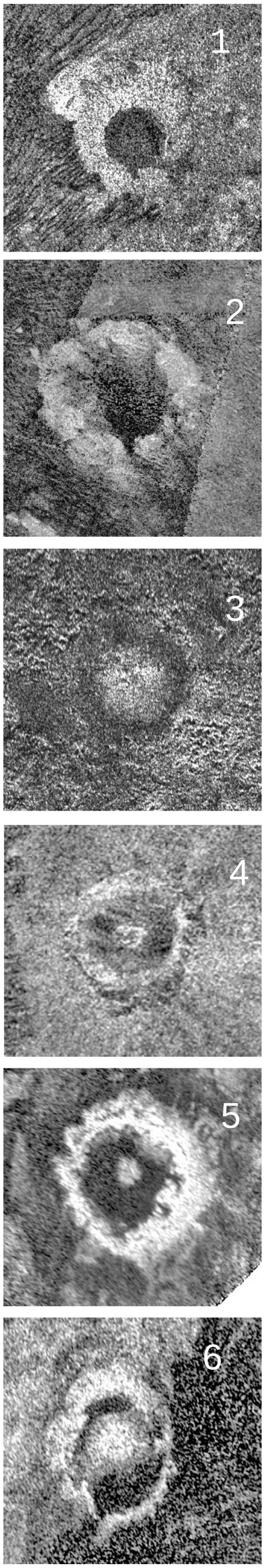
MORPHOLOGICAL CLASSIFICATION OF TITAN'S IMPACT CRATERS. C. A. Wood[1], [1]Planetary Science Institute, 1700 E. Ft. Lowell Blvd, Tucson, AZ 85719; tychocrater@yahoo.com.



Introduction: Impact craters are standard collisional products formed all across the solar system. Images for Titan's craters have lower resolution than for most other worlds, degrading our ability to identify crater characteristics, and even to determine what is and is not an impact crater. Titan's craters have a variety of morphologies, and it is challenging to determine which are formational and which result from later modification. Clear evidence exists for modification by mass-wasting, fluvial erosion, coverage by dunes, and shallowing by unknown processes [1]. Modeling shows that fluvial erosion can explain the eroded shapes of degraded-craters, but not the infilling of unbreached craters [2].

Observations: Enough certain and near certain craters >10 km diameter are now depicted in Cassini RADAR images to classify their morphologies. I recognize six morphological types, based on rim and floor characteristics, and named for prominent examples (Fig. 1, to left):

1. Mystis – bright narrow rims, dark, flat floors, bright ejecta deposits (3-40 km diameter).
2. Guabonito – broad rounded rims, small dark floors, no central peaks. Guabonito-type crater Momoy may be surrounded by a thick ejecta blanket (26-68 km).
3. Ancient Xanadu – large, unnamed, clearly eroded craters in Xanadu, broad, bright floor deposits and central peaks surrounded by annular deposit of dark material (61-63 km).
4. Ksa – lunar-like morphology with central peaks, inner wall erosion channels, ejecta deposits (29 – 115 km).
5. Forseti – bright, jagged rims, some central peaks, dark flat floors, possible remnant ejecta near rims (58-144 km).
6. Paxsi – broad bright central zones with peaks, dark floor annulus; Menrva tentatively in this class (35-445 km).

Graphs of the diameter distribution of each crater type (Fig. 2) show that this morphological classification sequence is also a general diameter sequence. The numbers at the bottom and right side of Fig. 2 show the percentage occurrence of central peaks and ejecta for each diameter interval and crater type. Most craters < 60 km in diameter do not have central peaks, whereas 50% to 100% of larger crater do. Craters <70 km diameter do not have ejecta, except 100% of Mystis-types do, and the 35 km wide Paxsi-type crater Beag has unique ejecta rays on one side. Craters >70 km tend to have preserved remnants of ejecta, but interpretation as ejecta is not always certain.

