CRATERING RECORDS OF ENCELADUS, DIONE AND RHEA – RESULTS FROM CASSINI ISS IMAGING.
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Introduction: Determining the cratering record of the Saturnian satellites is an important step in deciphering the geologic history of these satellites. The Cassini ISS cameras have provided new and higher resolution images of several of the Saturnian satellites including Enceladus, Dione, and Rhea. Here we have begun crater counts starting with these particular satellites using this new data in order to provide new constraints into their geologic histories.

Previous Work. Voyagers 1 and 2 provided the first images of the Saturn system. From these low resolution (> 1km/pxl) and limited-coverage images, Smith *et al*. [1,2] performed preliminary crater counts on the major satellites and noted the differences between them (e.g., Rhea is heavily cratered and Enceladus has a highly variable crater density). Their main conclusion, however, was that two different population of impactors (Populations I and II) were represented in the cratering record. Population I was present on the older surfaces and had a higher abundance of larger craters (> 20 km) and Population II was present on younger surfaces and had a relative lack of larger craters. Plescia and Boyce [3] then performed a more detail analysis on the Voyager data providing crater densities of the major satellites and absolute ages. Lissauer *et al*. [4] concentrated on the cratering records of Rhea, Mimas and Iapetus, presenting their own cratering densities for each. More recently, using the better coverage and higher resolution Cassini ISS images, Neukum *et al*. [5] has presented initial crater counts for Phoebe, Tethys and Iapetus, and Porco *et al*. [6] Schenk and Seddio [7] for Enceladus.

Data: The crater counts for Enceladus were performed on a controlled global mosaic (100 m/pxl) composed of images from the Cassini S3, S4 and S11 passes. This base map was divided into 12 geological units identified as either cratered plains (cp) or ridged plains (rp). Cratered plains are distinguished by their relatively higher density of craters and ridged plains by the presence of ridges and relatively lower density of craters. Crater counts for Dione and Rhea were performed on several different images of varying resolution, which are summarized in Table 1.

Results: The results comparing the cumulative and relative (R) size-frequency distributions for the three satellites are shown in Fig. 1. The labels for each distribution relates to the labels given in Tables 1 and 2. The two Dione distributions represented by the dark blue (sp) and light blue (cp) unfilled circles are from the same mosaic (500 m/pxl), but represent cratered plains and smooth plains. Their cumulative slopes are similar (see Table 2), along with the shapes of the R-plots, but the densities are different (91±24 and 240±44 per km^2 at D = 20 km, respectively). The region with a lower density may have been resurfaced at some point, although, it was likely to have been in the distant past as the region is still relatively heavily cratered.

Table 1. Dione and Rhea Images

Identifying Name	Image	Resolution (m/pxl)
Dione (cp,hr)	1507745645 1507745663 1507745681	25
Rhea	1511737622 1511737677 1511737694	100
Rhea (hr)	1511737558	10

Table 2. Slopes of Cumulatitive Distributions

Identifying Name	Diameter Range (km)	Slope
Dione (sp)	5-80	-2.23
Dione (cp)	5-135	-2.13
Dione (cp,hr)	0.25-4	-1.64
	4-15.5	-1.44
Rhea	1-26	-1.49
	26-32	-5.49
Rhea (hr)	0.1-0.4	-1.19
	0.4-0.7	-2.24
	0.7-0.9	-3.65
Enceladus (cp)	1-3	-1.28
	3-7	-2.12
	7-19	-3.08
	19-29	-4.67
Enceladus (cp,hr)	0.65-1.25	-1.31
	1.25-4	-2.44
	4-4.5	-5.86
	4.5-9.5	-1.59
Enceladus (rp)	1-1.5	-1.02
	1.5-16	-2.16

