CHARACTERISTICS AND DISTRIBUTION OF CENTRAL PIT CRATERS ON GANYMEDE: IMPLICATIONS FOR PIT FORMATION MODELS. N. Alzate and N. G. Barlow, Dept. Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011-6010; na84@nau.edu; Nadine.Barlow@nau.edu.

Introduction: Morphologic variations among impact craters yield important insights into the characteristics of planetary crusts. Central pit craters are common on bodies with volatile-rich crusts, including Mars and icy moons such as Ganymede and Callisto. Several models for central pit formation have been proposed, including release of impact-generated gases during crater formation [1, 2], collapse of a central peak in the weak icy crust [3], excavation into an underlying liquid layer [4, 5], and impactor properties [4]. We are conducting a study of central pit craters on Ganymede and comparing the results to central pit craters on Mars to provide better constraints on the environmental conditions under which central pit craters form on these two bodies.

Survey of Central Pit Craters on Ganymede: We are compiling a catalog of impact crater morphologic and morphometric information for Ganymede using Galileo and Voyager data [6]. The Catalog currently contains 5441 craters, of which 432 (~8%) are classified as central pit craters. Central pit craters are those which display a central depression within the crater (Fig. 1).

Martian central pit craters are classified as either floor pit craters, where the pit lies directly on the crater floor, or as summit pit craters where the pit lies atop a central peak or other rise [7]. At the resolutions used in this study, central pit craters on Ganymede are always floor pit craters—we have seen no evidence of summit pit craters on Ganymede. However, most central pit craters on Ganymede display updomed floors, with the pit lying near the center of the dome. This updoming is almost certainly due to post-impact rebound of the ice-rich target [8]. A topographic study of martian central pit craters shows no evidence of crater floor updoming, consistent with much lower ice concentrations in the martian crust (estimated at ~15-20% from layered ejecta deposit studies) [9]. These observations indicate that central pits form in targets with a wide range of ice concentrations. The absence of central pit craters on volatile-poor bodies such as the Moon and Mercury indicate that target volatiles are necessary in the formation of central pits.

Figure 1: Example of a central pit on an updomed crater floor on Ganymede.

Distribution of Central Pit Craters: Our preliminary results show no strong latitudinal or regional trends in the distributions of central pit craters on Ganymede. No statistically significant variations in central pit crater concentration is seen on bright versus dark materials. We are still investigating whether there are any significant variations with geologic unit. The lack of any obvious regional concentrations in central pit crater distribution suggest that either the target material across Ganymede is relatively uniform to depths of a few kilometers (the excavation depth of these craters) or that variations in the near-surface substructure do not affect central pit formation. This has implications for the model suggesting that central pit formation requires layered target materials.

Sizes of Central Pit Craters: Central pits are seen in craters in the 5 to ~100 km diameter range. The frequency of central pit craters peaks near a crater diameter of 35-40 km (Fig. 2). Contrary to reports from Voyager-based studies, craters within the diameter range of central pit craters can also display other interior morphologies such as central peaks. Therefore, the argument that central pits form in place of central peaks within their specific crater diameter range is unsupported from our analysis.

Central pit craters on Mars range from 5 to 57 km in diameter with a frequency peak in the 10-15 km diameter range. Mars' gravitational acceleration is 2.6 times greater than that of Ganymede. The frequency peak in diameter for Ganymede is about 3 times greater than that for Mars. Therefore, the greater diameter range and larger diameter at peak frequency for central pit craters on Ganymede is probably simply related to the lower gravity of the moon relative to Mars.

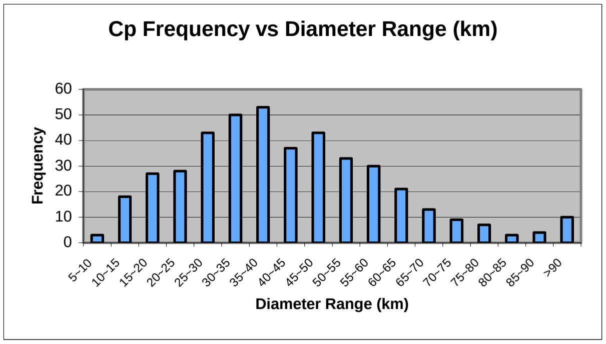

Figure 2: Central pit (Cp) craters on Ganymede range in diameter from 5 to ~100 km. The frequency of Cp craters peaks in the 35-40 km diameter range.

