Ganymede's Cratering Record. Elena Martellato[1,2], Simone Marchi[3], Valentina Galluzzi[2], Pasquale Palumbo[1,2], and Alessandra Rotundi[1,2], [1]Depart. of Sciences and Technologies, University Parthenope of Napoli, Centro Direzionale Isola C4, 80143, Napoli, Italy, [2]Institute for Space Astrophysics and Planetology, Via Fosso del Cavaliere 100, 00133 Roma, Italy (email: elena.martellato@collaboratore.uniparthenope.it), [3]Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, Colorado 80302 USA.

Introduction: Planetary landscapes are all populated by a common landform [1]. This is given by impact craters, which have accumulated randomly and continuously. Therefore, their spatial density, once coupled with the crater production function and the chronology model, represent the primary tool to derive absolute ages of planetary and small body terrains.

One of the most commonly used chronological model was initially developed for the Moon and is based on relating crater counts at the Apollo/Luna landing sites to radiometric ages of the collected samples [2]. The lunar chronology has been then extrapolated to other planetary bodies, including the Galilean satellites (e.g., [3]), by making a number of assumptions including the source of the projectile population. Specifically for the Galilean satellites, other chronologies based on current estimates of the impact flux have been derived [4]. All these chronologies, however, suffer from a limited understanding of the variation of the impact flux with time for the Galilean system.

The aim of this project is to perform new crater counts to refine the age of the Ganymede surface, and therefore the geological processes that have shaped it. This is included in the scientific activities of JUICE, JUpiter ICy moons Explorer, the ESA mission planned, which to be launched in 2022 and to arrive at Jupiter in 2029, and will make detailed observations of Jupiter and three of its largest moons.

Ganymede: Ganymede was observed firstly by Voyager 1 and 2 in 1979, and then by Galileo between 1996 and 2000 through six flybys, which revealed that the surface has two main types of terrains, which differ in albedo, crater density, and surface morphology [5]. The first one, the "dark" terrains, is low albedo terrains, covered by regolith material, and heavily cratered. The second one, the "light" terrains, has higher albedo and lower crater density, suggesting a younger age. They can occur as smooth elongated and polygonal shaped areas, or as grooves. An accurate chronology for Ganymede can therefore provide information about resurfacing and the evolution of the surface, including the extent of the cryovolcanism [6].

Method: The present global image mosaic of Ganymede is available at a resolution of ~1 km/pixel. Being only 74% of the surface at a resolution better than 2 km/pixel, either image resampling or degradation was applied [7], [5]. For this work, we select the areas of Ganymede acquired at the highest resolution, i.e., ≲100 m/pixel (less than 1% of the whole surface). We firstly considered those areas having additionally portion of the surfaces acquired at even better resolution (few tens of meters per pixel).

On the existing global geological map [7], [5], we performed cartographic refinement to better define the contours of the geological units used in this study. Crater counting is then performed by selected impact structure by means of photo-interpretation (e.g., primary vs secondary, degradation degree, peculiar morphology, ejecta blanket, etc.).

Results: Among the various region investigated, we reported here two exemplificative case studies (cf. Figure 1).

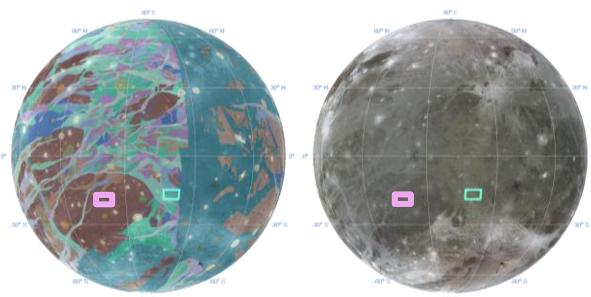

Figure 1. Geological map (on the left side) and mosaic (on the right one) of the hemisphere of Ganymede showing our two exemplificative case studies: (i) the water green box shows Harpagia Sulcus (~16°S, 309°W); (ii) the pink box shows Nicholson Regio (~15°S, 337°W).

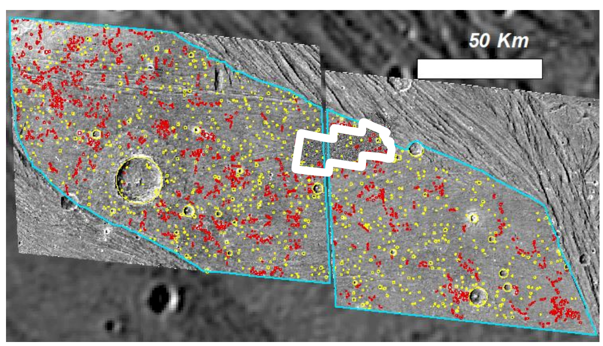

Figure 2. Crater counts performed in Harpagia Sulcus: Primary craters (yellow), and Secondary craters (red).

