Crater Chains on Rhea: Impacts from Tidally-Disrupted Comets?

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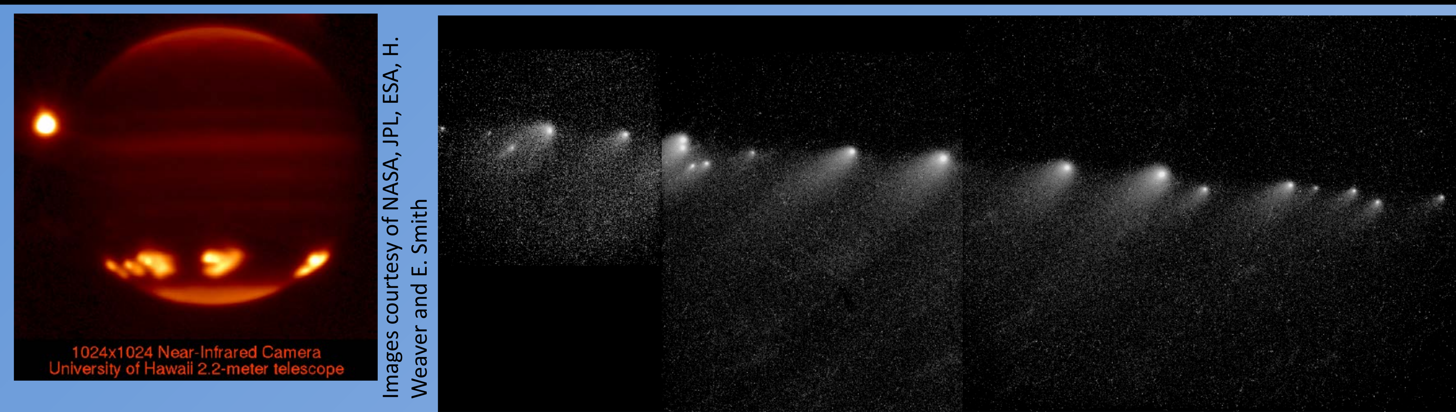


