CRATER STATISTICS ON ARIEL AND MIRANDA USING NEWLY PROCESSED IMAGERY AND TOPOGRAPHY. M. E. Borrelli*, C. J. Bierson¹, J. G. O’Rourke¹, School of Earth and Space Exploration, Arizona State University, Tempe, AZ, *meborrel@asu.edu

Introduction: Uranian satellites Ariel and Miranda are icy bodies that were observed by Voyager in the 1980s. The resolution of this imagery is about 1 km/pixel on Ariel and ~250 m/pixel for Miranda [1]. Due to the timing of the Voyager flyby, we only have coverage for the southern hemisphere of each moon. Data exists for the Titania, Umbriel, and Oberon, but the resolution is too poor to confidently collect crater statistics (~2.9–5 km/pixel). We used newly reprocessed stereo-derived topography data to analyze crater statistics on both moons [1]. We can use crater statistics to learn about properties of the surface material, the moons’ resurfacing histories, and the impactor population in the Uranian system.

Ariel’s surface appears to have been largely resurfaced, as evidenced by troughs with smooth floors [1]. A large cryovolcanic event could have erupted molten ice that produced a fresh-looking surface. A period of significantly elevated heating associated with one or more resurfacing events could have caused much of the outer ice shell to melt into a (still extant?) ocean.

Miranda’s surface can be categorized into two different terrains: rough, resurfaced areas called coronae and smoother, cratered plains [1]. Other studies determined that the cratered plains are older than the coronae, and that the coronae may have formed by cryovolcanic resurfacing of the cratered plains [1].

The crater size distributions were originally mapped by Schenk 1989 [2]. In this work, we remap these craters using newly processed topography [1] and lessons learned from the mapping of icy satellites in the Saturn and Pluto systems [3, 4, 5]. We used crater depth-to-diameter ratios and size-frequency distributions to learn about the surfaces of Ariel and Miranda. When combined with crater morphology information, depth-to-diameter ratio plots can help determine the simple-to-complex transition diameter (the size at which craters transition from bowl-shaped to having more complex topography such as central peaks). Additionally, R plots show us the relative frequency of craters of varying sizes present in a given surface area. This data can be compared to crater production functions to see how old the surface may be and to test the accuracy of the impactor population models for the Uranian satellites.

Methods: We collected depth, diameter, and location data for as many craters as possible within the outlined areas on Miranda and Ariel. We collected data for 87 craters on Ariel and 136 total craters on Miranda. We used this data to create R plots and depth-to-diameter ratio plots for each region.

![Figure 1: A) Ariel imagery with study area outlined in yellow. B) Miranda imagery with tectonized north area outlined in red and smooth middle outlined in blue.](image-url)
on the crater floor to get a depth. We measure 4 depth values, and report the average of those 4 depths for each crater. We do not report a depth for every crater because topography is not available (or not available at high enough resolution) for all locations.

**Crater statistics:** We conducted two types of crater statistics using the data we collected: depth-to-diameter ratio measurements and relative size-frequency distributions. The depth-to-diameter ratio can be used to determine whether relaxation has likely occurred by allowing us to determine the predicted initial depth of a crater with a given diameter. It can also illustrate the simple-to-complex transition diameter. This transition diameter can reveal the strength of the surface material and allow us to compare and contrast crater statistics across planetary bodies [4].

The R plot for Ariel and for each of the two regions on Miranda is shown in Figure 2. We also compared our results with those from Singer et al. (2019) for various regions of Pluto and Charon [5]. Singer et al. reported that a change in slope on the R plot is in roughly the same position (~10–15 km diameter) for all regions of Pluto and Charon, indicating that this feature is a result of the impactor population. We do not see a break in slope at the same diameter across Miranda and Ariel, indicating potential differences in the surface properties or changes in size distributions over time.

**Figure 2:** Relative frequency of various size craters (R plots) for Ariel and two regions on Miranda. There is a higher crater density at all sizes present on Miranda’s smooth middle, indicating an older surface than the tectonized north.

**Discussion:** We found a simple-to-complex transition diameter of ~17.5 km on Ariel, which agrees with the result from Schenk (1989) of 15 ± 5 km [4]. We were unable to determine a simple-to-complex transition diameter for either region on Miranda due to the lack of large, complex craters. This feature may arise from the limitations of available imagery or Miranda’s surface gravity being too low to create complex craters.

Ariel’s surface is lightly cratered. The largest crater, Yangoor, has a diameter of ~78 km and a negligible depth, indicating that this crater is relaxed [1]. Crater relaxation occurs when the surface material is too viscous to hold the shape of the crater topography. Other craters of a similar size such as Domovoy (diameter ~70 km) are not relaxed (depth ~3 km). This discrepancy may indicate that Ariel underwent a period of heating after the formation of Yangoor but before the formation of Domovoy.

Our results in Figure 2 also show consistently more craters on Miranda’s smooth middle than the tectonized north, implying the surface of the smooth middle is older. The tectonized north on Miranda may have experienced a resurfacing event or encountered a period of elevated heating in which older craters were erased. Ariel also may have encountered a period of elevated heating as indicated by the relaxation of large crater Yangoor and similar size of simple crater Domovoy.

**Ongoing work:** We will incorporate production functions into the R plots to see how our results compare with the modeled impactor population and to learn about the expected ages of the surfaces. We will also model crater relaxation on Ariel using Domovoy and Yangoor craters. By modeling relaxation with varying heat fluxes, we will place additional constraints on Ariel’s past heat flux.

We currently only have images of one hemisphere of the Uranian satellites. With more and better spatial coverage, we would be able to improve these crater studies to include many more regions and potentially other types of terrain. Until we see the other hemispheres of these moons, we cannot have a complete picture of their cratering and resurfacing histories. If we were to see more relaxed craters, we could also use them to better gauge for the amount of heat flow they may have experienced in the past. We could also expand these studies to the other 3 Uranian satellites if given data with a comparable resolution to that of Ariel and Miranda. We thus hope to see a return to the Uranian system to collect higher resolution data and more complete images of these surfaces.