CRATER SHAPES ON THE SATURNIAN SATELLITES: NEW MEASUREMENTS USING CASSINI STEREO IMAGES. O.L. White[1] and P.M. Schenk[1]. [1]Lunar and Planetary Institute, 3600 Bay Area Boulevard, Houston, Texas, 77058 (white@lpi.usra.edu; schenk@lpi.usra.edu).

Introduction: Following the imaging of the surfaces of the outer planet icy satellites during the Voyager flybys, the depths of impact craters on the satellites were determined using photoclinometry and shadow length measurement [1]. Differences were identified in crater depth and simple/complex morphology transition diameter between craters on icy satellites and terrestrial planets. These differences were attributed to the differing mechanical properties between ice and "rock", an especially important influence on the morphologies of simple, bowl-shaped craters, in addition to differences in impact velocity and surface gravity [2]. The ice component of the crusts of these satellites [3] has resulted in viscous relaxation of several of the large impact basins (>100 km diameter); gauging the extent of relaxation of such basins will bolster understanding of lithospheric rheology and the thermal states of their parent satellites [1].

The operations of the Cassini orbiter at Saturn have yielded new image datasets that exceed the Voyager datasets in quantity and resolution for each of the Saturnian satellites. For example, Voyager achieved a best resolution of 0.72 km/px at Rhea [1]; by comparison, the Cassini orbiter has imaged Rhea locally at spatial resolutions better than 10 m/px [4]. In addition, Cassini's orbital tour has allowed it to image several areas on each satellite at different viewing angles as well as high resolutions, which was not possible for the Voyager spacecraft flybys. This study reports initial results of crater dimension measurements that use high resolution and global topography maps created using Cassini stereo images.

Methods: The satellites studied to date are Rhea, Iapetus, Dione, Tethys, Mimas and Hyperion. Global topography maps with resolutions of 0.4 to 1 km/px were created for all six satellites except Hyperion, with high resolution, localized maps currently only being available for Rhea, Iapetus and Hyperion (reaching maximum resolutions of 0.142, 0.092 and 0.110 km/px respectively). Between 3 and 6 profiles were drawn to derive the mean depth and diameter across each crater. The depth was defined as the mean of the two depths measured from the base of the rim scarp to the crest of the rim. Where applicable, the diameters and heights of central peaks were also measured for each profile and mean values calculated.

Results: Table 1 shows statistics relating to crater morphologies on each of the satellites. Fig. 1 displays logarithmic plots of crater depth against crater diameter for Rhea and Iapetus. Rhea is the only satellite for which a significant number of craters have been measured across the simple and complex diameter ranges to date, and for which simple/complex transition diameters have been determined. Measurements for the other satellites are currently in progress, although preliminary values for them are shown in Table 1.

Table 1. Preliminary crater depth/diameter statistics. Equation of the form log (d) = log (depth at 1 km diameter) + slope × log (D), where depth (d) and diameter (D) are in km. Errors in parentheses are 95% (2σ) confidence limits. Lunar values in italics have been obtained from [2].

Satellite (crater type)	Count	Slope	Mean d/D
Rhea (simple)	63	0.8079	0.221 (±0.081)
Rhea (complex)	36	0.4941	-
Rhea (large basins)	5	0.0388	-
Iapetus (complex)	49	0.5506	-
Iapetus (large basins)	5	0.3716	-
Dione	16	-0.1439	-
Tethys	16	0.2388	-
Mimas	9	0.5852	-
Hyperion	3	2.5339	0.295 (±0.451)
Moon (simple)	-	*1.013*	*0.199 (±0.002)*
Moon (complex)	-	*0.313*	-