Introduction

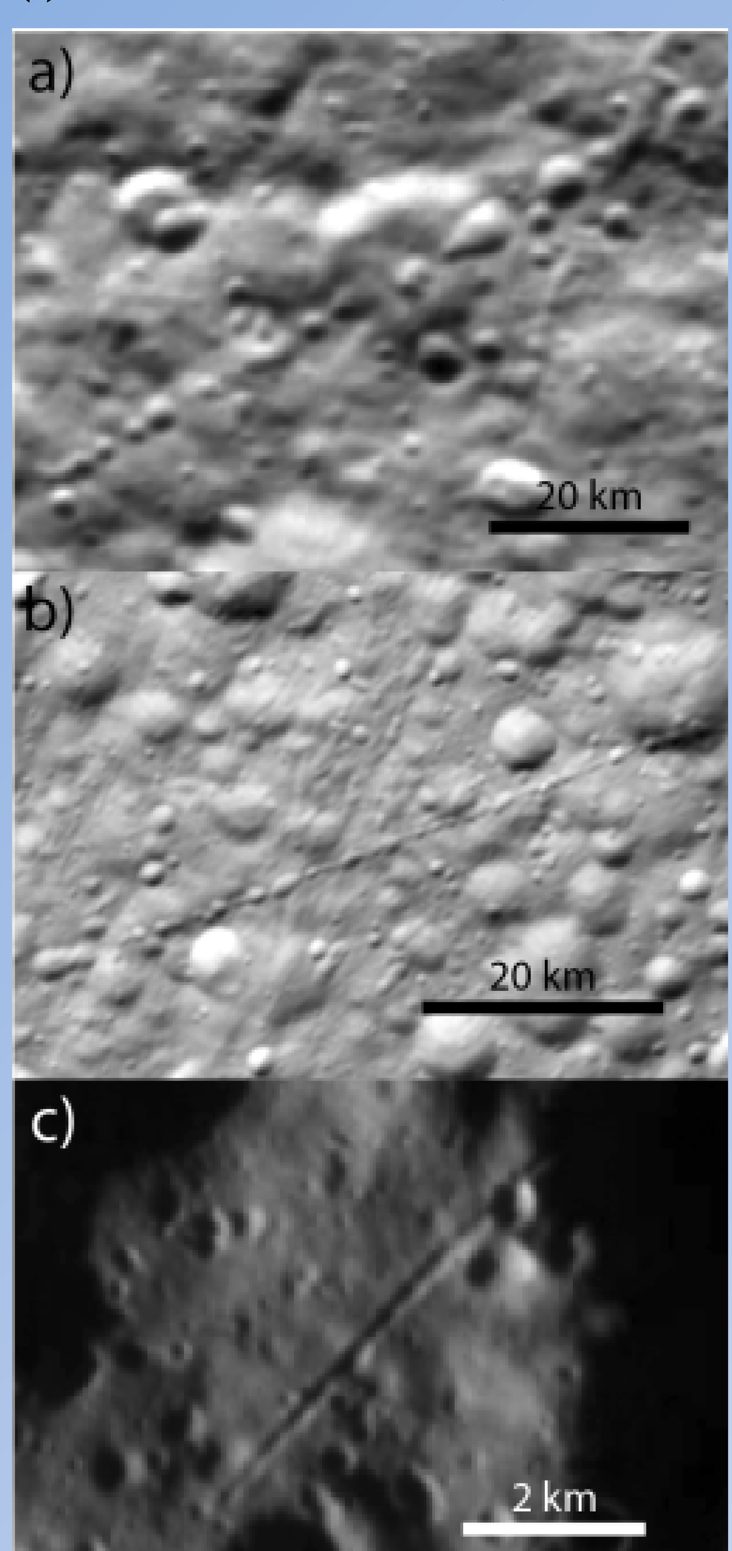
Crater chains are defined as linear strings of closely spaced, roughly similar-sized, aligned circular depressions. Many were designated as simply secondary impacts from the ejecta of initial basin impacts. With the appearance of Comet Shoemaker-Levy 9 in 1992 and its subsequent breakup into the "string of pearls" (seen above), and its impact into Jupiter in 1994, a new process became illuminated as a possible origin for some of the crater chains: tidally disrupted cometary impacts.

Previous studies have focused on searching the Jovian system for possible crater chains created by tidally disrupted comets. We expanded the search to the Saturnian system, specifically the icy moon of Rhea. With the arrival of Cassini at Saturn in 2004 there is adequate global coverage at appropriate resolutions to search the surface for crater chains.

Methods

The initial step involved identifying as many crater chains as possible within the Voyager and Cassini image data sets and each was catalogued into one of three morphological classes: pearls, grooves, and needles (see Fig. 1).

Figure 1. Crater chain morphologies (a) Pearl chain located at 5.5°S, 63.1°W. (b) Groove chain located at 33.5°N, 167.8°W. (c) Needle chain located at 4°N, 45.7°W.



The catalogue records the center coordinates, azimuth, length, maximum width, and morphology type of each chain. A scaling law previously applied to lunar secondaries [7] was used to determine the smallest possible size of the primary impactor from the largest crater diameter in the chain: $D_2 \approx 0.14 D_p^{0.77}$, where D_2 is the diameter of the largest crater in the chain and D_p is the smallest diameter of the primary basin.

Preservation state of the "secondary" and the potential source basin needed to be roughly similar.

