INTERIOR MORPHOLOGIES OF IMPACT CRATERS ON GANYMEDE. R. Godwin and N. G. Barlow, Dept. Physics and Astronomy, Northern Arizona University, Flagstaff, AZ 86011-6010; rcg46@nau.edu; Nadine.Barlow@nau.edu.

Introduction: Recent imagery from the Galileo orbiter in addition to the Voyager data reveals a variety of interesting interior morphologies for impact craters on Ganymede. Central peaks, domes and pits are commonly found on this large, icy Jovian satellite. A catalog of all the craters found on Ganymede including their location, size, preservational state, and interior morphologies is the purpose of the current project. A complete catalog of this nature will help elucidate how environmental factors influence certain ejecta and interior morphologies. Upon catalog completion the data will be available in ASCII and GIS format for further study.

To date the catalog contains nearly 2000 craters, which are divided into four morphologic classes: simple crater, complex crater, multi-ring basin or a palimpsest. Of these, 1298 have been classified with an interior morphology.

Methodology: The primary focus of the study will be utilizing the data collected with the Galileo Solid State Imager (SSI). SSI data have resolutions of ~50-200 m/pixel compared to Voyager resolutions of ~1km/pixel. This allows for an in-depth analysis of the areas where these high resolutions are available. However, much of the moon is only covered by Voyager data, which allows interior morphologic analysis of craters with diameters greater than ~7km. Smaller craters are quite common, yet their interior features are indistinguishable and will consequently be omitted from this analysis.

Data sources for this project are the geologic and shaded relief maps produced by the US Geological Survey (USGS) and Voyager and Galileo imagery data from the Planetary Data System. We also are utilizing the USGS GIS maps of Ganymede available through the PIGWAD system.

Diameters are determined from an average of three or four rim-to-rim distances. Preservational states of the craters are estimated using a method similar to that for Martian crater studies, although based solely on morphologic characteristics [1]. A scale from 0 to 3 is used to indicate the level of degradation of a crater, where 0 is a nearly destroyed crater and 3 is a very fresh crater. Class 3 craters display sharp rims, pristine interior features and obvious ejecta blankets. Palimpsests are examples of class 1 craters.

Two large regions were observed with the Galileo spacecraft to allow for comparisons between areas with varying albedo. The brighter region is Uruk Sulcus (Jg-8) and the darker region is Galileo Regio (Jg-3). Smaller regions of high and low albedo are also included in this analysis. Differences in crater characteristics between these regions provide constraints on what effect environmental conditions , particularly ice versus ice-soil mixed targets, have on the formation of different crater morphologies.

Analysis of crater depth is performed as a means of comparison to help determine the influence of the environment on crater formation and morphology. The craters were measured from rim peak to crater floor utilizing shadow length techniques (Clow and Pike appendix in [2]). We measure the shadow length (L) and obtain the azimuthal angle of the sun and the phase angle between the spacecraft and the sun from spacecraft data. We calculate the depth (d) using

$$d = \frac{L\cos(\theta)}{\sin(\rho)}$$

Crater preservation strongly affects measured crater depth and results are subdivided based on preservation class. Comparative analysis of the depth (d) to diameter (D) ratios for craters on Ganymede versus other objects such as Mars provide constraints on how rocky versus icy target affect crater morphology and morphometry. Variations in fresh crater d/D between terrain types on Ganymede also provide insights into variations in target properties across the moon

Interior Morphology Results: To date we have classified 1974 craters covering all or part of the Jg-3 (Galileo Regio), Jg-8 (Uruk Sulcus), Jg-12 (Osiris), Jg-7 (Memphis Facula), Jg-2 (Perrine Regio), and Jg-6 (Dardanus Sulcus) regions of the moon (Figure 1). 1298 of these 1974 craters display an interior morphology which can be classified. 786 of these interior morphology craters (61%) display central peaks, making central peaks the most common interior morphology seen in Ganymede impact craters. Central domes are the next most frequent interior morphology (244 out of 1298 interior morphology craters, or 19%) followed by central pits (201, or 15%). The remaining 67 craters have interior features which do not fall into one of these three classifications.

