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Crater chains, double and multiple craters on the satellites of Saturn: morphology and stratigraphy

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Abstract

Crater chains, double and multiple craters occur on the terrestrial planets and were formed by impacts of broken-up projectiles [1]. On the icy satellites of Jupiter, similar features, e.g. long chains of craters, could be observed [2]. On the icy satellites of Saturn, double and multiple craters (including chains) can also be distinguished in the Cassini ISS camera data. In this paper, we examine ISS images of the mid-sized satellites of Saturn (1) to identify morphologic types of these impact features, (2) to define their stratigraphic position and (3) to discuss implications on the origin of impactors creating these forms.

1. Introduction

Terrestrial planets as well as the icy satellites of Jupiter and Saturn exhibit groups of craters, consisting of at least two or more craters. Several modes of formation of such groups are possible: (1) A weak projectile can break-up by tidal forces prior to impact [1][2]. (2) A second mode is the impact of mutually orbiting small impactors [3][4][5][6]. (3) A third mode of origin discussed, e.g., for craters on the Galilean satellite Europa could be material ejected in an impact on another satellite (projectiles termed *sesquinaries*) [7]. Craters in groups formed by double or multiple impactors are characterized by (a) similar morphology, (b) similar degradational state, in a number of cases (c) similar size and/or (d) common crater rims, and (e) similar orientation of linear chains.

2. Morphology

We identified 3 different morphologic classes of groups of craters. Individual craters in each group may or may not have common rims. In extreme cases, craters created by a double or multiple impactor can be separated by a distance of several tens or hundreds of kilometers. **Class 1: linear crater chains** (*catenae*). Chains are linear groups of more than three craters. Chains are singular or occur as sets of parallel chains, as those shown in Fig. 1. The craters in each chain are either of similar sizes but in some chains crater diameters can differ up to a factor of 2. **Class 2: double craters.** Double craters are common on the mid-sized satellites. The two craters are either of similar size (Fig. 2, top), or their diameters differ by factors of 2-5 (Fig. 2, bottom). In general, they have one common rim (Fig. 2). In some cases, craters with similar diameter, similar morphology and degradational state can be observed which are several tens of kilometers apart but could have been created by a double impactor also. **Class 3: multiple craters.** This type is less abundant than classes 1 and 2 and is characterized by three or more craters generally having common crater rims (Fig. 3). A similar shape implying a similar impact angle is also a strong indicator for a common origin in the same impact event.

3. Stratigraphy

The three morphologic classes can be subdivided into at least two degradational types: degraded forms, and fresh forms. Most of the double and multiple craters were formed at comparably recent times and appear fresh. Older double and multiple craters also occur (e.g. on Rhea or Iapetus) but are much less discernable because of their higher degree of degradation. It is not clear, therefore, whether the percentage of split or multiple impactors with respect to single impactors has changed over time.

4. Summary

1. Double and multiple craters are formed by tidal disruption of a weak asteroid or comet [1][2], by the impact of binary asteroids or comets [3][4][5][6], or by ejected material from an impact on another moon

[7]. **2.** Three morphologic classes can be defined: crater chains, double craters, and multiple craters which may be subdivided into two degradational types: fresh and degraded forms. **3.** Chains, double and multiple impact craters occur on all mid-sized icy satellites of Saturn. They seem to be best distinguishable on those moons with younger, resurfaced units, such as Enceladus and Dione. They are less easily discernable in old, densely cratered units, e.g. on Rhea or Iapetus. **4.** On Dione, linear, parallel crater chains cover a major part of the southern latitudes of this satellite. They do not originate from a major basin-creating event but could have been created from a disrupted small moon.

Acknowledgements

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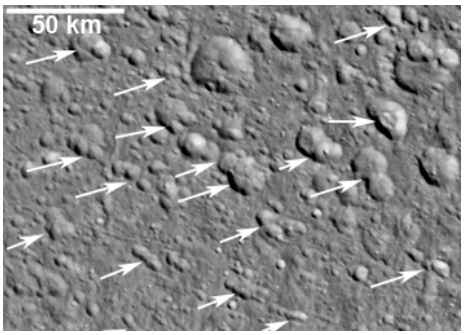

Figure 1: Example of linear chains and clusters of craters on Dione.

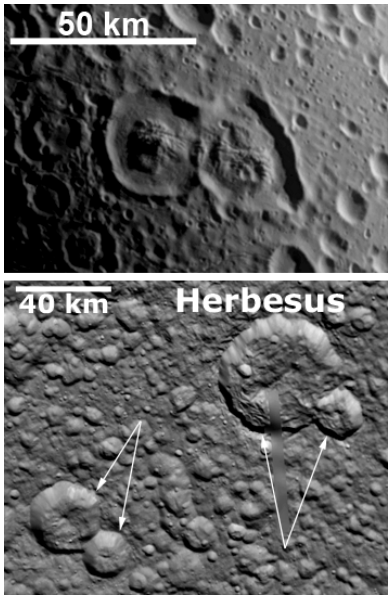

Figure 2: Double craters on Enceladus (top; Aladdin and Ali-BaBa) and Dione (bottom).

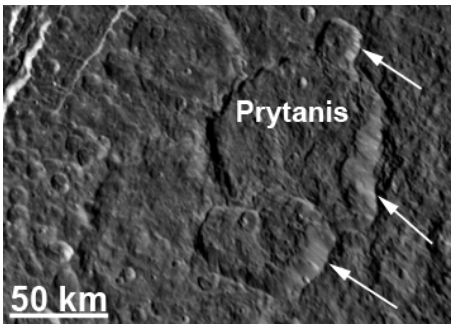

Figure 3: Example for multiple craters on Dione.