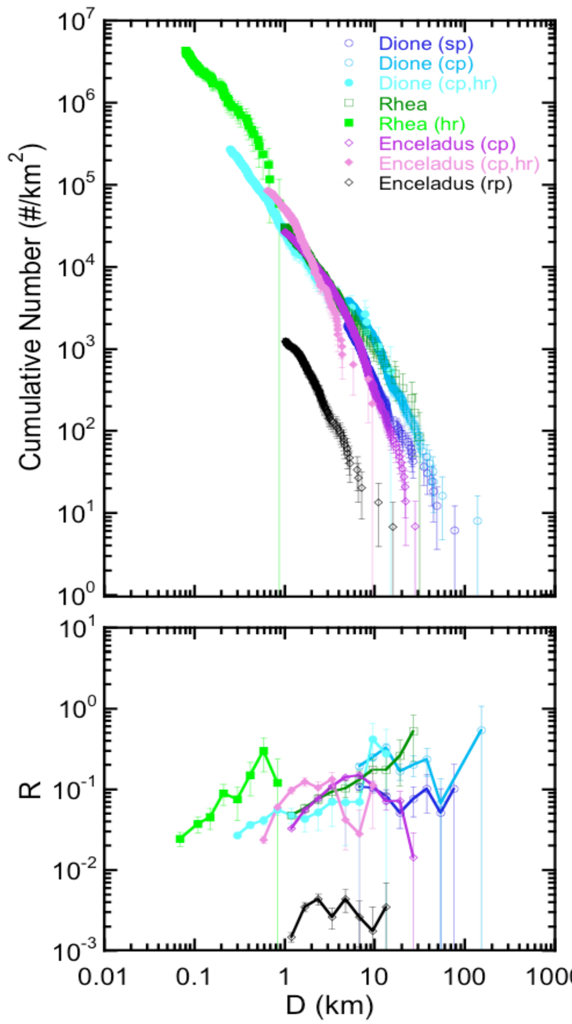

Figure 1. Cumulative (top) and relative (bottom) size-frequency distributions for selected regions (see text) on Dione, Rhea and Enceladus. The relative plot (R-plot) shows the ratio of the actual distribution to a distribution with a cumulative slope of -3. *sp* – smooth plains; *cp* – cratered plains; *hr* – high-resolution; *rp* – ridged plains.

When comparing the overall densities and shapes of the cumulative and relative plots for the heavily cratered regions of Dione and Rhea for diameter ranges where they overlap, they appear very similar. Their cumulative slopes are alike (Table 2), except at large D (> 25 km) and the R-plots are steeply sloped towards large diameters. Therefore, these heavily cratered regions of these bodies likely represent the same population impactors that were present throughout the Saturnian system.

The heavily cratered regions of Enceladus, however, show differences from these other two satellites, especially in the R-plot. The Enceladus data show a turndown of the R values at small diameters (< 7 km). This may be a result of resurfacing or viscous relaxation affecting the small craters more than the large craters. Indeed, many small craters on Enceladus appear “subdued or “mantled” at high resolution, suggesting burial by plume fallout. The turndown, however, may also be a result of image resolution. More work with some of the higher resolution images is in progress to clarify if this is a real geologic effect or a resolution effect.

Finally, the ridged plains units of Enceladus have a considerably lower crater density than the cratered plains (Fig. 1). For a diameter of 5 km the density for the cratered plains is 2413±129, while the density for the ridged plains is 54±19. This implies that these regions are definitely younger. Future work will determine the approximate absolute ages using the Zahnle *et al*. [8] chronology for the Outer Solar System.

Conclusions: The heavily cratered regions of Dione and Rhea are likely to be produced by the same population of impactors according to the similarities of their cumulative and relative size-frequency distributions (Fig. 1, Table 2). From this work, we also conclude that smooth plains on Dione are not as heavily cratered as Rhea (Fig.1). That Dione has a variably cratered surface, and was likely resurfaced, was shown in previous work [1-3], but it is nice to confirm this. The heavily cratered regions of Enceladus do *not* appear to be similar to those of Dione and Rhea, especially at smaller diameters (< 7 km) according to the interpretations of the differences in the R-plots (Fig. 1). This “roll off” of the R-plot at low diameters may be due to the geology of Enceladus (i.e., burial) preferentially affecting smaller craters, but it may also be an effect of counting craters near the image resolution. Finally, crater densities indicate that the ridged plains on Enceladus are relatively younger than the cratered plains.

More counts are planned on medium and high-resolution images. We will compare these counts to the current ones to possibly determine if the roll off at small diameters on Enceladus is real, and if two different impactor populations are identifiable. We will also determine the approximate absolute ages using the Zahnle *et al*. [8] chronology for regions presented here and others being counted.

References: [1] Smith B. A. et al. (1981) *Science, 212,* 163-191. [2] Smith B. A. et al. (1982) *Science, 215,* 504-537. [3] Plescia J. B. and Boyce J. M. (1985) *JGR, 90,* 2029-2037. [4] Lissauer J. J. (1988) *JGR, 93* 13776-13804. [5] Neukum, G. (2005) *LPS XXXVI,* Abstract #2034. [6] Porco C. C. et al. (2006) *Science, 311*, 1393-1401. [7] Schenk P. and Seddio S. (2006) *DPS 38*, Abstract #18.01. [8] Zahnle et al. (2003) *Icarus, 163*, 263-289.