THE RESURFACING AND BOMBARDMENT HISTORY OF SATURN'S MOON DIONE FROM ITS GLOBAL CRATER DATABASE. M. R. Kirchoff[1] and P. Schenk[2]. [1]Southwest Research Institute, Boulder CO (kirchoff@boulder.swri.edu). [2]Lunar and Planetary Institute, Houston TX (schenk@lpi.usra.edu).

Introduction: From analysis of impact craters and surface morphology using *Voyager* images researchers discovered Saturn's moon Dione has an interesting and unique history [e.g., 1-3]. Two terrains of great interest were identified – "wispy terrain" on the trailing hemisphere and "smooth plains" on the leading – along with the possibility of multiple impactor populations. However, the formation timing and mechanisms for terrains on Dione, and the bombardment history, could not be reliably determined from the modest *Voyager* imaging. *Cassini ISS* cameras have provided higher resolution images and global coverage of several of the Saturnian satellites, including Dione. Analyzing these images yields new information on the extent and formation of Dione's unique terrains and its bombardment history. In previous work [4,5], we presented preliminary results on compiling and analyzing a "global" crater database for diameters (D) ≥4 km. Here we now present the complete database and improved inferences for Dione's resurfacing and bombardment history.

Methods: The database is built by measuring the position and diameter of identified impact craters on controlled *Cassini ISS* images of Dione. Images used have pixel scales ranging from ~200-400 m/pixel and solar incidence angles between 45-80º. Therefore, we chose a conservative D=4 km for the database minimum to avoid issues related to resolution or incidence angle. The total area encompassed by the database is indicated by all colored regions in Fig. 1a.

After the crater database is completed, spatial crater density maps are generated using a counting circle analysis (e.g., Figs. 1b, c). In this analysis, a circle of 10º radius is positioned every 5º in latitude and longitude and the number of craters within the defined diameter range per circle area is computed. Densities calculated near the area boundary (black lines in Figs. 1b, c) are excluded due to edge effects.

Using these spatial density maps and the original images, geologic units (colored regions in Fig. 1a) are then subjectively defined based upon changes in crater density and surface morphology (e.g., surface roughness). The crater size-frequency distributions (CSFDs) are then presented for each unit in the relative (R) plot format [6; Fig. 2]. Symbol colors in the R-plot (Fig. 2) correspond to unit colors in Fig. 1a.

Results: We have identified 7 geologic units for Dione (Figs. 1a, 2). The red and orange units have the highest crater density and are called the "Red or Orange Dense Cratered Terrain (RDCT or ODCT)". The only difference between the two is that the red unit has a higher crater density for D<10 km (Fig. 1b). The yellow unit, which we call the "Average Cratered Terrain (ACT)", has a slightly lower crater density than the RDCT/ODCT, but is higher than the other units. The green unit, which covers most of the trailing hemisphere, has lower crater density for D<30 km than the ACT, but equivalent density for larger craters. This unit also contains the "wispy terrain", large fault systems, and several impact basins (D>100 km); therefore, we call this the "Fault and Basin Terrain (FBT)". The blue-green unit, which covers most of the leading hemisphere, has higher crater density for D<10 km than the FBT, but lower density for larger craters. This unit also has a smooth morphology, so we call it the "Smooth Terrain (ST)". The blue unit, which is the smallest, has a unique crater distribution with a very low crater density for D<10 km increasing up to a very high crater density for large craters. This unit also contains four relatively fresh, large (D>60 km) craters; therefore, we call it the "Recent Large Craters Terrain (RLCT)". Finally, the purple unit, which is located on Evander basin, has a low crater density at all diameters. Due to this unit's location we call it the "Evander Terrain (ET)".

Discussion: The RDCT and ET are the only units that do not have a decreasing crater density for D<10 km (Fig. 2). We suggest this can be explained by either of two possibilities. (1) Some process(es) is increasing small crater density on these two units and the other units' CSFDs represent the primary small impactor SFD. (2) Some process(es) is removing small craters on the other terrains and the RDCT and ET CSFDs represent the primary small impactor SFD. We note that an evolving small impactor population is NOT the likely answer as both CSFD shapes are seen on terrains of varying relative ages (vertical position in Fig. 2).

In support of hypothesis #1, the decreasing small crater density is seen on other inner saturnian satellites: Mimas, Enceledus, and Tethys [7,8]. Furthermore, the ET small crater density could be increased by formation of Evander secondary craters [8]. However, it is not clear how the RDCT small crater density would be increased. No recent basins are found near this unit, nor is it located on the hemisphere opposite (trailing) to Evander (leading) where "sesquinaries" (ejecta that escapes the satellite, then impacts [e.g., 9]) are expected to form [10]. The latter may imply further work should be done on sesquinary formation, especially for basins formed at high latitudes. Moreover, the varia-

tion seen in the CSFD shape for *D*>20 km among the other units cannot be explained.

In support of hypothesis #2, there is considerable observational evidence on Dione for processes that effectively erase small craters: cratering, tectonism, and cryovolcanism. In the ODCT, ACT, and RLCT, observations of large craters suggests that subsequent cratering would be the primary process. Meanwhile, within the FBT, observations of faults and recent, large craters implies tectonism and cratering are the processes acting there. Finally, the observations of volcanic vents and smooth surface [11] and few large craters within the ST, indicates that cryovolcanism is the process. However, again the reason why the RDCT retained a higher small crater density is not clear.

