THE CRATERING RECORD OF THE SATURNIAN SATELLITES PHOEBE, TETHYS, DIONE AND IAPETUS IN COMPARISON: FIRST RESULTS FROM ANALYSIS OF THE CASSINI ISS IMAGING DATA.

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Introduction: The two cameras aboard the Cassini spacecraft which was placed into orbit around Saturn on July 1, 2004, have provided a wealth of new image data of the Saturnian moons Phoebe, Tethys, Dione and Iapetus and their cratering record [1]. In this work, we will present and discuss the first results of measurements of CSFDs (crater size-frequency distributions) on high-resolution Cassini ISS images of these bodies. Also, similar investigations will be carried out on image data of Mimas, Rhea and Enceladus to be returned in the first two months of the year 2005.

Previous work: First crater counts of the satellites of Saturn were based on Voyager data with limited resolution (>1 km/pxl) [2]. It was discussed that the Saturnian satellites were bombarded by two different impactor populations, P1 and P2. P1 was attributed to an early heliocentric population, similar to the one that bombarded the terrestrial planets, and having been responsible for the larger craters, while P2 was believed to represent a Saturno-centric population for later cratering of the satellites, producing the smaller craters [3]. In an opposite view, [4] and [5] have put the existence of these two populations into doubt. It was shown by [4] that shapes of CSFDs on the Jovian and Saturnian satellites are rather similar to those measured on the terrestrial planets, including some asteroids, implying Main Belt asteroids as primary source in the two satellite systems. More recently this could be verified for the large icy moons of Jupiter by image data from the Galileo SSI camera [6][7]. On the other hand, a preferential source of impactors from the asteroid belt is still questioned by others. A major contribution of comets and Kuiper Belt Objects (KBOs) to the cratering of planets and satellites in the outer solar system was emphasized by [8]. Also, a general lack of small cometary impactors as well as a larger role of secondary cratering on the icy satellites is still in debate (e.g. [8] [9]).

Data processing: Crater counts were carried out on map-projected images (in the context of Voyager base maps, where possible) in order to account for scale differences with viewing geometry, except for Phoebe, where craters were measured in regions which were imaged more or less orthogonally to the surface. Spatial filters (highpass) were used to enhance detail. Craters were counted on a high-precision Zeiss stereocomparator.

Results - ***Phoebe****:* Data were taken from a single flyby prior to Saturn Orbit Insertion (SOI) of the Cassini spacecraft (June 11, 2004). Cumulative frequencies of Phoebe CSFDs are shown in *Fig. 1* [10]. Craters from 80 km down to about 1-2 km are more or less in production. Smaller craters <1 km are about a factor of 3 within equilibrium (indicated by the lunar equilibrium distribution for small craters), but still slightly steeper than a -2 slope. The shape of the Phoebean distributions are similar to lunar highland distributions as well as CSFDs from Ganymede's dark terrain (red and green curves respectively) but are shifted leftward in log-D to account for different crater scaling on the three bodies. Impact velocity (*v*) has the strongest influence on the size of a crater (*D*) created by a given projectile, the crater diameter scaling with $D \sim v^{2/3}$ [11]. The shift of lunar CSFDs to smaller crater diameters is consistent with a smaller impact velocity in the Jovian and Saturnian satellite systems [4][6][7][this work]. The similarity in shapes of CSFDs on Phoebe, Ganymede and the Moon is also consistent with a similar underlying impactor size distribution.

Tethys, Dione: Crater counts on Tethys were carried out on imagery comparable to Voyager resolution while for Dione image resolutions down to 430 m/pxl could be used. For both satellites, crater frequency is high, comparable to lunar highlands. Tethys' CSFDs show a production function steeper than -2 down to about 5 km crater diameter, coming close to equilibrium for craters of ~15 km and smaller. CSFDs measured on Dione show a -2 distribution which also might indicate equilibrium.

Iapetus: Images of Iapetus' dark terrain *Cassini Regio* revealed a number of very large basins up to 600 km in diameter. CSFDs of this satellite are given in *Fig. 2*. Remarkably, the large craters and basins show a slope of about -1.5, similar to the CSFD of large basins on the Moon. Craters below a diameter of about 40 km seem to follow a -2 equilibrium slope more or less. The kink in the distribution between 40-

50 km appears to indicate a major resurfacing effect, probably by one of the large impact basins.