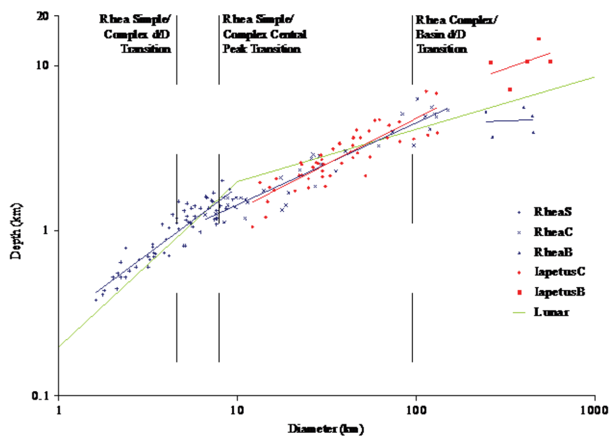

Fig. 1. Depth/diameter measurements of craters on Rhea and Iapetus. A trendline is fitted through the data for each crater type on each satellite, and compared with the lunar curve. Rhea transition diameters are highlighted. S = simple, C = complex, B = large impact basins.

The Rhea plot displays a simple/complex d/D transition diameter of 4.5 km, a simple/complex central peak transition diameter of 7.8 km, and a complex/basin d/D transition diameter of 97 km. Large impact basins tend to be distinguished from complex craters by such features as concentric mountain chains and irregular rims that have been extensively modified by impacts and collapse. For comparison, the simple/complex d/D transition diameter obtained using Voyager data was measured as 8.6 km based on photoclinometry and 12.4 km based on shadow length measurements, while the simple/complex central peak transition diameter was measured as 15 km [1]. The trendlines in Fig. 1 indicate that simple craters on Rhea tend to be slightly deeper than those on the Moon. In contrast, photoclinometry and shadow length measurements using Voyager data [1] found that simple craters are systematically shallower on Rhea relative to those on the Moon. A similar revision has been made to Galilean satellite d/D measurements using Galileo data [5], indicating that measurements based on Voyager data have been systematically underestimated. The complex crater trendlines for Rhea and Iapetus indicate that complex craters on these satellites become significantly deeper with increasing crater diameter relative to craters on terrestrial planets, which is consistent with previous findings [1].

The complex crater fits for Rhea and Iapetus virtually overlap in Fig. 1, except beyond the ~100 km complex/basin transition diameter, they diverge: large impact basins on Iapetus continue to deepen with increasing diameter, while the Rhea curve levels off and does not increase with diameter. Large basins on Rhea display a correspondingly low depth/diameter ratio. Large impact basins on Iapetus may therefore be considered as having undergone very little relaxation since formation, while those on Rhea have undergone extensive relaxation [6]. Rhea and Iapetus have similar surface gravities (0.264 ms^{-2} and 0.223 ms^{-2} respectively); if it is assumed that this would result in large impact basins displaying similar depth/diameter ratios upon formation, then the extent of relaxation of the Rhea basins can be deduced. Relaxation values calculated for the Rhea basins using this method range from 3.4 km (Izanagi, having lost 61% of its original depth) to 6.9 km (a very degraded and heavily cratered, unnamed, 450 km-wide impact basin centered at 15.5°S, 20.7°W, having lost 36% of its original depth). In the cases of the more eroded basins, a significant proportion of the apparent relaxation may be accounted for by erosion of the basin rim by subsequent impact and redistribution of ejecta.

Additional crater dimension measurements across a wide diameter range are being performed on the remaining satellites in order to more confidently compare the d/D fits between satellites. For instance, to date only three measurements have been obtained for Hyperion and nine for Mimas. However, new data have now been released that will improve these statistics considerably. Nevertheless, even with these minimal measurements, some distinctions may be identified between satellites: Mimas displays a particularly high mean depth/diameter ratio (0.138), which correlates with its low surface gravity and previous assertions that craters on Mimas are unrelaxed [1]. Hyperion may also have a very high mean d/D ratio of 0.295, which may potentially result from the high porosity of Hyperion (>40%) as inferred from previous studies [7]. However, previous measurements of the depth/diameter ratios of 13 of Hyperion's craters using shadow lengths have determined a mean depth/diameter ratio of 0.21, similar to values of fresh lunar craters [7]; further processing of these data will allow refinement of the shapes of craters on Hyperion and their relation to its interior properties.

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