Craters of the Saturnian Satellite System: II. Mimas and Rhea

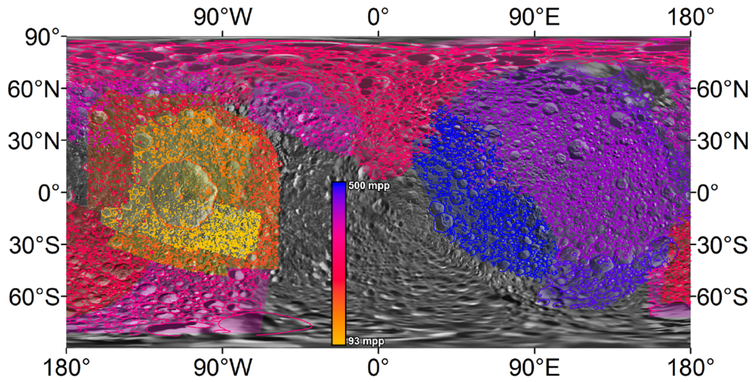
Stuart J. Robbins[1], Beau Bierhaus[2], Luke Dones[1]

[1]stuart@swri.boulder.edu, Southwest Research Institute, @DrAstroStu [2]Lockheed Martin Space Systems Company

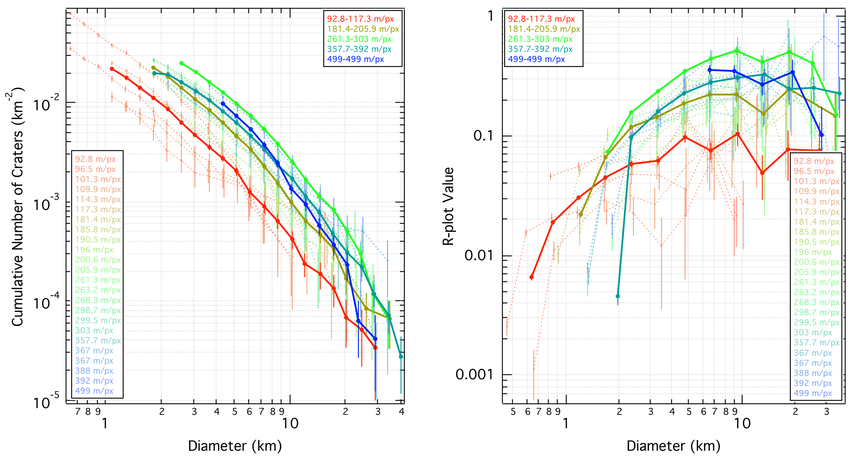
Abstract

We are working to generate a census of craters across most large Saturnian satellites with the goal to better understand the origin(s) of the crater populations: the exosystem impactors (mostly comets), intrasystem impactors (sesquinary craters), and secondary ejecta impactors (secondary craters). We present our approach to processing the data, our results for Mimas, and our results to-date for Rhea. This is inherently a comparative planetology investigation, so our results to-date are a report of the crater population and preliminary interpretation.

Mimas

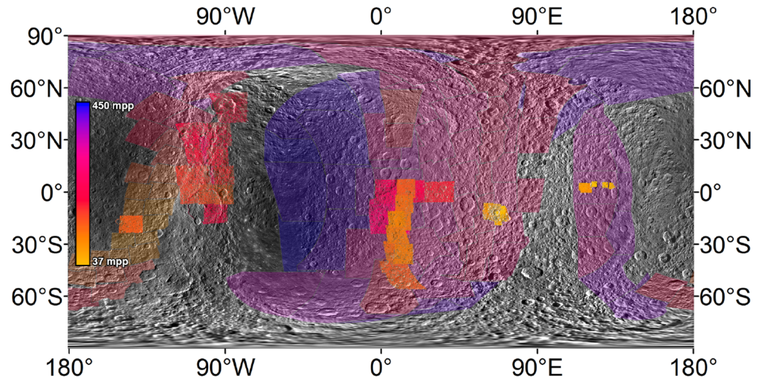


We have identified 10,981 craters on 27 images of Mimas, covering 77% the surface area. This covers all images with pixel scales ≤500 m/px.

