ANALYSIS OF CALLISTO'S MULTI-RING IMPACT BASINS.

S. C. DeFour-Remy[1], V. J. Bray[1], P. M. Shenk[2], O. L. White[3,4]. [1]Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ (defourremy@email.arizona.edu). [2]Lunar and Planetary Institute, USRA, Houston, TX. [3]SETI Institute, Mountain View, CA. [4]NASA Ames Research Center, Moffett Field, CA.

Introduction: Greater understanding of the evolution of worlds that have been geologically inactive for much of their history, such as Callisto, is important as it provides a baseline for comparison when analyzing more active worlds such as Io, Europa or Ganymede within the Jovian system [1]. The morphologies of impact basins, features that are virtually ubiquitous on airless outer solar system icy bodies, can yield insight into the subsurface heat flow and physical state at the time of the impact [2-5]. If the relative impact time is known for a series of basins across a planetary body, a rough model of heat flow evolution across the globe can be constructed from the ring spacing and morphology.

Valhalla is Callisto's largest multi-ring basin, and the largest multi-ring basin in the solar system. It consists of a bright central region ~650 km across (a palimpsest), an inner ridge and trough zone, and concentric rings extending up to ~2300 km from the center [6]. Reaching >3800 km in diameter (more than a quarter of Callisto's circumference), Valhalla covers almost 15% of Callisto's surface area. An impact structure of this scale most likely punctured not only Callisto's lithosphere, but also underlying, softer material (be it warm ice or even a liquid ocean [6-9]), and so should provide a record of the physical conditions that prevailed to depths of >100 km at the time of its formation. We have recorded ring spacing and morphological information for eight transects across Valhalla, the first in a survey of three Callistoan multi-ring basins that will allow us to construct a global record of temporal variation in crustal thickness.

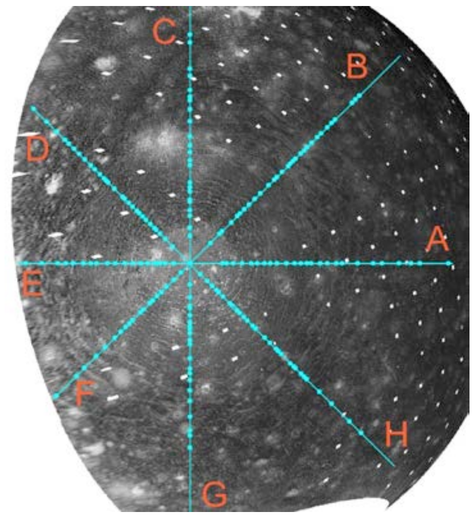

Figure 1: Mosaic of Valhalla, image projected about the basin center. Transects labeled.

Methodology: We used Galileo imaging to assess the morphometry of Valhalla's rings. The basin was orthographically projected to its geographic center, acquired by tracing a series of great circles oriented orthogonally to the ring arcs surrounding the basin, and calculating a mean coordinate from the locations of their intersections. From this central coordinate we drew eight radial transects at 45° separations (Fig. 1). For each ring encountered by each transect, we recorded whether it is a ridge or trough, passes through

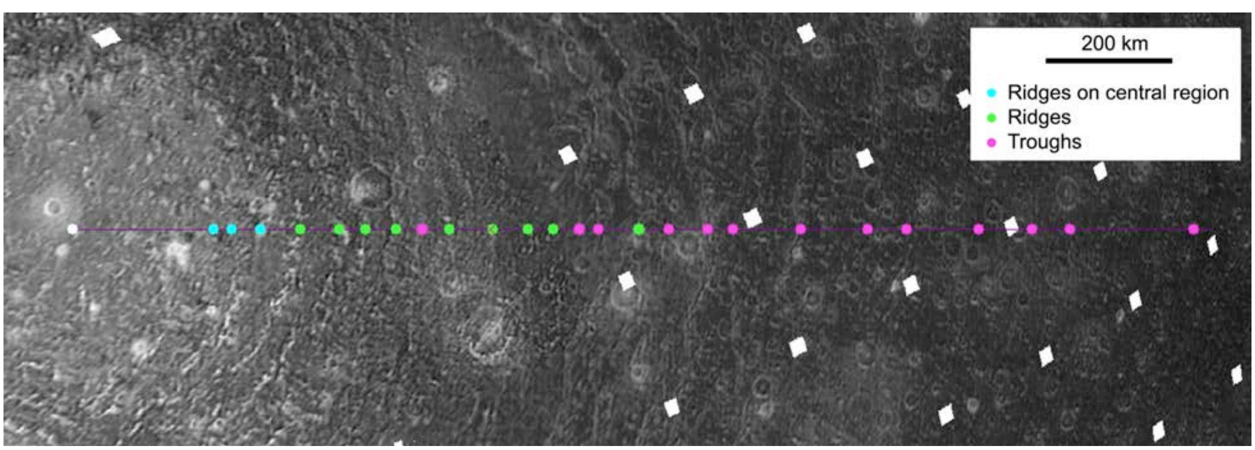

Figure 2: Transect A. The different tectonic features are marked and color-coded as in Fig. 3.

a palimpsest, is obscured by a crater, etc. A subjective confidence level was also assigned to each ring, ranging from 1-3, with 1 being the highest confidence. The geodesic distance from the basin center to each ring was calculated, and the spacing between rings calculated for those with high confidence.

