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Ray system of a crater on Dione: implications to the formational age of its dark terrains

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Abstract

Dione has numerous craters with bright ray system as seen on the Moon and Mercury. Through the image analyses, we find (i) almost all small craters with bright rays are formed by secondary impactors originated from the Creusa crater, (ii) the ray system originated from the Creusa crater extends all over the surface of Dione, and (iii) the dark terrains of Dione are formed after Creusa crater, which is estimated to be at most a few Ma.

1. Introduction

We study craters with the bright ray systems on Dione, one of Saturn's mid-sized icy satellites, which has a mean radius of ~560km. Rayed Craters can be seen on the surface of solid bodies; such as, the Moon, Mercury, Galilean satellites, and saturnian satellites, which are considered to be geologically fresh structures [1][2]. After a rayed crater forms, they are estimated to fade out within a few hundred My due to the space weathering and the interaction with surrounding regolith. In the case of the Moon, the density of rayed craters implies that this takes place in less than ~750 Ma [3].

We define streaks as representing large linear rays of ejecta which can have global extent, and rays as more localized linear distributions of crater ejecta related primarily to smaller or secondary impacts.

2. Analysis and Result

We use the 1735 images obtained by the Cassini ISS camera prior to March 2012, which aerially cover the almost entire surface of Dione. The largest crater with bright rays on Dione is the Creusa crater, whose diameter is ~33km [2]. Moreover, we find few potential craters with ray system larger than 10 km in diameter. The frequency of rayed craters comprises roughly 1 % of all craters on Dione; a much lower frequency than the Moon or Mercury. We note that in the case of the Moon and Mercury, the frequency of rayed craters is roughly a tenth that of all craters [4]. In contrast, we find numerous small craters with ray system on Dione, whose frequency is quite high and not at all homogeneous. Through analyses of images, we find numerous brightly textured streaks encompassing Dione (Fig. 1), which are often identified in a region with numerous small rayed craters. Bright steaks on the leading hemisphere, typically share the same directionality, while those on regions such as the southern trailing hemisphere extend in multiple directions. To critically study the distributions of bright streaks in more detail, we develop a cylindrical projection map using the images where the solar incident angle is close to perpendicular (Fig. 3). This lighting condition improves the visual clarity and brightness of textures. The results confirm (i) that all bright steaks extend from the Creusa crater, and (ii) the region where the streaks extend to in all directions coincides with the antipode to the Creusa crater. Interestingly, the Creusa crater is the only one containing a global ray system in the solar system.

3. Discussion

The result which bright streaks are originated from the Creusa crater implies that numerous small craters with bright rays also form as secondary impactors resulting from the initial Creusa impact. Moreover, we find that the bright streaks and rayed craters become more obscure approaching the trailing side Dione (Fig. 3). The region without bright rays coincides with the dark terrain, which lies on the trailing hemispheres. This relationship indicates that the dark terrain may post-date the Creusa impact. The dark terrains are considered to have originated as contaminations from the dark materials (referred as the low-albedo materials), found widespread on Saturn system bodies and rings; such as Rhea, Hyperion, Iapetus, Phoebe, the F-ring, and in the Cassini Division [5]. Spectral data suggest that these materials have a shared origin [5]. Further, since the Creusa crater is considered to be formed within a few hundred Ma [2], we can conclude that the contaminations of the dark materials within the Saturnian system, and hence the dark terrains on Dione both formed within the last few hundred Ma..

4. Figures

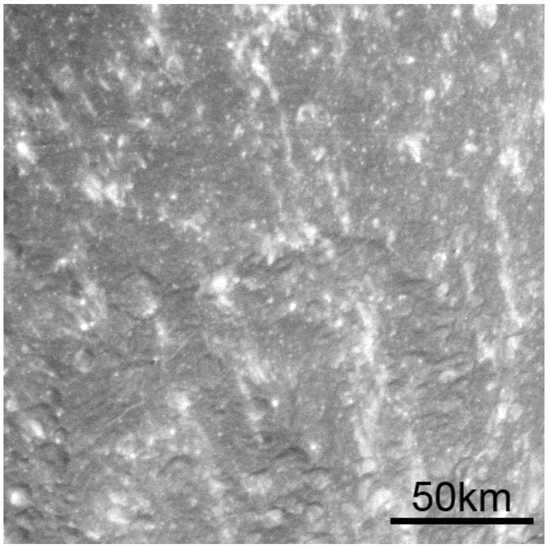

Figure 1: Numerous streaks with bright texture (from upper to lower). Numerous small craters with rays can also be observed in this image (image center: lon. 33.8, lat. 9.9) (N1649318802).

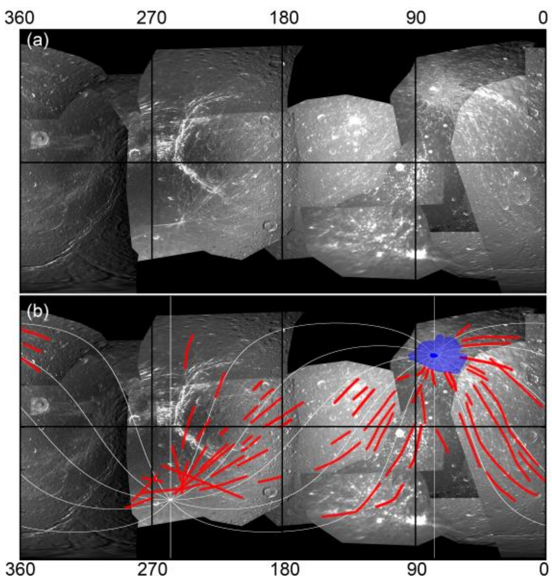

Figure 2: (a) The cylindrical projection map using the images where the solar incident angle is close to perpendicular. (b) Red lines indicate the locations of bright streaks. The blue region represents Creusa crater and its ejecta. The white lines highlight the orthodromic distance between the Creusa crater and its antipodal point. For this image, we use 14 images: (N1593074283, N1514077920, N1649317673, N1649313601, N1643300578, N1643300999, N1643298118, N1581274186, N1581192726, N1649318982, N1649318523, N1649318427, N1649331848, and N1532405095).

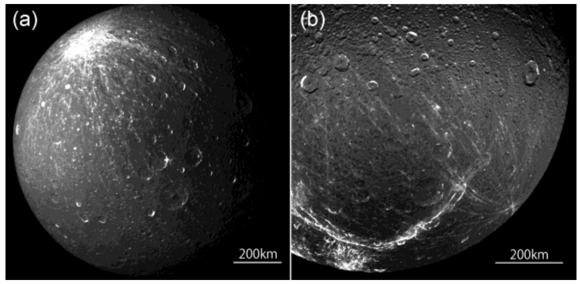

Figure 3: (a) Creusa crater (upper left) and its bright ray system. (b) The opposite side of a. The antipodal point of Creusa crater is in the lower right of the image. (N1649331848 for a) and N1643300999 for b).

References

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