Results

- 66 total catalogued chains
- No chains found at the poles
- Most needles were found in higher resolution images
- Grooves tended to be the morphology of the longer chains
- 52% of crater chains recorded lie between 105°W and 215°W, 31% of the moon's surface
- Due to the differences in global resolution a resolution map was begun to illustrate which areas had higher chain counts and whether that correlated with the better resolution

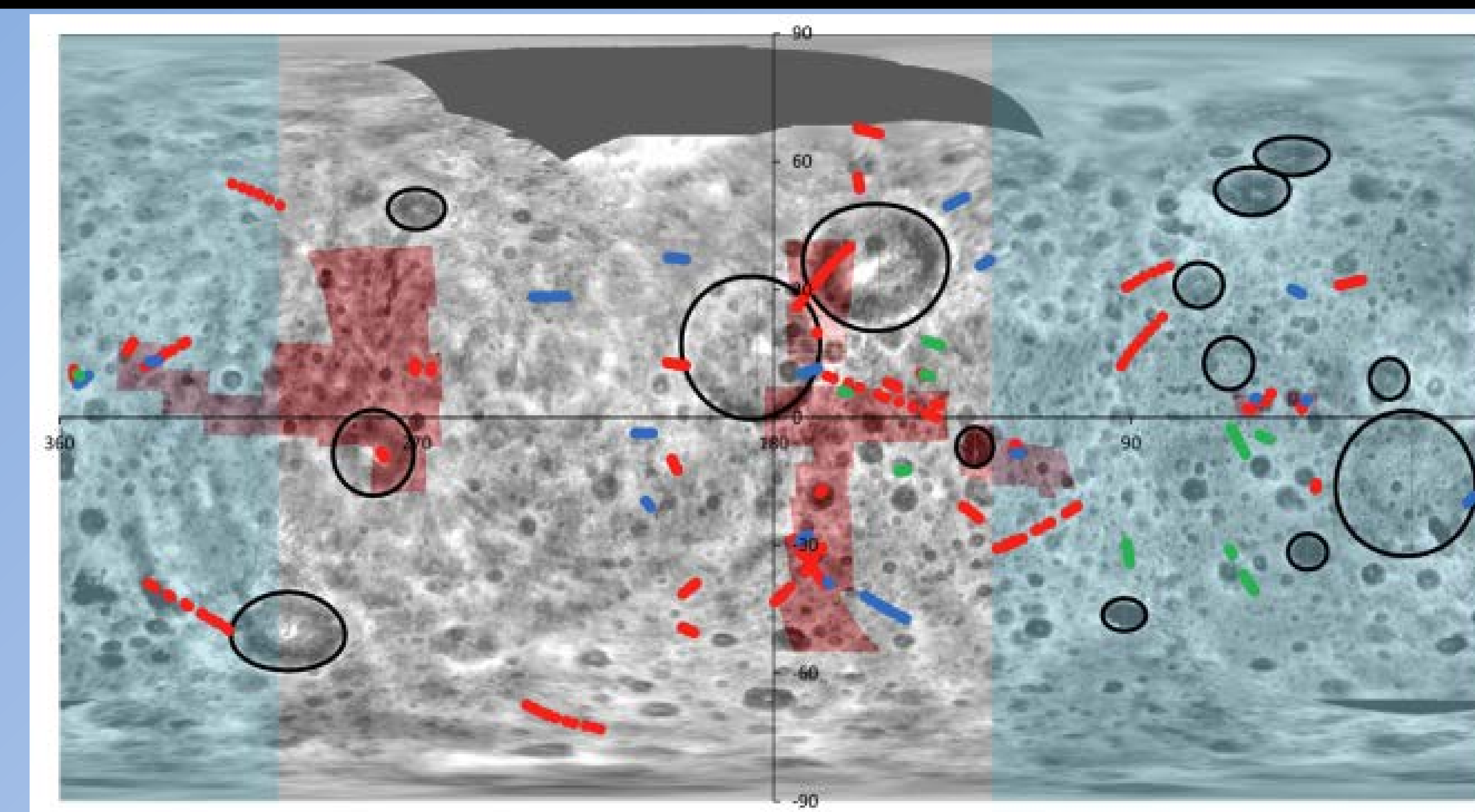
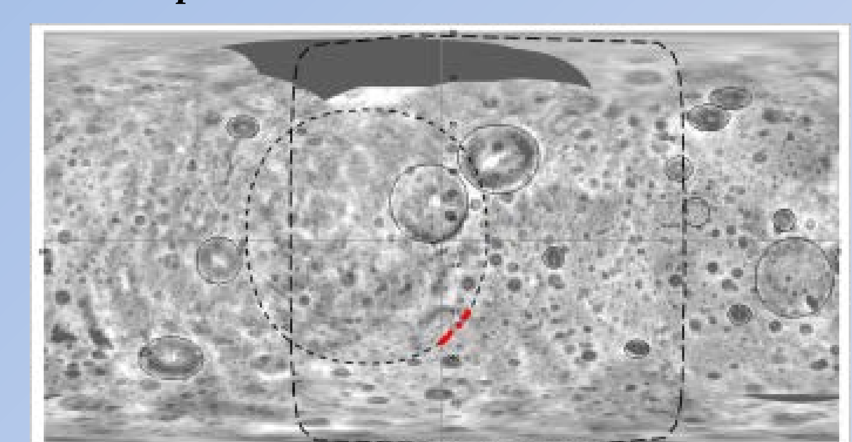