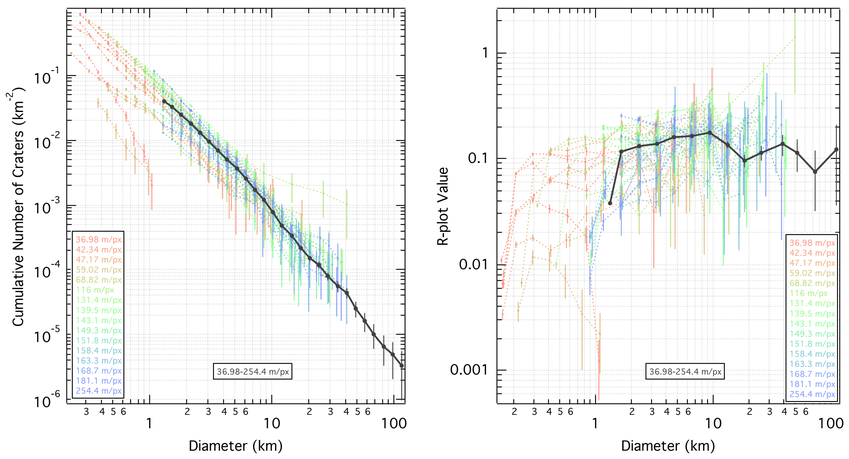


Cumulative size-frequency distributions (left) and R-plots (right) of craters on each image footprint (pastel colors, dashed lines) and grouped by natural breaks (darker colors, bold lines).

Rhea

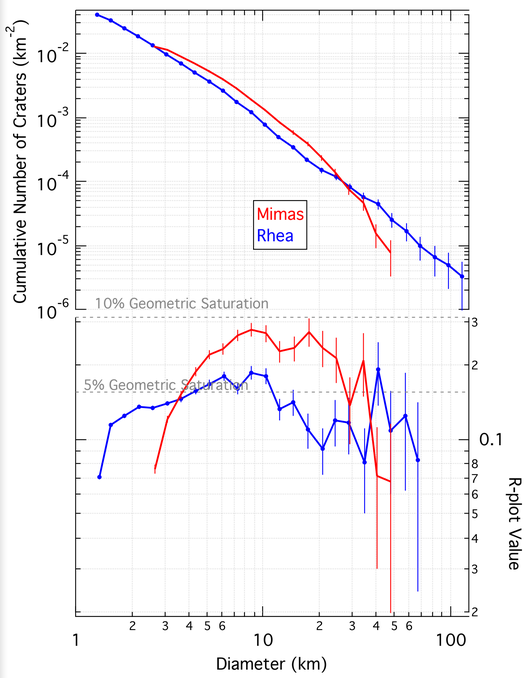


We have identified 75,197 craters on 43 images of Rhea so far, covering 8.2% the surface area. There are 99 more images with pixel scales ≤450 m/px (12 of those have pixel scales ≤150m/px).



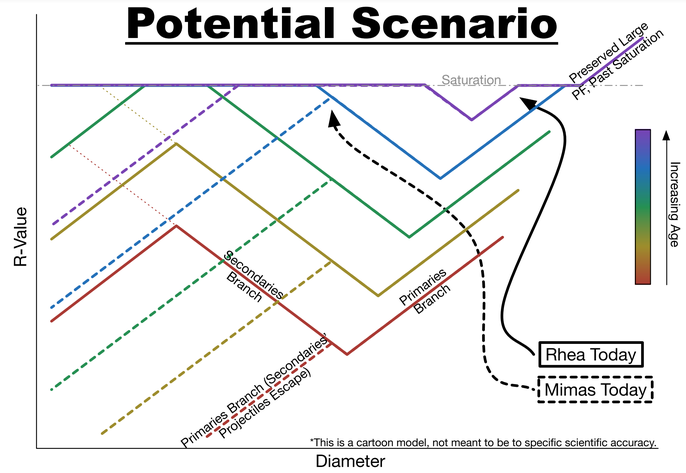
Cumulative size-frequency distributions (left) and R-plots (right) of craters on each image footprint. Natural breaks not shown due to small numbers in some sets, but overall average is.

