GEOLOGY, AGES AND TOPOGRAPHY OF SATURN'S SATELLITE DIONE OBSERVED BY THE CASSINI ISS CAMERA.

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Introduction: More than two decades ago, the cameras aboard the two Voyager spacecraft imaged Saturn's satellite Dione (1124 km in diameter) at spatial resolutions of at least 1 km/pxl. Its surface is characterized by (1) cratered plains with varying crater frequencies and ages, (2) smooth plains which were believed to be volcanic extrusions of an H_2O-NH_3 eutectic melt, and (3) tectonic features such as scarps, troughs and ridges [1][2][3]. These features which are indicative of extension as well as compression could have been a consequence of several periods of global expansion and contraction through time [3][4]. The trailing hemisphere, imaged only at low resolution (> 5 km/pxl) by Voyager, shows a system of very bright, filament-like linear markings termed *wispy material* [2]. It was interpreted as a surficial deposit associated with volcanic exhalations along cracks [1][2].

Image data base: Since the Cassini Orbiter has been inserted into an excentric orbit around Saturn on July 1, 2004, image data at resolutions up to 15 m/pxl were obtained by the Cassini ISS cameras (Narrow (NAC) and Wide Angle Camera (WAC)) in two non-targeted flybys (Dec. 2004, June 2005), and a targeted flyby in Oct. 2005. The areas not very well covered by Voyager were imaged in these encounters showing more or less unknown terrain in much better detail (e.g. *Fig. 1*).

Procedure: The topics addressed in this paper are: **(1)** What are the **geologic units** seen in the areas imaged by Cassini ISS, what is their **stratigraphic sequence**, and how do they compare to the units mapped on Voyager data ? **(2)** What are the **ages** of these units, obtained from *crater size-frequency measurements* and from application of *impact chronology models* ? Is there a *Crater Population I* & *II* as has been suggested by [1] ? **(3)** Is there evidence for past **cryovolcanic activity** ? **(4)** What is the nature of the ***wispy terrain*** seen on the trailing hemisphere ? Ages are assigned by means of impact cratering chronology models. Two such models are currently used: (a) *Model I* with a lunar-like (exponential) decay in cratering rate with time (Late Heavy Bombardment (LHB)), and with a more or less constant cratering rate since about 3 b.y. (billion years) [5][6][7], and (b) *Model II* with a constant cratering rate throughout most of solar system history [8].

Results: (1) Heavily cratered plains are the most extensive and oldest units on Dione, confirming Voyager results [1][2][3] (*fig. 1*). Degraded tectonic features indicate early episodes of tectonism. Unexpectedly, there are no old, degraded impact basins as seen on other icy satellites, such as Rhea, Iapetus, or the Galilean satellite Callisto [9][10][11]. Model ages of this oldest unit are either higher than 4 b.y. (*Model I*) or higher than 2.5 b.y. (*Model II*). **(2)** Resurfacing has been caused by ***tectonism*** rather than cryovolcanism. So far, no evidence for flows or pyroclastic deposits in Cassini ISS has been found. **(3)** The wispy material has been shown to be of tectonic rather than of cryovolcanic origin. Light ist scattered from numerous fault scarps. Several episodes of extensional tectonism (with an unknown contribution of shear) can be recognized. At smaller scale (high-resolution), bright lineaments, in some places sets of parallel, densely-spaced lineaments, indicate incipient tectonism where no further displacements have occured (*fig. 3*). According to crater size-frequency measurements and model ages, tectonic episodes may date back to > 3.7 b.y. (*Model I*) or > 1 b.y. (*Model II*). **(4)** Less densely cratered plains in many cases are associated with younger craters, basin(s) and their ejecta. Higher-resolution ISS data of some of these craters show distinct ejecta pedestals not seen before in Voyager data, comparable to pedestals observed in crater ejecta on the Galilean satellite Ganymede [12]. Since there are stratigraphically younger large craters, there is no conclusive evidence for two different crater populations I (heliocentric projectiles during LHB creating craters > 20 km in diameter) and II (smaller, post-LHB Saturno-centric projectiles) as suggested by [1]. **(4)** Only one basin with a diameter of about 400 km was discovered so far (see *Figs. 1, 2*). This basin is stratigraphically young, with model ages of 3.2 b.y. (Model I) or only 0.33 b.y. (Model II). Stereo data revealed that this basin has at least two rings and a central peak complex (*fig. 2*). **(5)** The youngest units on satellite surfaces are associated with bright ray craters. Such features have not yet been observed on Dione. One feature named Cassandra and presumed to be a ray crater turned out to be actually a set of radial scarps radiating away from a point source and exposing bright ice on their slopes. At higher resolution and lower phase angles, small ray

craters on the order of 1 km in diameter or even smaller can be discerned, as well as groups of small, presumably secondary craters (*fig. 3*).