Harpagia Sulcus, east of the prominent crater Enkidu, which gives an example of smooth material, fine material, and slightly grooved material [5]. The image data was ~116 m/pixel. The total number of the impact structures is 2657, 841 of which are considered bonafide “primary” craters (cf. Figure 2). A small selection of the studied area was available also at very high resolution (~16 m/pixel, cf. white box in Figure 2). We performed there an additional crater counts, finding 1575 impact structures, 619 of which are primaries.

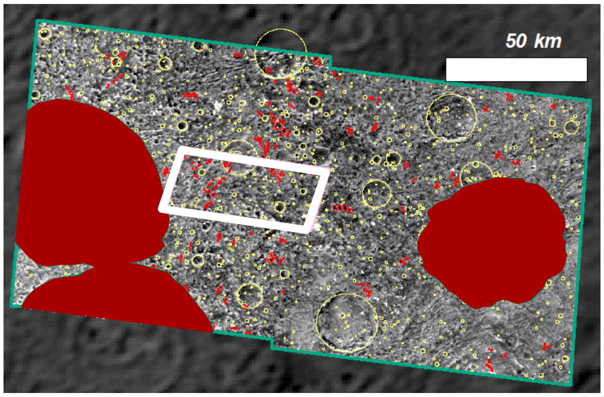

Figure 3. Crater counts performed in Nicholson Regio: Primary craters (yellow), and Secondary craters (red).

Nicholson Regio is representative of dark, heavily cratered terrains [5]. The image data was ~124 m/pixel. The total number of the impact structures is 1191, 685 of which are considered bonafide “primary” craters (cf. Figure 3). A small selection of the studied area was available also at very high resolution (~28 m/pixel, cf. white box in Figure 3). We performed there an additional crater counts, finding 1067 impact structures, 540 of which are primaries.

In both the case studies, when comparing the two cumulative distributions of the primary craters for the counts at the higher and lower resolution, respectively, we found a lower precision in the determination of center and diameter for craters lower than about 15 pixels. Furthermore, about 35% of the primary craters counted in the lower resolution images resulted false positives once compared to the craters counted in the higher resolution images.

Summary and Conclusion: This study highlighted how a minimum crater diameter threshold of the order of ten pixels would be opportune to adequately develop crater statistics.

Additionally, cross-referencing between different counters would be highly recommended to increase the accuracy of crater counting. In Figure 4, we compared the cumulative distributions of our counts with [8]. We obtained an N(1), i.e. the cumulative number at 1 km, of about 6×10^{-3} and 1×10^{-2}, respectively for Harpagia Sulcus and Nicholson Regio datasets. The previous study of [8] found N(1)~4×10^{-3} for Harpagian aged terrains (which are based on the bright tectonically resurfaced materials in Harpagia Sulcus), and N(1)~0.9×10^{-1} for the Nicholson aged terrains. For both the two counting areas, our results agree with [8] within the error bar, as also shown in Figure 4.

This updated crater database and the new chronology model will improve our understanding of the geological evolution of the Galilean satellites, and lead the way to future investigations of the Jupiter System by the ESA JUICE mission.

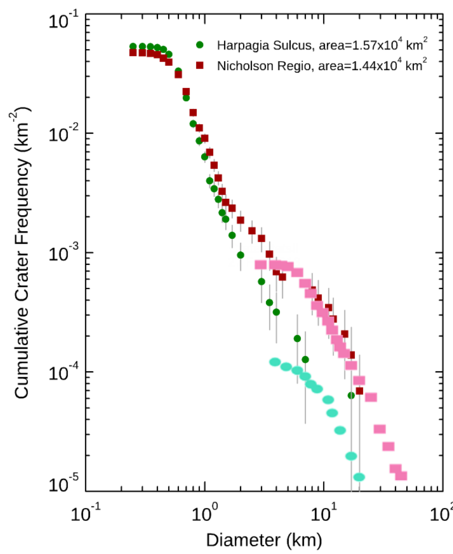

Figure 4. Cumulative size frequency distributions of the primary craters of this study (green squares: Harpagia Sulcus; red dots: Nicholson Regio) compared with [8] (water green squares: Harpagia Sulcus; pink dots: Nicholson Regio).

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