Conclusion: *Cassini ISS* imaging has allowed us to gather a near-global crater database for *D*≥4 km for Dione. From the database we have deduced the extent and relative formation age of seven terrains on Dione's surface, two of which appear to be a result of resurfacing by non-impact processes. However, Dione's bombardment history is still inconclusive, although evolving impactor populations seem unlikely.

References: [1] Smith, B.A., et al. (1981) *Science* **212**, p.163-91. [2] Smith, B.A., et al. (1982) *Science* **215**, p.504-37. [3] Morrison, D., et al. (1984) in *Saturn*. Univ. Arizona Press, p.609-39. [4] Kirchoff, M.R. & Schenk, P. (2010) *LPSC XLI,* Abst. #1455. [5] Kirchoff, M. & Schenk P. (2011) *EPSC-DPS,* Abst. #1545. [6] Crater Analysis Techniques Working Group (1979) *Icarus* **37**, p.467-74. [7] Kirchoff, M.R. & Schenk, P., *Icarus* **206**, p.485-97. [8] Bierhaus, E.B, et al. (2012) *Icarus* **218**, p.602-21. [9] Zahnle, K., et al. (2008) *Icarus* **194**, p.660-74. [10] Alvarellos, J.L., et al. (2005) *Icarus* **178**, p.104-23. [11] Schenk, P.M. & J.M. Moore (2009) LPSC *XL,* Abst. #2465.

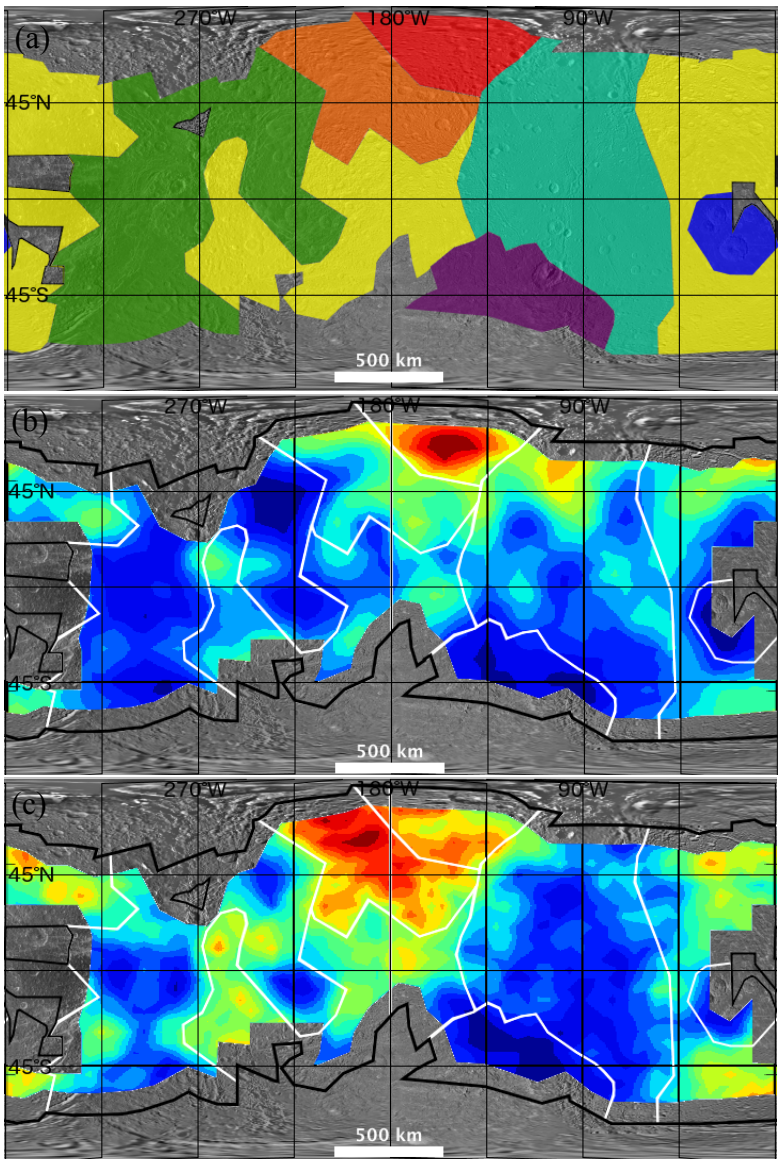

Fig 1. (a) Dione geologic units defined by this work. Crater density for (b) D=4-10 km and (c) D=10-100 km. Hotter colors = higher density.

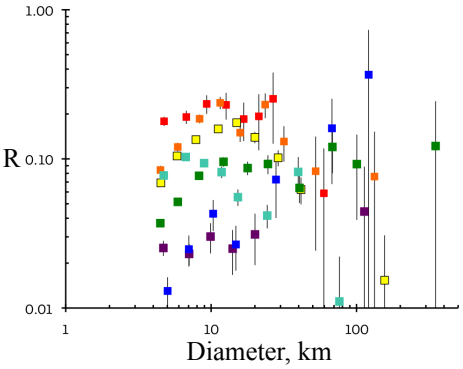

Fig 2. Crater size-frequency distributions (CSFDs) in R-plot format for geologic units shown in Fig. 1a. Symbol colors for each CSFD correspond to those for the unit in Fig. 1a. Errors are √N, where N is the number of craters in each bin.