

REINVESTIGATING CRATER SIZE DISTRIBUTIONS ON THE GALILEAN SATELLITE GANYMEDE, AND AN OUTLOOK TO ESA'S JUICE MISSION. R. J. Wagner¹, N. Schmedemann², S. C. Werner³, B. A. Ivanov⁴, K. Stephan¹, H. Hoffmann¹, and R. Jaumann¹, ¹Institute of Planetary Research, German Aerospace Center (DLR), Berlin, Germany (Email: roland.wagner@dlr.de); ²Institute for Geological Sciences, Free University Berlin, Germany; ³CEED, University of Oslo, Norway; ⁴Institute for Dynamics of Geosphere, Moscow, Russia.

Introduction: The nature and origin of potential impactor families and cratering chronologies on outer Solar System bodies is still intensely debated and an unsolved issue (e.g., [1]). Incomplete image coverage by the cameras aboard Voyager and the Galileo Jupiter orbiter impedes to measure craters over the full range of diameters on the icy Galilean satellites. In the mid-term future, ESA's **JU**piter **IC**y moons **E**xplorer (JUICE) will provide an excellent opportunity to complete global coverage and to obtain sufficient high-resolution coverage of these bodies, especially of Ganymede and Callisto [2][3]. In this work we reinvestigate crater size distributions measured in units derived from the recently published global geologic map of Ganymede [4], based on Voyager and Galileo SSI images at a map scale of 1 km/pxl. These units are used as context for crater studies at higher resolution in selected areas targeted by the Galileo SSI camera. Furthermore, we discuss strategies for crater investigations by the Janus camera aboard the future JUICE mission [2][3].

Motivation: In this paper we focus on the following fundamental issues: (1) similarity versus dissimilarity of crater distributions on Ganymede compared to inner Solar System bodies, especially the Earth's moon; (2) production versus equilibrium distributions in the most densely cratered regions on Ganymede; (3) variations in crater frequencies with respect to the distance of the apex or antapex point of orbital motion; (4) stability of crater distributions with time.

Methodology: Currently, Voyager and Galileo SSI images are being reprocessed in order to establish an imaging data base for the upcoming JUICE mission (mosaics at all levels of spatial resolution, combining higher-resolution SSI with lower-resolution Voyager and/or SSI images). Geologic mapping is carried out with the software package *ArcGIS*, additionally using a plug-in tool to measure crater size frequency distributions [5]. The software tool *craterstats* developed at FU Berlin [6] is used to obtain crater size frequency diagrams and cratering model ages. While a production function for Ganymede (as well as for the other icy Galilean satellites) was previously derived by an empiric shifting of the lunar production function to impact conditions on Ganymede [7], we apply much more exact crater scaling in this work [8][9][10].

Results: Measurements of crater distributions on Ganymede show a complex shape similar to lunar highland distributions in the diameter range ~ 20 m to ~ 200 km. This implies that the craters on Ganymede (accordingly on the other Galilean satellites) were formed by members of a *collisionally evolved projectile family*. This supports either Main Belt asteroids (MBAs) as primary impactors or infers collisional evolution of outer Solar System bodies, e.g. JFCs and TNOs. The similarity allows that a production function polynomial can be derived for Ganymede based on crater scaling [8][9][10] which can be used to fit crater distributions. An example is shown in *Fig. 1* for a target area of dark cratered plains material of Nicholson Regio. The cratering model age of 4.12 Ga is based on a lunar-like chronology model [7]. From the alternative chronology model by Zahnle et al. [11], based on cometary impactors and a more or less constant impact rate, the age of this terrain is on the order of 4.3 Ga.

At the smallest crater sizes ($\ll 100$ m), the cratering record is not well known because of insufficient imaging by the Galileo SSI camera. At the largest sizes (diameters > 100 km), large impact features are difficult to identify because of a high state of degradation. Therefore an unknown number of such features may have been lost from the cratering record.

