ANALYSIS OF CENTRAL PIT CRATERS ON GANYMEDE AND IMPLICATINS 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 (craters which contain a central depression either directly on the crater floor or atop a central rise) 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, 3], collapse of a central peak in the weak icy crust [4], excavation into an underlying liquid layer [5, 6], and impactor properties [5]. 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.

Ganymede Central Pit Craters: We have compiled a catalog of impact crater morphologic and morphometric information for Ganymede using Galileo and Voyager data [7]. The catalog currently contains 5441 craters (5km – 120km), of which 432 (~8%) are classified as central pit craters. These 432 central pit craters constitute all the central pit craters larger than 5-km-diameter on Ganymede.

Central pits are seen in craters in the 5 to ~100 km diameter range. The frequency peak for Ganymede central pit craters occurs near 40 km, about 3 times larger than the frequency peak for martian central pit craters. This difference is likely due to the 2.6x difference in gravity between the two bodies. 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. We see no statistically signifcant variation in the sizes of central pit craters as a function of either location on Ganymede or crater age.

We see no strong latitudinal or regional trends in the distributions of central pit craters on Ganymede (Fig. 1). No statistically significant variations in central pit crater concentration is seen on bright versus dark materials. The lack of any obvious regional concentrations in central pit distribution suggests that either the target material across Ganymede is relatively uniform to depths of a few kilometers (the excavation depth for these craters) or that variations in the near-surface substructure do not affect central pit formation.

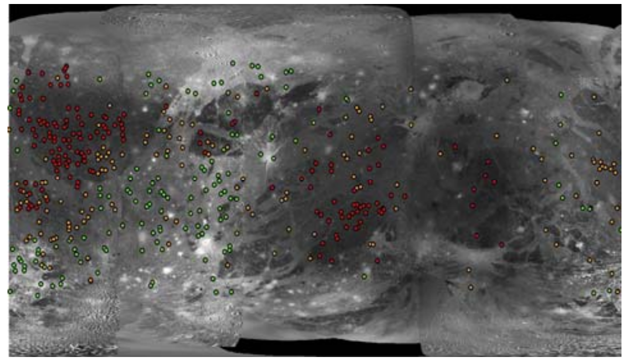

Figure 1: Central pit crater distribution across Ganymede. Colors refer to the albedo of the underlying terrain: red = dark, green = bright, yellow = intermediate.

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. 2). 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; summit pits have D_p/D_c for summit pits range between 0.05 and 0.19 with a median of 0.11 [9]). This indicates that Ganymede central pits are typically larger relative to their parent crater than martian central pits. 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.

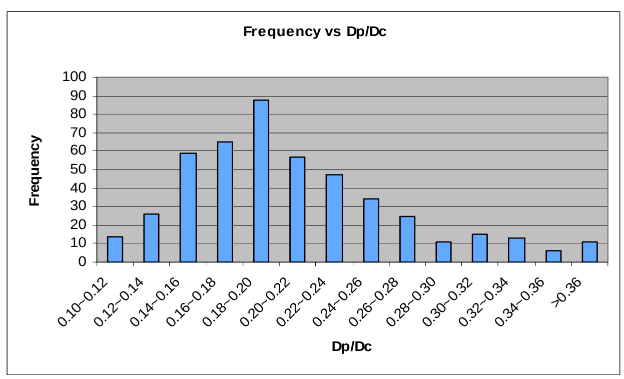

Figure 2: Comparison of pit diameter (Dp)-crater diameter (Dc) ratios for central pit craters on Ganymede.

We have completed an analysis of central pit distribution by geologic units, using the 1:5,000,000 scale geologic maps of Ganymede by the USGS (Fig. 3). The purpose is to determine whether any significant variations occur and also determine if there are regional or latitudinal variations in central pit crater diameters and therefore excavation depth. We do not see any variations in central pit occurrence or size as a function of geologic unit across Ganymede. There is a slight enhancement in central pit occurrence between 60° and 180° longitude but this is likely due to image resolution.

Implications for Pit Formation Models: Our results for central pit craters on Ganymede, combined with observations from a corresponding study of martian central pit craters [9], provide constraints on the various formation models for these features.

- The model proposing layered targets with liquid layers at depth [5, 6] 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 [4] 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. The presence of central peak craters in the same regions and diameter ranges as central pit craters on both Ganymede and Mars also argues against central peak collapse as the formation mechanism for central pit craters.

Vaporization of subsurface volatiles during crater formation, supported by high temperature gradients under the transient cavity in numerical simulations [2, 3], 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 age which do not display a central pit. Impactor 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.

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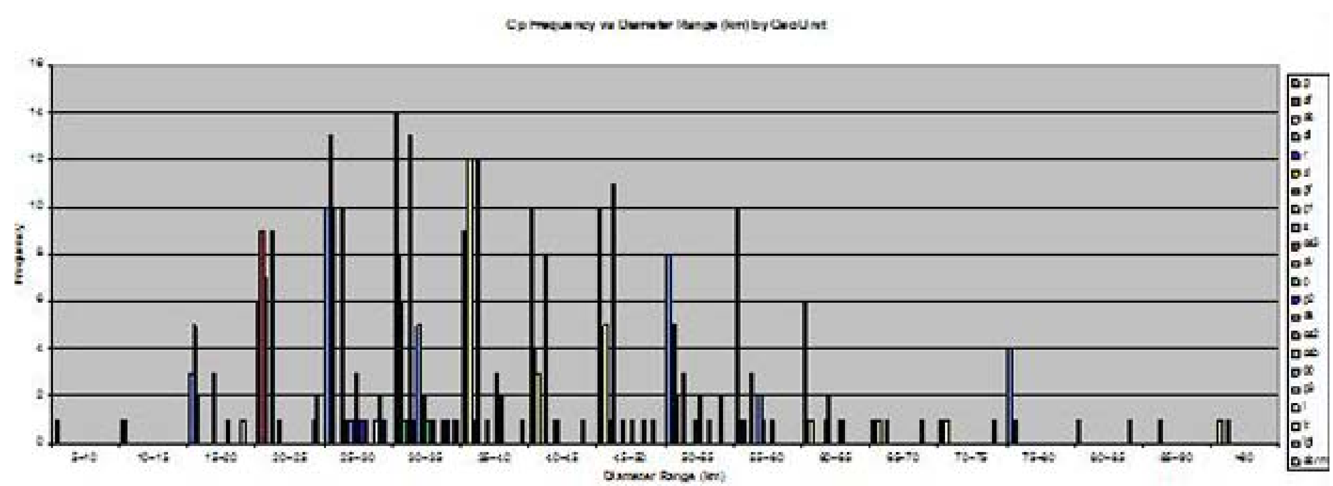

Figure 3: Frequency of central pit craters as a function of diameter and geologic unit.