Figure 2. Global distribution of crater chain morphologies on Rhea, superimposed on a digital elevation model. Pearls are green, grooves are red, and needles are blue. The rims of craters >100 km in diameter are highlighted in black. The sub-Saturnian point is located at 0°N, 0°E. The blue area highlights the hemisphere where disrupted cometary impacts are expected based on observations at the Galilean moons [4]. The red areas highlight Cassini coverage obtained at better than 0.2 km/px.



Thebeksan Catenae, the red chain, and its groundtrack. The square-like dotted line represents the minimum size basin required to create secondary impacts of Thebeksan's size. The resulting basin would have covered one full hemisphere of Rhea; a highly improbable occurrence with Rhea presently intact.

Thebeksan Catenae, an anomalous chain centered at 38°S, 175°W, is by far the largest chain catalogued in terms of area (length of 200 km, width of 54 km). It is composed of the large impacts running from SW to NE.

Discussion

- 80% of the recorded chains are satisfactorily associated with possible source basins and are secondary candidates. Some craters were associated with multiple chains (see Fig. 4 below)
- Anomalous chains do not have any associated basins that are parental candidates
- 13 anomalous chains could potentially have been created by tidally disrupted comet impacts

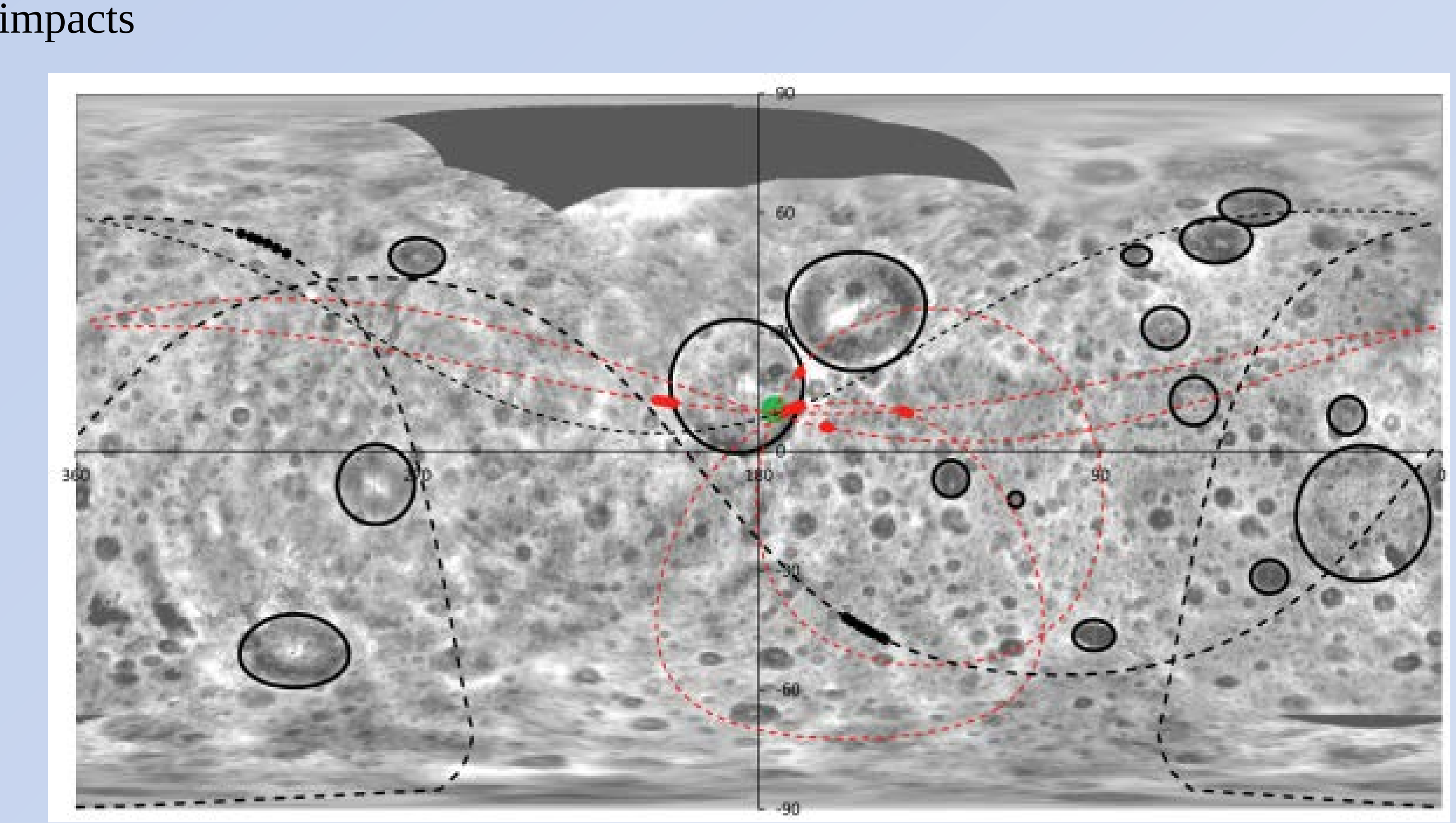


Fig. 4. The five red crater chains display small circle fits (red dashed lines) and sizes consistent with them being secondary chains originating from Fatu crater (in green). The two black chains (with small circles shown as black dashed lines) cannot be linked to any source craters.

- 9 out of the 13 anomalous chains fall within the cometary zone (blue area in Fig. 2)
- 4 may have originated during heavy bombardment early in Rhea's history (in the case of Thebeksan Catenae) due to the poor preservation state of the chains
- A majority of the chains considered to be comet-impact candidates fall within the cometary zone implies that orbital dynamics within the Saturn system do not preclude the fragmentation of comets and their subsequent impact into satellites
- Similar amount of anomalous crater chains found on Rhea as on Callisto and Ganymede together (resolution variance and resurfacing on Ganymede)

Rhea wide angle image - Cassini

Table 1. Counts and mean values for chain length, width and positive azimuth for the three chain morphologies.

	Pearl	Groove	Needle
Count	10	37	19
Length (km)	55	83	43
Width (km)	2.9	5.4	1.7
Azimuth (°)	56	50	61

