EPSC Abstracts,
Vol. 4, EPSC2009-557, 2009
European Planetary Science Congress,
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Candidate imaging target areas of Ganymede and Callisto for geologic investigations and crater size-frequency measurements in a future mission to Jupiter and its satellites

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Introduction. The surfaces of the two largest Galilean satellites of Jupiter, Ganymede and Callisto, were investigated by the cameras aboard several spacecraft, including Pioneer 10 and 11 (1973/74) [1], Voyager 1 and 2 (1979) [2], and the Galileo orbiter (1995 – 2003) [3]. Ganymede and Callisto are comparable in size (diameters 5268 km and 4816 km respectively) but are significantly different in surface geology. Both satellites show old, dark, densely cratered plains formed early in their histories [2][3][4][5][6][7]. In addition, two thirds of Ganymede's surface area are characterized by bright terrains created by extensive tectonism at later times [4]. Minor tectonism occured on Callisto [5]. Imaging of the surfaces of Ganymede and Callisto are incomplete at regional (about 200 m/pxl) and high resolution scale (100 – 10 m/pxl). Due to technical problems, Galileo could only image a small number of areas on each satellite at these scales [4][5]. Also, Galileo could not provide the lower resolution context for higher resolution observations in many cases. A future mission to Jupiter is necessary to complete imaging both at regional and high resolution and also to include stereo imaging of the Galilean satellites.

Plans for a future mission to Jupiter by NASA/ESA. NASA and ESA are currently planning a joint mission to Jupiter and its satellites termed *EJSM* (*Europa Jupiter System Mission*). The mission consists of two spacecraft in Jupiter orbit that will finally go into orbit about Europa (JEO led by NASA) and Ganymede (JGO led by ESA), respectively. Several cameras including high-resolution imagers will be implemented on these spacecraft. For the Ganymede orbiter (JGO), a sequence of 19 flybys at Callisto is planned.

Target area selection. We identify, suggest and select potential imaging target areas by general geologic topics rather than by a specific location because JGO flyby geometries are not yet known. The areas we suggest for further consideration in future imaging plans are grouped into five classes focused on: (1) impact forms, (2) erosion and degradation features, (3) tectonic forms, (4) cryovolcanic features, and (5) impact crater size-frequency distributions, especially at smaller (sub-kilometer) crater sizes. Measuring the superimposed crater distribution is generally used in relative and, by application of cratering chronology models [6][7], absolute chronology in order to date the ages of impact features, or ages of resurfacing events by erosion, tectonism, or cryovolcanism. Crater size-frequency distributions are also instrumental in the derivation of potential impactor families in the Jovian system [6][7].

Candidate target areas

Impact structures: Of all planetary satellites, Ganymede and Callisto exhibit the widest range in impact crater morphologies [8]. The Galileo SSI camera could image only a small number of their impact structures, including central pit and dome craters, palimpsests, and penepalimpsests. Ray craters which are the stratigraphically youngest impact features on both satellites could not be targeted by Galileo SSI. These craters, especially the dark ray craters unique to Ganymede should be considered as primary imaging targets (*Fig. 1*). These craters could not be dated because of the low resolution of Voyager images. The origin of dark rays, whether due to target material properties or impactor contamination and the reason why these features are only found on Ganymede is poorly understood [9][10][11].

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Erosion and degradation features. Landforms on Ganymede and Callisto, such as e.g. impact structures or tectonic features, are subject to erosion and degradation [4][5]. Both satellites, however, show significantly different forms of degradation. Callisto's surface is heavily degraded by sublimation of volatiles [5], involving a high abundance in CO_2, and a globally abundant lag of dark, smooth material was created. It is not known if this layer formed early in Callisto's history or at much later times [5][12]. Such widespread degradation is not found on Ganymede, neither in dark nor in bright terrains [4][5][12]. An important tool in deriving the erosion and degradation history of Ganymede and Callisto is the crater size-frequency measurement of small craters superimposed on larger craters or impact structures in various preservation states.

Tectonic structures and cryovolcanism. Ganymede's bright terrain was believed to originate from cryovolcanism associated with tectonism [e.g., 2] but Galileo SSI has verified that tectonic resurfacing was the dominant process in these regions [4]. Tectonic features on Ganymede are not restricted to bright terrain but occur in dark terrain also [4]. Emphasis should be placed on imaging the dark/bright terrain boundaries in order to examine the transformation of dark into bright terrain, and on high and highest-resolution imaging of Ganymede's tectonized regions. An important issue is the comparison of tectonic features on Ganymede with Callisto's "tectonism". The dark densely cratered plains on Callisto do show some tectonism (lineaments, joints and fractures) but this is in no way comparable to Ganymede's heavily modified regions [4][5]. More importantly, Callisto's tectonic features provided zones of weakness along which erosion and degradation acted most effectively, eventually creating numerous bright icy massifs or knobs [5][12].

Acknowledgment: This work has been partly supported by DLR and the Helmholtz Alliance 'Planetary Evolution and Life'.

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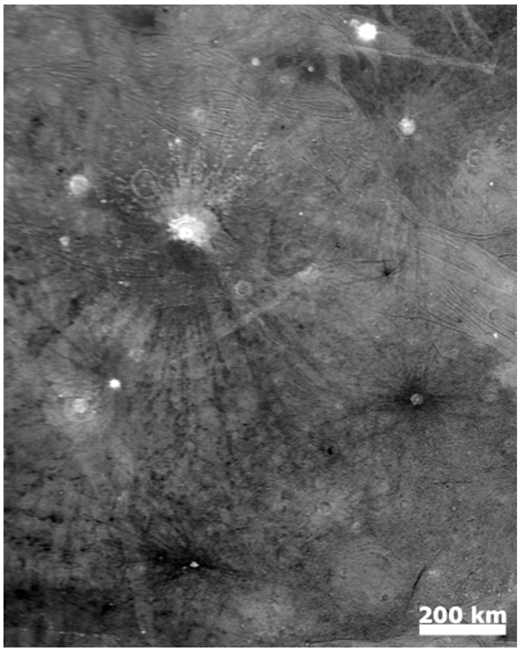

Figure 1: Candidate target areas: bright and dark ray craters on Ganymede west of Marius Regio. Mosaic of Voyager 2 images, centered at latitude 8° N, longitude 226° W.