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Resurfacing by erosion, degradation and tectonism on Saturn's satellites Dione and Rhea and a comparison with the Jovian satellites Callisto and Ganymede

R. J. Wagner (1), G. Neukum (2), T. Roatsch (1), T. Denk (2), U. Wolf (2), and C. C. Porco (3)

(1) Inst. of Planetary Research, German Aerospace Center (DLR), Rutherfordstrasse 2, D-12489, Berlin, Germany, e-mail: roland.wagner@dlr.de; (2) Inst. of Geosciences, Freie Universitaet Berlin (FUB), D-12249 Berlin, Germany; (3) Space Science Inst., Boulder, CO., USA.

Introduction: The icy satellites Dione (1124 km diameter) and Rhea (1538 km) are neighbours in orbit about Saturn and show similar geologic features, including cratered plains and basin materials, young bright ray craters, and tectonic features which are much more prevalent on Dione. The ISS NAC and WAC cameras aboard the Cassini spacecraft have returned regional and high-resolution images from their surfaces in close flybys in Oct. 2005 and Aug. 2007, and in various non-targeted flybys at a greater distance [1]. The two largest Galilean satellites of Jupiter, Callisto and Ganymede (4816 and 5268 km in diameter), were imaged by the Galileo SSI camera between June 1996 and August 2001 [2][3]. The surfaces of these two satellites are characterized by dark, densely cratered plains material, ring basins, and large, bright ray craters [4][5]. Furthermore, two thirds of Ganymede's surface are dominated by bright, tectonically resurfaced regions known as grooved terrain [4]. **Procedure:** The resurfacing history of these satellites is derived by (1) photogeologic mapping, based on albedo and morphology, and (2) by crater size-frequency distributions. Resurfacing processes are revealed by crater obliteration below a critical crater diameter, resulting in a flatter slope of the (cumulative) crater distribution, and recratering with a steep slope, but at lower crater frequency at smaller crater sizes. (3) Absolute ages are assigned by impact cratering chronology models: (a) *Model I,* based on a lunar-like cratering rate, preferentially by asteroids [6], and (b) *Model II* with a constant cratering rate, primarily by comets [7]. **Results:** Each of these four satellites shows unique characteristics in terms of degradation and tectonism. On Dione, cratered plains are old, possibly 4 - 4.2 Gyr [6][7]. Arcuate zones of scarps and troughs were formed by extensional tectonism. Fractures developed in densely cratered plains, about 3.7 Gyr ago [6] or about 1 Gyr ago [7]. At high resolution, Dione's surface seems densely cratered and less affected by erosional processes. On Rhea, tectonically resurfaced areas have not been imaged at high resolution so far. The cratered plains show a high crater frequency, in some areas close to an equilibrium distribution. Cratering model ages of these cratered plains units are on the order of 4.1 - 4.3 Gyr [6][7]. Locally, landslides inside crater walls with a lower superimposed crater frequency can be detected. The old (about 4 - 4.3 Gyr [6][7][8, and refs. therein]) surface of the Galilean satellite Callisto poses a strong contrast to the surfaces of these two Saturnian satellites, indicating radically different surface processes. The bright, icy surface material on Callisto has started to degrade along zones of weakness by sublimation degradation, triggered by the presence of highly volatile CO_2 in the crustal material [5, and refs. therein], eventually forming a dark, globally abundant lag [8]. Crater distributions show a characteristic shallower slope below 1 - 2 km diameter and a steep distribution below 300 - 400 m, implying that after the lag was formed, erosion has either stopped or has been going on at a very slow rate [8]. Such a feature is not seen in crater distributions from Ganymede's old dark materials [9]. These distributions are steep and close to equilibrium at small crater sizes, inferring much less effective erosional processes on this satellite. The tectonic event which created the bright grooved materials has almost completely erased the pre-existing craters. In a number of cases, heavily degraded crater remnants in the bright materials are still detectable [4]. The crater distributions measured in these resurfaced areas are steep but can also be close to equilibrium [9]. Bright craters with extended ray systems, especially on Ganymede and Callisto, represent geologic units which so far have not, or have only little, been affected by erosional processes. Because of the uncertainties of the cratering chronologies, their ages - and hence erosional rates - cannot be constrained very well. The model ages are on the order of several 100 Myr [6] or much less than 10 Myr [7], in case of *Model I* [6] comparable to ray crater ages on the Moon.

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