Ongoing work: A comparative investigation of Dione and its outer neighbor satellite Rhea is underway. Rhea also shows wispy markings on its surface which could not be seen in detail so far. These features most likely also originate from tectonic stresses rather than from cryovolcanism. Moreover, major surface features on Dione and Rhea, such as basins, craters and tectonic structures unnamed so far will be assigned names.

References: [1] Smith, B. et al. (1981), *Science 212*, 163-191. [2] Plescia, J. (1983), *Icarus 56*, 255-277. [3] Moore, J. (1984), *Icarus 59*, 205-220. [4] Consolmagno, G. (1985), *Icarus 65*, 401-413. [5] Boyce, J. & Plescia, J. (1985), in: *Ices in the Solar System* (D. Reidel Publ.), p. 791-804. [6] Neukum, G. (1985), *Adv. Space Res*. 5, 107-116. [7] Neukum, G. et al., *LPSC XXXVI*, abstr. No. 2034 (CD-Rom). [8] Zahnle, K. et al. (2003), *Icarus 163*, 263-289. [9] Wagner, R. et al., *LPSC XXXV*, abstr. No. 1964 (CD-Rom). [10] Moore, J. et al. (2004), *Icarus 171*, 421-443. [11] Giese, B. et al. (2005), *Bull. Am. Astron. Soc. 37*, abstr. No. 47.08, p. 728. [12] Horner, V. M. & R. Greeley (1982), *Icarus 51*, 549-562.

Fig. 1: Part of the trailing and southern hemisphere of Dione. The false-color image shows cratered plains, degraded craters, tectonic features, and a large basin near the south pole with a diameter of 400 km. The south pole is located to the west of the basin.

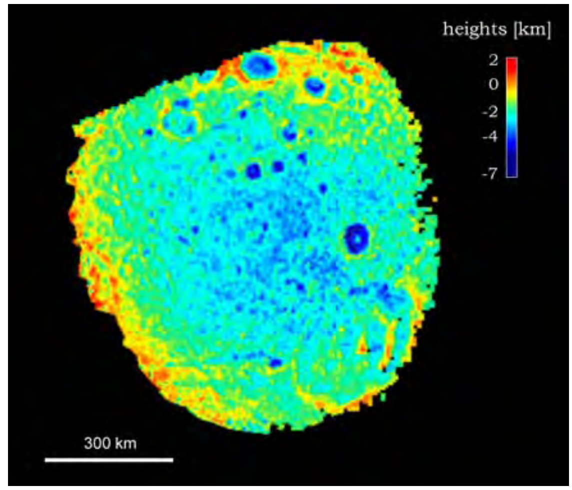

Fig. 2: Digital terrain model of the unnamed south polar basin.

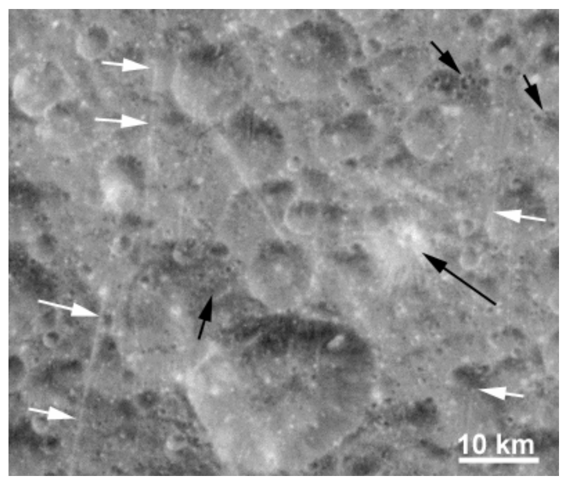

Fig. 3: High-resolution view (170 m/pxl) of Dione's densely cratered terrain approximately at lat. 29° S, long. 186° W (detail of ISS frame N1507742919). White arrows show fine, linear, bright markings indicative of incipient tectonism without further displacements. Black arrows indicate groups of small secondary craters. A stratigraphically young, small ray crater is shown by a long dark arrow.