Pit Diameter to Crater Diameter: The size of the pit may provide constraints on the formation mechanism of these morphologies. We therefore have measured the diameter of central pits (D_p) and ratioed them to the parent crater diameter (D_c). Fig. 3 shows the distribution of D_p/D_c for the 432 pit craters in this study. Values range from 0.11 to 0.38, with a median of 0.19. D_p/D_c values for martian central pit craters tend to be lower: floor pits have D_p/D_c between 0.07 and 0.28 with a median of 0.15 while D_p/D_c for summit pits range between 0.05 and 0.19 with a median of 0.11 [7]. Comparing these results indicates that Ganymede central pits are typically larger relative to their parent crater than martian central pits. The difference is much less than 2.6 and therefore is not clearly related to the difference in gravity between the two bodies. The larger pit diameters on Ganymede may be related to the higher ice concentration in the target or to higher impact velocities of the (mainly cometary) projectiles.

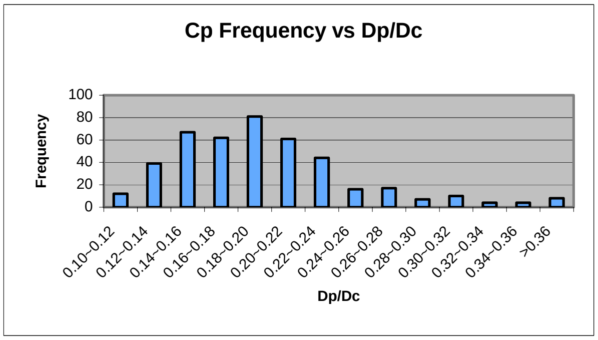

Figure 3: Comparison of pit diameter (D_p)-crater diameter (D_c) ratios for central pits on Ganymede.

Implications for Pit Formation Models: Our preliminary results for central pit craters on Ganymede, combined with results from the corresponding study of martian central pit craters, provide constraints on the various formation models for these features. The model proposing layered targets with liquid layers at depth [4, 5] appears contraindicated by the lack of any regional variations in central pit occurrence on either Ganymede or Mars. Collapse of a central peak in a weak ice-rich target [3] could explain the presence of central pits on Ganymede, but the existence of summit pit craters on Mars argues against the operation of this mechanism there. In addition, we find craters with the same diameter on Ganymede can show either a central pit or a central peak, so the target material is apparently strong enough to support some central peaks. Vaporization of subsurface volatiles during crater formation [1], supported by high temperature gradients under the transient cavity in numerical simulations [2], remains a probable mechanism for the formation of central pits. However, the question arises why central pit craters occur near craters of similar size and preservational state (a proxy for crater age) which do not display a central pit. Projectile characteristics, such as impact velocity, combined with the presence of target volatiles may help explain the observed characteristics and distributions of central pit craters on Ganymede and Mars. Our continued analysis of central pit craters on various worlds will help us to further refine the conditions under which these morphologies occur.

Acknowledgements: Funding was provided by NASA Outer Planets Research Program Award #NNG05G116G to NGB.

References: [1] Wood C. A. et al. (1978) *Proc. of 9th LPSC*, 3691-3709. [2] Pierazzo E. et al. (2005), *Large Meteorite Impacts III*, 443-457. [3] Greeley R. et al. (1982), in *Satellites of Jupiter*, Univ. AZ Press, 340-378. [4] Croft S. K. (1983) *JGR*, **88**, B71-B89. [5] Bray V. J. et al. (2006) *LPS XXXVII*, Abstract #1175. [6] Godwin, R. and N. G. Barlow (2007), *LPS XXXVIII*, Abstract #1243. [7] Barlow, N. G. (2007), *LPS XXXVIII*, Abstract #1242. [8] Schenk P. M. (1993) *JGR* **98**, 7475-7498. [9] Kagy H. M. and N. G. Barlow (2008) *LPS XXXIX*, Abstract #1166.