The complex shape of crater distributions measured on Ganymede shows that they are production distributions. Highest crater densities on Ganymede (as well as on Callisto) are factors of about 2 to 4 lower than lunar highland distributions [7]. At smaller diameters, however, equilibrium distributions with a cumulative slope of -2 can occur in some localities.

No evidence for variations in crater frequencies with respect to angular distance to the apex or antapex point of orbital motion was found. This indicates that the craters mainly were formed by impactors in planetocentric orbits [12]. The production function shown in *Fig. 1* was derived on the assumption of preferentially rocky bodies impacting at planetocentric impact velocities [12]. Alternatively, however, Ganymede may have rotated non-synchronously at early times when the dark terrain was formed [11].

Imaging data from Ganymede are insufficient to investigate significant changes in the shape of crater distributions in detail which in turn might infer changes in the size distribution of impactors with time. At

least for the two major geologic units on Ganymede, dark and bright terrain, our results show that the impactor population has been stable during the time these units were formed (e.g., [7]).

An outlook to future data from the Janus camera aboard the JUICE Mission: The JUICE mission, with a launch planned for 2022 and Jupiter arrival in 2030/31, the Janus high-resolution camera aboard will improve considerably the current imaging data base of Ganymede. JUICE will orbit Ganymede for about a year in 2032/33 [13]. Globally, geologic mapping and crater counts at spatial resolutions of ~ 400 m/pxl or higher will be possible, and crater size-frequency measurements at highest resolution (several meters per pixel) can be carried out in selected target regions. Highly degraded impact features can be identified by stereo imaging, supported by laser altimetry data of the GALA (Ganymede Laser Altimeter) instrument and complete the investigation of Ganymede's cratering record between meters and hundreds of kilometers in crater diameters.

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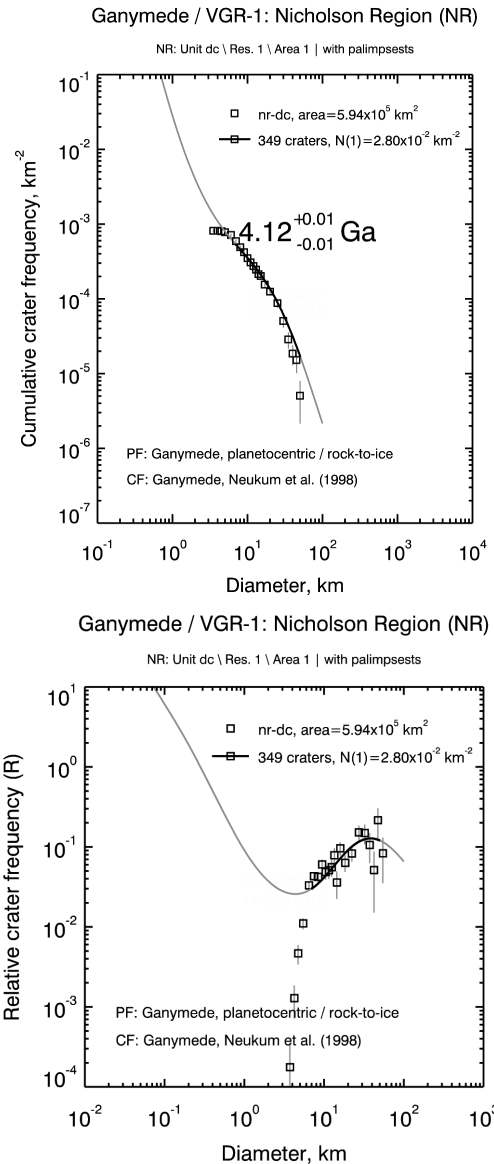


Figure 1: Cumulative (top) and relative (bottom) crater size diagram of an area of measurement in Nicholson Region (dark cratered terrain [4]). The curve shown is a production function polynomial derived for rocky projectiles impacting from planetocentric orbits [10][12]. Cratering model age is obtained from the model by [7].