Discussion: The Titan crater sequence of Figure 1 mimics the morphological pattern found on the Moon and other worlds: small craters lack central peaks and larger ones possess them. However, the morphological peculiarities of different crater types differ from what is seen on other worlds. In particular, none of the Mystis–type craters, which range from 3 to 40 km in diameter, have central peaks. Ganymede and Titan have similar gravity, and hence their transition diameters from simple to complex (from peakless to central peaks) should be similar. On Ganymede, the 8.5 km Nargel and smaller craters have well-developed peaks; this suggests that Titan's Mystis-type craters should have formed with peaks. Instead they have broad floors of dark material. Two crater depths exist for this type, showing that they are only about 40% of the depth of similar diameter Ksa and Momoy [2], confirming the shallowness suggested by broad floors and narrow rims. Presumably the dark material is infill that has covered floors and any central peaks.

Craters with ejecta deposits are considered younger than ones lacking them. Thus, Mystis craters, with bright ejecta deposits, are young. Their inferred shallowness suggests that crater infill is more rapid than ejecta erosion. Mystis-type craters often occur near each other; does their ejecta armor them, preserving an old cratered surface, or are they not formed by impact?

Ksa-type craters are the morphological equivalent of lunar complex craters. The three Ksa-types (includes Sinlap and Afekan) look very much like lunar or Martian craters; there are, however, only three seen so far on Titan. Because of their extensive ejecta deposits all are young. Menrva could be classed as a Ksa-type based on its rim, but its broad and high central region differs from small basins on other worlds.

Forseti-type craters are also similar to complex craters on other planets, except for their rims, which are like jagged mountains. They do not look they have the ejecta-draped, uplifted layers as do lunar complex craters. Neish et al [3] propose that Forseti-type craters are older, eroded versions of Ksa-types. They do appear to be older because their ejecta deposits are much sparser and possibly even non-existent compared to the thick deposits of Ksa-types. However, their rough rims look fresh, rather than eroded, and their possible ejecta, including putative impact melt at Forseti, suggests a lack of deep erosion. Unlike icy worlds, Forseti and other large Titan craters have central peaks, not pits.

The three Paxsi craters (includes Beag and tentatively the basin Menrva) are distinctive because they have very broad, bright and mountainous interiors, unlike Ksa or Forseti-types. Their narrow rims suggest that Paxsi and Beag are shallower than Ksa or Foresti-types. These do not look like fresh craters elsewhere. Were their interiors uplifted by viscous relaxation?

The two ancient-looking craters in Xanadu are clearly more eroded than other craters in this study. Their rims are breached in various places, but they are still elevated, rising above surrounding terrain. Their dark floors seem to be the same level as the surrounding dark flat terrain, so they no longer appear to have their original depths. Their central peaks rise above the surrounding dark areas. Have these floors also been lifted by viscous relaxation? A difficulty is that on other icy moons, such relaxed craters have low rims. These Ancient Xanadu craters do not look like Ksa or Forseti-types that have been strongly eroded.

Guabonito-type craters are weird. Their rims are very thick and bulky, unlike crater rims elsewhere. They have relatively small, dark floors. Stereo estimates give a depth of 680 m for Momoy [4], which makes it one of the deepest craters measured on Titan. Momoy also is interpreted by Neish (pers. com.) to be surrounded by an ejecta blanket thick enough to deflect dunes. Preservation of ejecta suggests that Momoy is relatively young, and thus may have had a vastly different formational morphology than Ksa/Forseti types.

These observations raise questions about the relationship of Titan's crater types. Most do not look like modified versions of the others. Familiar crater morphologies (Ksa-types) occur rarely, and Mystis and Guabonito-types are unfamiliar as formational morphologies elsewhere in the solar system. Were they formed by impacts?

References: [1] Wood, C. A. et al, (2010) *Icarus*, *206*, 334-344. [2] Neish, C. D. et al, (2016) *Icarus*, (fluvial erosion) in press. [3] Neish, C. D. et al (2015) *GRL*, *42*, 3746-3754. [4] Neish, C. D. et al, (2013) *Icarus, 223*, 82-90.