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The large bright ray crater Osiris on Ganymede: its age, role as a potential time-stratigraphic marker, and target for detailed imaging by the JUICE/JANUS Camera

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1. Introduction

Bright ray craters are known from more or less any major planetary body which represent comparably young geological units on their surfaces. On, e.g, the Moon, Mercury, or dwarf planet (1) Ceres, a major ray crater was identified as a marker horizon to define the youngest time-stratigraphic system, or chronologic period, on these bodies, termed Copernican (Moon, [1] and ref's therein]), Kuiperian (Mercury, [2]), and Azaccan (Ceres, [3] and ref's therein). Ganymede, the largest icy Jovian satellite, features several large bright craters with extended ray systems, e.g., Hershef, Tros, Tashmetum, and Osiris. Unfortunately, these craters could not be imaged by Galileo SSI due to technical reasons [4]. In this study we use reprocessed Voyager images and focus on Osiris, its stratigraphic position in the context of dark and bright materials, try to constrain its age, and propose a new candidate time-stratigraphic system for Ganymede's young geologic history. Also, Osiris is an important candidate target area for detailed imaging (high-resolution; color data) by ESA's JUICE spacecraft to orbit Ganymede in 2030 – 2033.

2. Procedure

Image processing: In a previous study [5], relative and absolute model ages, henceforth termed AMAs, of Osiris and other large bright ray craters could only be estimated with a high degree of uncertainty in a global Voyager and SSI basemap at a resolution of 1 km/pxl. Since the spatial resolutions of Voyager images during the two Jupiter encounters in 1979 varied considerably, we reprocessed Voyager (and Galileo SSI Voyager gap fill) images to produce a global basemap at a resolution of 700 m/pxl. The images were high-pass filtered to enhance fine detail. From the basemap, 15 quadrangle mosaics were derived following the U. S. G. S. quadrangle scheme for Ganymede. ***Geologic mapping:*** Geologic units were mapped based on the global geologic map by [6]. Units were modified locally to account for suitable crater count areas. The authors [6] proposed the following time-stratigraphic systems and chronologic periods for Ganymede, from oldest to youngest: *Nicholsonian* (based on dark cratered plains in Nicholson Regio); *Harpagian* (based on bright tectonically resurfaced materials in Harpagia Sulcus), and *Gilgameshan* (impact of the youngest large crater/basin Gilgamesh). ***Crater counts and cratering chronologies:*** We used recent improvements of the method of crater counting and age dating, including buffered crater counting [7] and the Poisson timing analysis [8] to obtain AMAs from measurements of the crater size distribution on a geologic unit. AMAs in units of 10^9 (Ga) or 10^6 (Ma) years were derived from two model chronologies, one assuming a lunar-like time scale, henceforth termed LDM [9], and one derived from the impacts of Jupiter-family comets, termed JCM [10]. Geologic mapping and crater counts were carried out with *ESRI/ArcGIS* and a *CraterTool* plug-in, and crater statistics analysis was performed with the program *craterstats2* ([7][8], and ref's therein).

3. Results

Osiris (107 km, lat. 38˚ S, long. 193.69˚ E) and part of its extended bright ray system of discontinuous ejecta are shown in ***Fig. 1***. The age of Osiris is constrained by the identification of a single small crater (1.4 km, close to the resolution limit) superimposed on its floor (***Fig. 1***, left, red arrow). In addition, an age can also be estimated from the area of bright ejecta material superimposed on older terrain (***Fig. 1***, right) (see procedure described in [5]). Both data points can very well be fitted by the crater production function of Ganymede [9][this study], shown in ***Fig. 2***. By this procedure we obtain AMAs of **750 Ma** (1.4 Ga / 300 Ma upper/lower uncertainty) (LDM [9]), versus **80 Ma** (240 / 30 Ma) (JCM [10]), rendering a good estimation of Osiris' formation age in the currently available image data. For the bases of the three time-stratigraphic systems of Ganymede [6], we found AMAs of *3.75±0.05 Ga* (LDM, [9]) versus *1.47 Ga* (3.14 Ga / 550 Ma) (JCM [10]) for the *Gilgameshan Period* (***Fig. 2***, green symbols), *3.85±0.06 Ga* (LDM [9]) versus *2.26 Ga* (3.97 Ga / 930 Ma) (JCM [10]) for the *Harpagian Period* (***Fig. 2***, blue symbols), and *4.1±0.02 Ga* (LDM [9]) versus *4.33 Ga* (4.56 / 2.87 Ga) for the *Nicholsonian Period* (***Fig. 2***, red symbols). The crater distribution measured in the dark cratered plains surrounding Osiris also show a *Nicholsonian* age (***Fig. 2***, dark brown symbols). Craters measured within the bright rays, however, as those indicated by the yellow arrows in ***Fig. 1*** (right), give an approximately *Harpagian* age inferring they were formed prior to Osiris and are not superimposed on its ejecta (not included in ***Fig. 2***).

Summary and Future Work

Osiris represents a prominent impact feature on Ganymede characterized by water ice as a major constituent in its floor and ejecta material [11], resurfacing a large surface area. Taking an AMA of 750 Ma as an upper limit, our results reveal that bright, ice-rich crater rays may remain stable on Ganymede's surface for ~ 1 Ga, comparable to bright rays on, e.g., rocky bodies such as the Moon. Osiris represents a stratigraphic marker horizon which we choose to propose a base for a time-stratigraphic system termed ***Osirian***, characterizing a period where erosional processes are not effective enough to completely remove thin deposits such as bright crater rays. Osiris should be envisaged as an important target for detailed observations by the JANUS camera aboard ESA's JUICE Mission [12], involving image coverage at resolutions at least of 400 m/pxl (or better) in four colors, and local hi-res imaging.

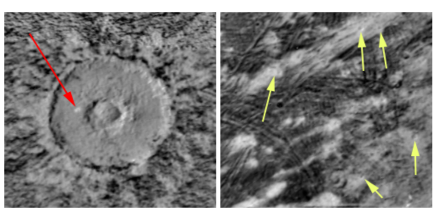

Figure 1: Crater floor and continuous ejecta close to the rim of Osiris (*left*), and part of the bright ray system (*right*). *Red arrow*: small post-Osiris crater on its floor. *Yellow arrows*: craters within the bright ray system, most likely pre-dating Osiris.

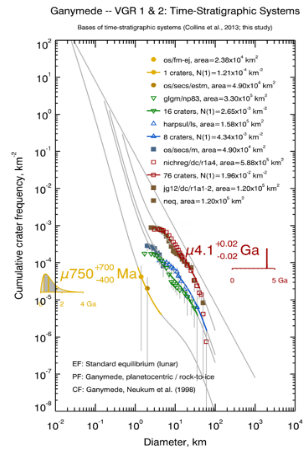

Figure 2: Cumulative crater diagram showing Osiris' age (yellow symbols) within the context of Ganymede's time-stratigraphic system (further explanation given in text). Curve shown is the crater production function of Ganymede [9]. The straight line represents an equilibrium distribution, indicating that crater distributions on Ganymede in general are below the saturation limit for craters in the diameter range shown here.

References

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