Conclusions: (1) The lunar-like shape of CSFDs measured on these satellites is compatible with an asteroidal source of impactors. If the underlying projectile distribution was, or still is, primarily due to cometary bodies derived from the Kuiper Belt, as suggested by e.g. [8], their collisional evolution must have been similar to that of the asteroids. **(2)** The existence of two different projectile populations P1 and P2 cannot be seen in our data. Instead, the results imply a single population of impactors. Resurfacing by geological processes (such as basin-creating events) more likely explains the observed changes (kinks) in slope, otherwise interpreted as the effect of different impactor populations (e.g. [3]). **(3)** The leftward shift in log-D of the lunar production function towards smaller crater diameters is, within the uncertainties of the still poorly understood crater scaling on icy bodies, in good agreement with differences in average impact velocities between the Moon and the Saturnian satellites derived by [12] and can mostly be reconciled with a primarily planetocentric projectile family. **(4)** The high crater frequencies and the large basins imply a very high surface age, especially in the case of Iapetus, of at least 4 Gyr, probably close to 4.4 - 4.5 Gyr.

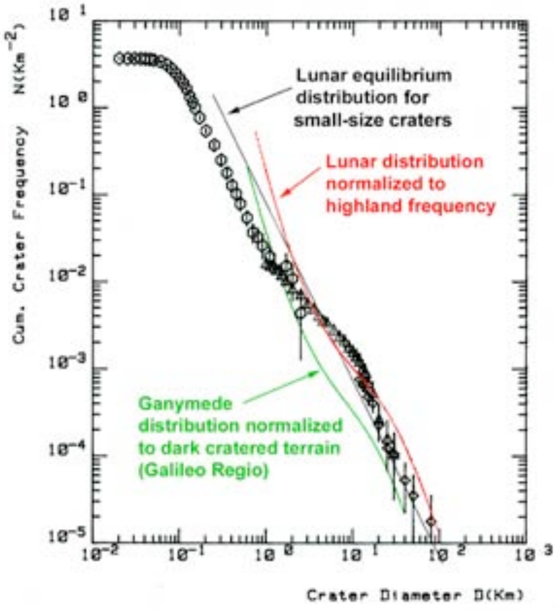

Figure 1: Cumulative diagram of CSFDs measured on Phoebe (diagram from [10]). Craters were measured at three different resolutions: 4 km/pxl (diamonds), 360 m/pxl (triangles), and 30 m/pxl (hexagons). Curve shown is the lunar production function for lunar highlands (red) and for Ganymeds's dark terrain (green; shifted in log-D to account for differences in impact conditions [6][7]). The equilibrium distribution (-2-slope) for small crater sizes on the Moon is also included.

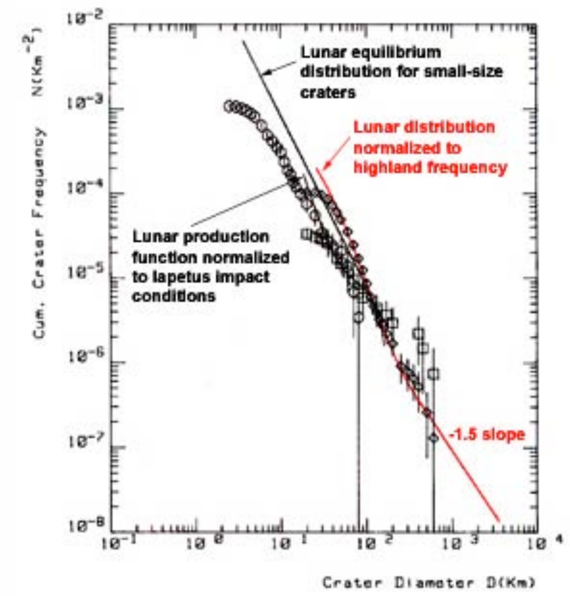

Figure 2: Cumulative diagram of CSFDs measured on Iapetus dark material. Left curve shown is the lunar production function fitted to the data between 30 and 90 km crater diameter, normalized to impact conditions on Iapetus (about a factor of 7 difference between a lunar crater and one on Iapetus, created by the same projectile (same diameter)) [12]. Also included are data from the lunar highlands and basins (diamonds), and the two lines indicating the lunar equilibrium distribution (-2-slope), as well as the -1.5-slope for the large basins.

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