COMPLEX IMPACT CRATER DIMENSIONS ON LARGE ICY BODIES. V. J. Bray[1], M. F. Zeilnhofer[2], P. M. Schenk[3], M. T. Bland[4]. S. J. Robbins[5]. [1]Lunar and Planetary Lab., University of Arizona, Tucson AZ. [2]Department of Space Studies, American Public University System, Charles Town WV. [3]Lunar and Planetary Institute, USRA, Houston TX. [4]U. S. Geological Survey, Astrogeology Science Center, Flagstaff AZ. [5]Southwest Research Institute, Boulder CO. vjbray@lpl.arizona.edu

The process of impact crater formation is affected by, among other things, the surface and subsurface properties of the impacted body. As a result, impact craters and comparison of their morphology between different bodies in our Solar System can facilitate the comparison of the crustal properties of these bodies. This abstract presents two ongoing comparative studies: That of Galilean icy moons Ganymede and Callisto, and comparison of the dwarf planets Ceres and Pluto.

Callisto vs. Ganymede: Impact cratering in the Jupiter system is recorded on the surfaces of its solid satellites. In the case of Ganymede and Callisto, the crater population reflects two bodies with distinctly different geological histories. Ganymede displays clear geologic activity with its contrasting dark and bright tectonic terrains [1]. It is thought to be differentiated, with an upper crust of water ice. Callisto, further from Jupiter and with lesser tidal heating in its history, displays the heavily cratered surface of a likely undifferentiated [2], tectonically inactive body [1]. The gravities of the two bodies are similar (Ganymede: 1.34 m s^{-2}**,** Callisto: 1.235 m s^{-2}), removing one variable that affects crater dimensions. Differences in their impact crater morphology then come from their different impact velocity (Ganymede: ~21 km, Callisto: ~15 km [3]) and the crustal properties. Crater dimensions for Ganymede have been presented in [4, 5], and the depth-diameter of Callisto and Ganymede compared in [6]. We facilitate further comparison of these bodies by adding more Callisto crater dimensions to the literature.

Pluto vs. Ceres: Crater depth and wall slope data has been published by [7, 8]. We add to these data with measurement of central features. Pluto presents a more difficult body for comparison. The only bodies with surface gravities of close to 0.66 m s^{-2} are other outer-Solar System dwarf planets, which remain unimaged. Other bodies with similar gravity include Ceres (0.27 m s^{-2}), and some icy moons of the outer solar system – e.g., Charon 0.29 m s^{-2}, Callisto 1.24 m s^{-2}, Titania 0.39 m s^{-2}, Triton 0.78 m s^{-2}. However, even with a suitable gravitational match, the predicted mean impact velocity of 2 km/s on Pluto is low compared with the icy moons of the gas giants. Triton's ~ 8.2 km/s impact velocity [9] is close and topographic data available [10], but only covering 4 clear central peak craters at present [11]. Non-ideal, but suitable comparisons for Pluto are then its binary-partner Charon, and the dwarf planet Ceres, with a mean predicted impact velocity of 4.57 km/s and a gravity of 0.27 m s^{-2}. Crater dimensions for Ceres presented for comparison in this work come from [12] and include crater diameter, depth, rim height (when available) and central peak diameter.

Methods: The lack of laser altimetry in the Pluto and Galilean systems restricts height measurements to image-based methods. The latest topographic data available for Pluto is presented in Schenk et al. [13] and is based on stereogrammetry. Galilean system digital terrain models are based on a combination of photoclinometry and stereogrammetry, as presented in [14]. We extracted topographic profiles from these data and measured the crater dimensions of >50 impact craters on Pluto and >40 on Callisto. Measurements include depth, diameter, wall slope, rim height, central peak diameter and height. Impact craters included in this study were the freshest available in their local areas, retaining a defined crater rim and central structure. However, the dataset does include some clearly degraded craters by necessity, still being the "freshest" in their local area. We compare these crater measurements to published data for Ganymede from [4 and 5] and Ceres from [12].

Results and future work: A selection of the measured crater dimensions are presented in Figure 1. Craters smaller than 10km in diameter have similar depths on all bodies shown here, with depth-diameter trends diverging for larger craters. Ceres and Pluto have the greatest crater depths of our presented data, with craters on Ceres being deepest across the crater diameters presented. Crater depths are generally shallower on Ganymede and Callisto, with no statistically significant difference between those two over the crater diameters compared in Fig. 1. This progression in crater depth between the study bodies could be the result of craters on lesser gravity bodies experiencing less collapse. The deepest craters being on Ceres is not unexpected, due to its higher non-ice content and greater assumed crustal strength than the others [15].