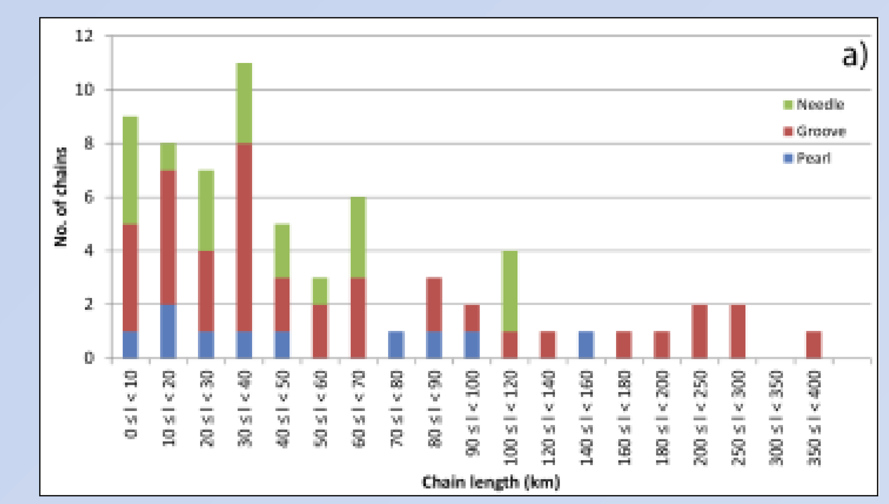
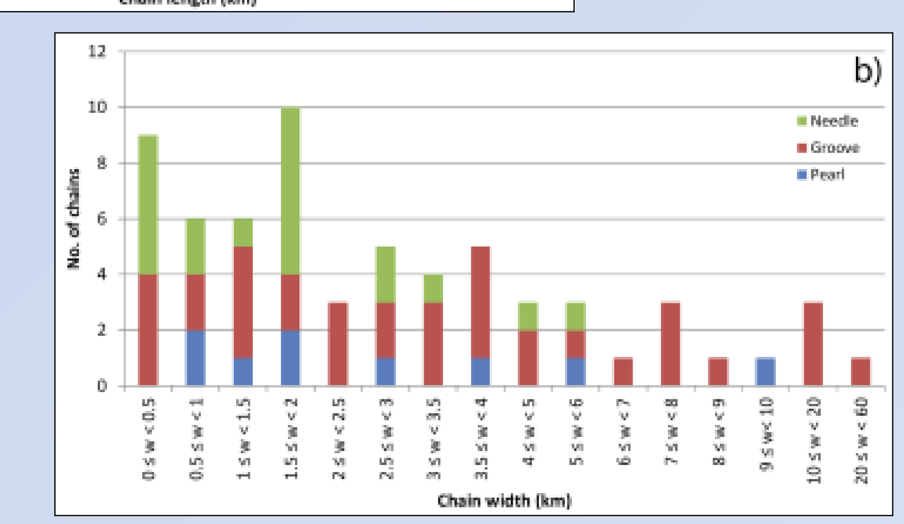
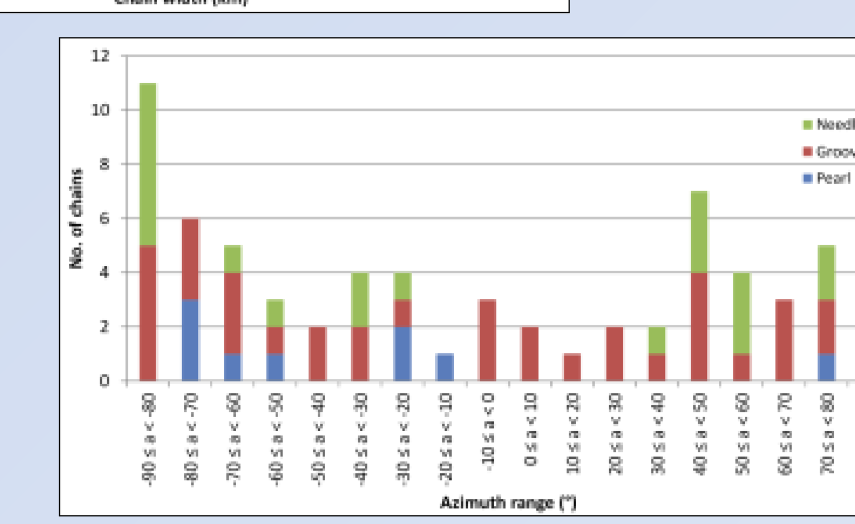


Fig. 3. Histograms of (a) chain length, (b) chain width and (c) chain azimuth for the three chain morphologies.





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