Comparison of Crater Populations



- Mimas is more heavily saturated than Rhea.
- Rhea's spatial density of large (D > 50 km) impacts is larger than Mimas'.
- Mimas' population of smaller (D < 10 km) craters decreases rapidly relative to Rhea's.
- Rhea's larger surface gravity retains faster-moving ejecta that makes small secondaries which may be why Rhea has more smaller craters than Mimas.

Potential Scenario



- Secondary craters require a minimum velocity to form which may be greater than the escape velocity of the moon, *e.g.* Mimas.
- Below that corresponding diameter, no secondaries will be present.
- Largest craters may show production population beyond saturation.
- Rhea and Mimas are the largest and smallest end-members for spherical Saturnian satellites without atmospheres.

Methods

Images:

1) *Cassini* ISS "clear" and "green" filter images with resolutions ≤1 km/px were downloaded from PDS.
2) Processed in USGS's *ISIS* using standard radiometric and geometric corrections, and the default SPICE kernels. Output in equirectangular projection, and north or south polar if the image extended >±50° latitude.
3) Imported into ESRI's *ArcMap* software, sorting by best resolution within individual "flyby shooting" sequences. This and the following steps were done in different files for each map projection.
4) Georectified individual images to latest basemaps [1].
5) Using highest spatial resolution images first, iteratively mapped footprints of usable portions of each image. This takes into account smear due to off-nadir pointing, incidence angle, data dropouts, and image quality.

Crater Identification & Measurement:

6) Identified craters by using *ArcMap*'s "streaming" tool to place vertex points tracing the crater rim, also saving image in which the crater was identified.
7) Exported to Igor Pro software where custom circle- and ellipse-fitting algorithms fit each identification, saving location, size, and ellipse properties [2].

Data Analysis:

A) Standard size-frequency analysis for craters from each individual image.

B) Grouped images by using natural breaks in image pixel scale sets to create aggregate size-frequency distributions (shown for Mimas, not Rhea).

C) We are examining spatial distributions globally, across each satellite.

D) We are examining spatial distributions relative to large impact structures for both crater erasure and secondary craters.

References & Acknowledgments

[1] Schenk, P., pers. comm. Also: JPL Press Release, 09 Dec 2014, "Saturn's Moons: What a Difference a Decade Makes."

[2] Robbins, S.J. and B.M. Hynek (2012). *"A New Global Database of Mars Impact Craters ≥1 km: 1. Database Creation, Properties, and Parameters."* Journal of Geophysical Research, 117, E05004. doi: 10.1029/2011JE003966.

[3] Bierhaus, E.B. et al. (2012). *"The Role of Ejecta in the Small Crater Populations on the Mid-Sized Saturnian Satellites."* Icarus, 218, p. 602-621. doi: 10.1016/j.icarus.2011.12.011.

[4] Bierhaus, E.B., and L. Dones (2015). *Craters and Ejecta on Pluto and Charon: Anticipated Results from the New Horizons Flyby."* Icarus, 246, p. 165-182. doi: 10.1016/j.icarus.2014.05.044.

This work was funded by the NASA CDAPS.

Conclusions & Future Work

- Mimas' crater counts generally agree with published work that covered more limited areas.
- Rhea's larger g_{surf} retains faster-moving ejecta that makes small secondaries, potentially explaining the observed difference at small diameters.
- Many of the small, unclustered craters on Rhea may be "background" secondaries [3,4].
- Continuing to identify craters on ≤150 m/px Rhean images, then on to Iapetus!