AN ANALYSIS OF THE GEOLOGIC HISTORIES OF GANYMEDE'S DARK TERRAIN AND CALLISTO THROUGH IMPACT CRATERING DISTRIBUTIONS.

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Introduction: It was found in an earlier project, which compared Ganymede's relatively young light terrain to Callisto, that the impact population for the two bodies might be different [1]. By studying Ganymede's heavily cratered dark terrain and Callisto's surface we can better ascertain if a difference in the impact population does exist along with a further comparison of the two bodies. Also, since the dark terrain includes the oldest topography on Ganymede, we can further analyze its geologic history granting us new insights into this satellite's evolution. One of these being the ability to further evaluate Ganymede's apex-antapex asymmetry, which was found earlier by Zahnle et al. [2] to exist by a factor of 4 on the light terrain.

Methods: Measurements of crater diameters were taken on controlled mosaics created by Dr. Paul Schenk. The two high-resolution Callisto images are centered at 73°S, 90°W ("Callisto1") and 7.2°S, 6.6°W ("Callisto2") with resolutions of 200 and 700 m/pxl, respectively. Ganymede data is primarily from a 1 km/pxl global mosaic and one high-resolution image in Nichelson Regio (100 m/pxl). Palimpsests were included in the data sets by measuring the diameter of the continuous ejecta deposits, D_e, then finding the crater diameter, D_c, using the equation $D_c=\exp(\ln(D_e/2.442)/0.906)$ [3].

To analyze the counted areas on Ganymede for apex-antapex asymmetry along with other spatial crater density differences, the images were processed into ten degree thick slices relative to either the apex of motion (0°, 90°) or the center of a proposed nearby basin. Using the distance equation for a sphere, the angular distance in degrees was found for every crater from its point of reference. This angle (β) is then plotted versus the crater density within a given ten-degree slice.

Results: Fig. 1 shows the R-plot of the global counts for Callisto along with all our counted regions. Our Callisto counts show approximately the same crater density and curve shape as the general Callisto curve. The Ganymede lines, with the exception of Galileo Regio, shows roughly the same shape as Callisto and is in the order of ¾ less densely cratered. Galileo Regio, on the other hand, is approximately one third less densely cratered than Callisto and about half as densely cratered than the other counted dark terrain regions on Ganymede. Its infliction point is also shifted more or less by 20 km in crater diameter.

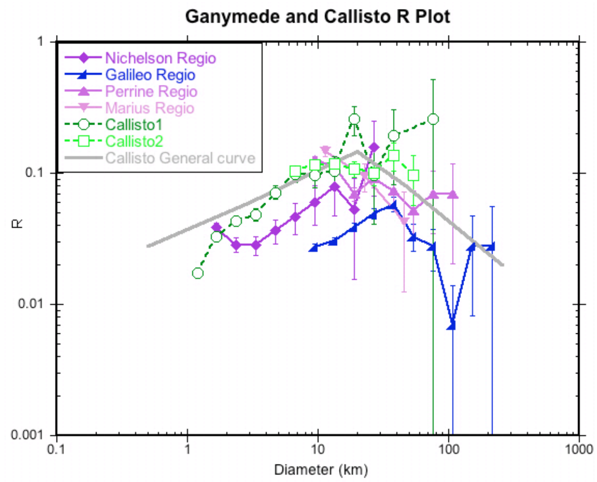

Fig. 1: R plot of all areas counted with the Callisto general curve for comparison.

Fig. 2 graphs the crater densities relative to the apex for the counted areas within Galileo Regio, Perrine Regio, Marius Regio and Nichelson Regio. The counted area for Nichelson Regio is small and hence only one data point is presented. The other regions, excluding Perrine Regio, show a decrease of ~ a factor of 2 from the apex (0°) to the anti apex (180°).

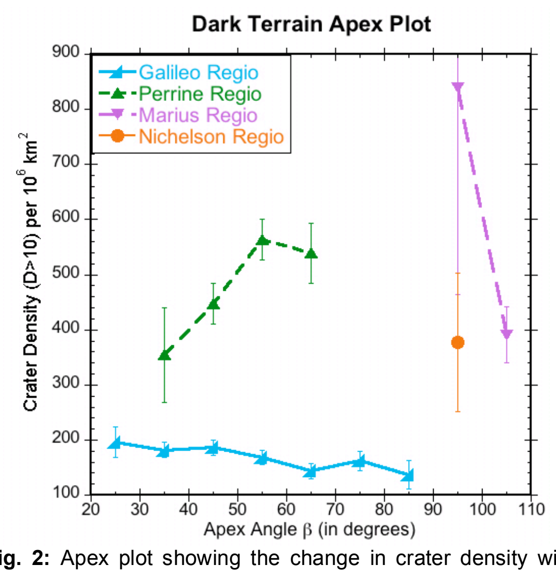

Fig. 2: Apex plot showing the change in crater density with respect to the apex (0°, 90°) of Ganymede.