Results: We plotted a total of 196 points along all transects for Valhalla. Of these points, 75% have been assigned confidence levels of 1 or 2. Those points of level 3 confidence are mainly due to low image resolution (1500 m), but transects D through F (See Fig. 1) also suffer from distortion due to the orthographic projection of imaging with a high emission angle.

All transects record the same general pattern in morphology as distance from the center of the basin increases: the bright central palimpsest appears flat with a sparse assortment of knobs and ridges. Ring arcs are noted within this region at the outermost limits of the palimpsest (blue in Fig. 2/3). Exterior to the palimpsest, there is a dense concentration of ridges (green in Fig. 2/3). For the distal regions, broad troughs dominate the ring morphology (magenta in Fig. 2/3). The transition from ridge to trough morphology is gradual, and regions with both ridges and troughs are observed. Fig. 3 displays the zones in which ridges or troughs are the *dominant* landform for all the completed Valhalla transects. Throughout all regions, sparse fractures are also observed in the imaging, perhaps marking troughs too narrow to be resolved.

The outermost ring around the basin is a sinuous fracture at a radius of 2306 km in transect A, and is the last of 25 potential ring-features along that transect (Fig. 2). Ring spacing between ridges on transect A varies from ~30 to 70 km with an average spacing of ~55 km, and does not increase notably with distance from the basin center. Ridge spacing is similar for the other transects. Ring spacing is greater for the troughs, averaging ~ 90 km between rings; trough spacing clearly increases with distance and is more variable between transects than the ridge spacing, with average trough spacing varying from 75 to 100 km on different transects.

Ongoing work: This abstract presents our preliminary work for the Valhalla basin. We will expand the survey to Asgard and Adlinda, and once all mapping and measurements are completed, the collated morphometric statistics and transects will be quantitatively compared. Crustal heat flow at the time of impact will be assessed using a similar approach to that of [2, 5] and variations with azimuth around the basin centers used to assess spatial differences in crustal properties and/or impact direction.

Acknowledgements: This work was funded by grant NNH18ZDA001N from NASA's Solar System Workings Program, and supported by the NASA Space Grant Internship Program.

References: [1] Smith D. et al. (2021) *Bull. AAS*, *53*(4), #095. [2] McKinnon W. B. & Melosh H. J. (1980) *Icarus*, *44*, 454-471. [3] Bjonnes E. et al. (2021) *Nature Astronomy*, *5*, 498-502. [4] Dombard A. J. & McKinnon W. B. (2006) *JGR Planets*, *111*(E1). [5] Johnson B. C. et al. (2018) *JGR Planets*, *123*, 3035-3050. [6] Greeley R. et al. (2000) *Plan. Space Sci.*, 48, 829-853. [7] Schenk P. M. (1995) *JGR Planets*, *100*, 19,023-19,040. [8] Klemaszewski J. E. & Greeley R. (2001) *LPSC XXXII*, Abstract #1818. [9] Moore J. M. et al. (2004) In *Jupiter: The Planet, Satellites and Magnetosphere*, pp. 397-426, pub. Cambridge University Press.

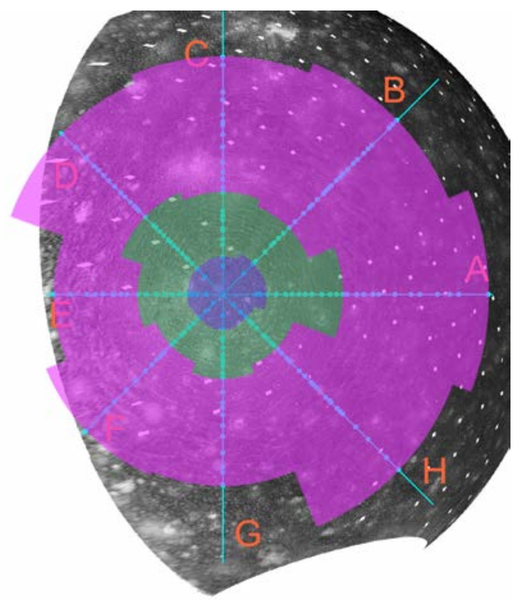

Figure 3: Summary of the regions in which tectonic expression is *predominantly* ridges (green) or troughs and fracturing (magenta). Blue marks the central bright palimpsest, which does display some raised ridges at its outer margin. Transects A-C, G and H record the farthest resolvable extent of the Valhalla rings. Transects D-F are curtailed due to poor image resolution and the edge of our mosaic.