Depths are currently being determined and have thus far covered parts of the Jg-2 (Perrine Regio) and Jg-3 (Galileo Regio) subquadrangles. Data are too sparse for each of the preservational types to determine if differences in d/D occur between different terrain types.

Central Peak Craters: Central peak (Pk) craters are complex craters that are found in abundance across all of the regions thus far studied. Craters with central peaks range in diameter from ~5 to ~35 km. The abundance of central peaks indicates that the ice targets into which the craters impacted behaved as a Bingham fluid, allowing the central peak to be produced [3].

Figure 2 shows the frequency of craters with a specific ejecta type by subquadrangle. Jg2, 8, and 12 are dominated by bright material while Jg3 and 6 are low albedo regions. Jg7 is a mixture of bright and dark material. Craters shown in the Jg2, and Jg6 regions only account for a portion of the craters in these regions. As can be seen from the graph, peaks are the dominant interior morphology in both bright and dark regions.

Central Dome Craters: Central domes (Cd) are found in complex craters and are characterized by a flat floor with a raised central complex that is surrounded by a rimmed moat. There appear to be various types of these particular craters, such as symmetric and asymmetric domes. Dome craters typically have diameters ranging from ~60 to ~ 180 km. Cd craters are less common than central peaks (Figure 2) but typically more common than central pits. Only in the high albedo regions of Uruk Sulcus (Jg8) and Osiris (Jg12) do pits outnumber central domes.

Central Pit Craters: Typically much larger in diameter than central peak craters, central pit (Cp) craters range from ~20-90 km. Central pit craters are characterized by a lifted central complex containing a pit. These craters are thought to form from impacts into ice-rich materials. Recent computer models suggest that ice-silicate mixtures at the surface are responsible for the formation of central pit craters on Mars [4] and similar conditions may be required on icy bodies such as Ganymede. The diameters of the pits will be added to the catalog and used to investigate trends suggested from Voyager analysis [5]. Results will also be compared with central pit data acquired for Mars [6, 7] in order to determine how increasing concentrations of silicates within an ice-rich target affect central pit characteristics.

Summary: Our current results support the idea that the local environment is a significant contributor to the type of interior morphology expressed by an impact crater. Comparison of crater morphologies of Ganymede with those on Mars and the Moon will allow us to more clearly elucidate how regional conditions in target materials affect crater formation.

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References: [1] Barlow N. G. (2004) *GRL*, *31*, L05703. [2] Pike, R. J. (1988) in *Mercury*, UA Press, 165-273. [3] Melosh, H. J. (1989) *Impact Cratering: A Geologic Process*, Oxford Univ. Press, New York. [4] Pierazzo E. et al. (2005) in *Large Meteorite Impacts III*, GSA SP 384, 443-457. [5] Schenk, P. M. (1993) *JGR, 98*, 7475-7498. [6] Barlow, N. G. (2006), *MAPS, 41*, 1425-1436. [7] Barlow, N. G. (2007) *LPSC XXXVIII*, this volume.

Figure 1. Current coverage of Ganymede crater morphologies are indicated by gray shaded areas

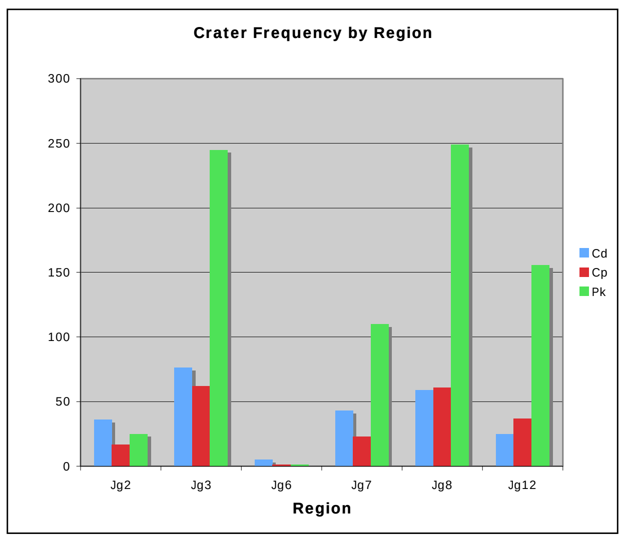

Figure 2. Graph showing the regional trends of the common crater morphologies