In an investigative effort to answer why Galileo Regio seems to be distinctive from the other studied dark terrain, we plotted its crater densities relative to the distance from the proposed furrow forming basin [4]. Two centers were proposed: 20.7°S, 179.2°W, "the least-square center of curvature for all furrows in Marius and Galileo Regio", and 32°S, 189°W, "the best-fit center for all furrows in Galileo Regio only". This data is plotted in Fig. 3 for crater diameters D>10 km and for diameters 10>D>8 km. The curve for the probable center shows a general increase between the endpoints by a factor of 2 for craters D>10 km. The data for diameters 10>D>8 km shows no such major fluctuations. The Galileo Regio only center fits show a general increase between the endpoints by a factor of 1.5 for craters D>10 km. Between the 95- and 105-degree bin for crater diameters 10>D>8 km, an increase by a factor of 2.8 is found, but the data here are less robust.

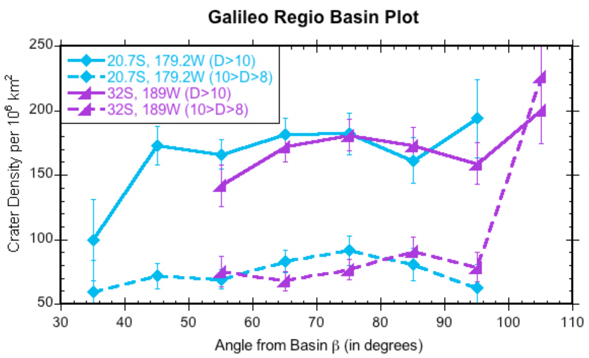

Fig. 3: Plot showing the change in crater density with respect to the proposed basins near Galileo Regio [4].

Discussion: In general, the dark terrains on Ganymede studied agree with most previous observations by being less densely cratered than Callisto [5-7]. This variance in crater density may suggest that Ganymede and Callisto have experienced differing amounts of tectonics, which could erode craters, or that the surface of Ganymede became rigid much later than Callisto's surface impeding it from fully recording its impact history [e.g. 7]. The dark terrain curves show approximately the same shape as the Callisto curves suggesting that the same impactor population most probably bombarded these two Jovian satellites.

Galileo Regio, in contrast, seems to have undergone some type of localized resurfacing seeing that it was found here and previously [5-7] to be half as densely cratered as the other investigated dark terrain. Here we propose the resurfacing may be an ejecta blanket that mostly covers the counted area of Galileo Regio reducing its crater density [5]. We performed a test using the basin plot in Fig. 3 to look for patterns in the spatial crater distribution that would be consistent with an ejecta blanket from the proposed basin of Schenk and McKinnon [4]. For a basin center 32°S, 189°W, the relative flatness of the graph between 55° and 95° may be taken to be the ejecta blanket coverage. The sharp increase in the crater diameter range of 10>D>8 km at the 105° bin may be considered to be the beginning of the secondary field, but may also be a statistical fluctuation. Furthermore, the modest decrease in density toward the probable basin center could imply coverage by an ejecta blanket, if it is real. This region could have also had fluid flows from the interior creating smooth terrain as suggested by Casacchia and Strom [6].

Finally, our apex calculations show that crater density decreases by a factor of ~2 from the apex to antipex of motion when observing Galileo Regio and Marius Regio. This value is less than what was found by Zahnle *et al.* [2], who found the asymmetry to exist by a factor of 4 on the light terrain, and is much less than their theorized value of 40. The lower factors in both terrains may occur because the surface of Ganymede rotated non-synchronously in the past [2]. The smaller differences for dark terrain with respect to the light terrain may hint to a geologic process that actively eliminates many but not all older craters like what is expected from a nearly saturated surface.

Conclusions: Our data show that most likely the same impact population bombarded both Callisto and Ganymede's dark terrain (Fig. 1). Galileo Regio is found to be half as densely cratered as the other studied dark terrains, consistent with past investigations [5-7]. If the modest decrease in density toward the proposed basin center (20.7°S, 179.2°W) is real (Fig. 3), it could indicate burial by ejecta. We have also discovered that the dark terrain has an apex-antapex asymmetry of a factor of 2 (Fig. 2). This value is less than the factor of 4 determined for the light terrain and much less than the predicted factor of 40 [2]. These differences imply that the surface may be nearly saturated. The apex-antapex curve for Perrine Regio, though, shows the opposite of what is expected. This requires further analysis of this region to attempt to explain this puzzling aspect. It would be advantageous to have a wider data set for Nichelson Regio, which is in the same longitudinal area as Perrine Regio, so that we may analyze its apex-antapex plot to explore whether this increase really represents this longitude range. Our basin plots for Galileo Regio do not definitively provide answers to the reason why it is different from the other dark terrain so an extended investigation of this area would also be valuable.

References: [1] S. Seddio and P. Schenk (2007) *LPSC XXXVIII* Abst #2350 [2] Zahnle *et al.* (2003) *Icarus*,163,263-282 [3] P. Schenk and F. J. Ridolfi (2002) *Geophysical Research Letters, 29,* 1590. [4] P. Schenk and W. B. McKinnon (1987) *Icarus, 72,* 209-234. [5] Murchie et al. (1989) *Icarus*, 81, 271-297. [6] R. Casacchia and R. G. Strom (1984) *JGR,* 89, B419-B428. [7] A. Woronow *et al.* (1982) **Satellites of Jupiter**, p. 237-276.