Craters with diameters less than 50 km on Pluto and Ceres have steeper wall slopes than Ganymede and Callisto, as expected due to their lower gravity. The large spread of Pluto wall slope values, compared to the other datasets, perhaps reflecting the range of different preservation states of the included craters. However, the craters measured were apparently the freshest in their region, suggesting that a range of crater slopes exists as a natural variation of Pluto craters, perhaps as a result of difference in the impact velocity, or depth of exotic ice cover at the time of impact, which resulted in greater rim collapse for some craters.

Central peak craters with diameters smaller than ~ 15 km in diameter appear to have similar central peak heights on Pluto as on the large icy Galilean moons. At larger diameters, Pluto's craters have taller central peaks. This could point to enhanced uplift occurring during Pluto crater formation, or to more ready collapse of the Ganymede and Callisto craters. Although some increase in central peak diameter is indicated in the data for Ganymede and Callisto, the central peak diameters on all bodies follow a similar trend, suggesting that peaks on Pluto are inherently taller. The available Ceres data shows even taller peaks than the Pluto dataset, perhaps indicating lower gravity and less crater collapse as a reason for the differences in central peak height across our study bodies.

Application of these datasets: In addition to straight-forward comparisons between different solar system bodies, our dataset is useful to other methods of crater study: Topographic profiles and crater dimension trends are necessary for the testing of hydrocode models, and for the starting point of viscous relaxation studies, for example. In turn, these data help constrain investigations into the ice shell structure and thermal properties.

[16] predict that craters with $D \geq 60$ km at Callisto's high latitudes should be deeper than similarly sized craters at lower latitudes, but this will not be the case on Ganymede. Our finished datasets will allow for this prediction to be tested and also looked for within the Pluto and Ceres datasets.

Acknowledgments: This work is supported by NASA's Solar Systems Working program grant #80NSSC20K0149 and the New Horizons mission.

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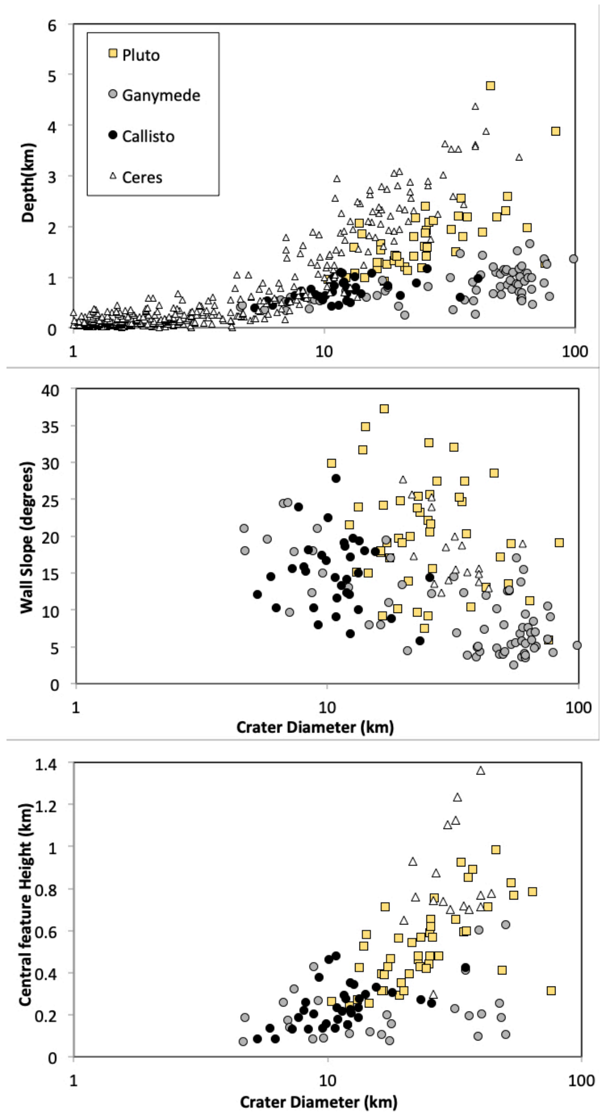

Figure 1: Comparison of crater dimensions on Callisto, Ganymede, Pluto and Ceres. Top) depth-diameter. Note that simple craters on Ceres are also included in this plot. Middle) Crater wall slope Bottom) Central peak height Key to all plots is top right.