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Clusters of craters on the Saturnian satellite Dione: morphology and size distribution

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Abstract

Crater clusters, mainly double craters as well as chains, occur on the terrestrial planets and on the Galilean satellites of Jupiter and were formed by simultaneous impacts of two or more impactors [1][2][3]. Cassini ISS images show that such features also can be found on the mid-sized satellites of Saturn [4][5]. In this paper we focus on the spatial distribution, morphology and size distribution of double and multiple craters on Dione.

1. Introduction

Multiple craters can form (1) by the impact of a tidally split weak ("rubble pile") projectile [1][2][3], (2) by impacts of mutually orbiting bodies [3][6], or (3) by material ejected from one satellite during an impact event, escaping the satellite and re-impacting on another satellite (so-called *sesquinaries*) [7]. Two or more craters created from impact events as just described have common rims and/or are characterized by similar morphologies, and by similar degradation state [4]. The most abundant type of multiple craters identified on the Saturnian satellites Enceladus, Tethys, Dione and Rhea are (a) doublets [4][5]. Another common type are (b) crater chains, whereas (c) clusters of craters are less common [4][5]. In this paper we briefly recapitulate results from mapping crater clusters on Enceladus and measuring their size distribution [5], and expand this procedure to similar forms on Dione. As has been done for Enceladus [5], we examine if age determinations obtained by measuring all craters in clusters as if they were formed by one single impactor instead of a split projectile could significantly affect the result.

2. Data base and procedure

Images: The surface of Dione has been imaged several times at regional spatial resolution on the order of 100 to 500 m/pxl by Cassini ISS [8] which allows the detailed geologic mapping of crater forms. The Dione basemap put together at DLR was also constructed from these imaging data [9][10]. The most recent orbit in which high-resolution data were taken was orbit 165. These data from May 2, 2012, are also included in this work. *Morphologic mapping:* Three classes, doublets, chains, and clusters (introduced and described in more detail in [5]), were identified, using the criteria described in section 1., and their spatial distribution was mapped in a distinct geologic unit (e.g., heavily cratered plains, or smooth plains) [4][5]. Examples for doublets and clusters on Dione in images taken during orbit 165 are shown in Fig. 1. *Crater size distribution and age determination:* The visual impression of specific regions on, e.g., Enceladus or Dione suggests that clustered impacts could significantly contribute to the total crater distribution which might affect age determinations if no discrimination is made between clustered craters and single (i.e., non-clustered) craters. Too high surface ages might result – similarly to the case if secondary craters are not excluded from crater counts. To examine this influence we used the following procedure: (1) In a specific geologic unit, clustered impacts are separately mapped. (2) The crater size distribution of all craters outside the clusters is measured. (3) The crater size distribution for each cluster is separately measured (i.e., each crater diameter is tabulated). (4) For each cluster, crater scaling is used [5][11] to recalculate the diameter of the unsplit projectile and the crater diameter created from this projectile. (5) Two crater size distributions are constructed for comparison, one with all craters, regardless if part of a cluster or not, and another one with the craters outside the clusters and the craters created from the unsplit projectiles.

3. Results

The procedure described in section 2. was tested in densely cratered plains west of the tectonized area

Samarkand Sulci on Enceladus [5]. About 10% of the total crater distribution are doublets, chains or clusters, a percentage comparable to clusters on Earth, Moon, or Venus [2]. Comparing the two size distributions, case 1: all craters inside and outside clusters, and case 2: craters outside clusters plus the single craters rescaled from each cluster, show that the two distributions are identical within the error bars. There is a small difference between the two measurements, however – the distribution in case (2) yields a slightly younger age, but the two cratering model ages in case (1) and case (2) are more or less identical within the uncertainties of impact cratering chronologies [11][12]. Currently, the procedure is being tested for geologic units on Dione. We anticipate similar results if the percentage of clustered craters is similar or less than on Enceladus. For a percentage significantly higher than 10%, however, it is likely that the effect on age determinations should be greater if no distinction is made between craters outside and inside clusters, as required in the procedure for case (2). Last, it must be noted that one major uncertainty remains: clusters may be chance associations, and also there may be an unknown contribution of unidentified clusters, especially in the case of doublet craters which are located further apart and do not share common rims. At least for an ~10% percentage of craters in clusters, the effect on age determinations when craters are counted as in case (1) is tolerable.

Acknowledgements

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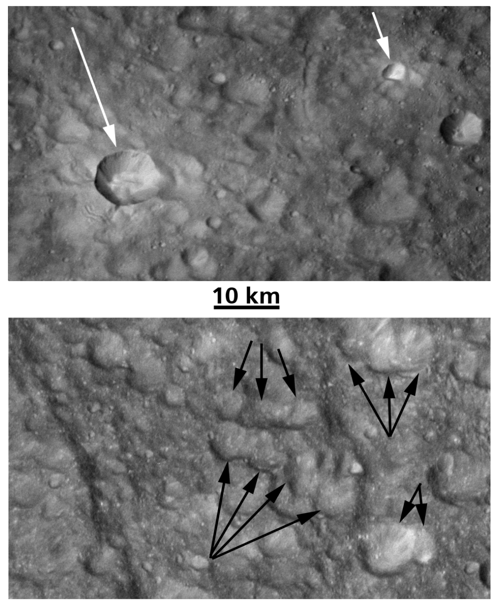

Figure 1: Examples of double craters and crater clusters on Dione. Images shown are from the recent orbit 165 (May 2, 2012). *Upper panel:* Detail of frames 1714685500 and 1714685017, showing a young bright fresh larger and smaller crater, possibly from a double impact (center lat./long.: 33° N / 132° W). *Lower panel*: densely cratered plains (detail of frame N1714685655) with several chains and clusters (center lat./long.: 42° N / 140° W).