

## GEOLOGY AND STRATIGRAPHY OF IMPACT CRATERS ON CALLISTO – RESULTS FROM HIGH-RESOLUTION IMAGES OF THE GALILEO SSI CAMERA

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**Introduction:** The surfaces of the two largest icy Galilean satellites Ganymede and Callisto exhibit a wide range of impact crater morphologies not known from the surfaces of the terrestrial planets in the inner solar system. Impact craters on these two satellites include flat, bright plains (palimpsests), craters featuring central domes, and craters with a „regular“ morphology reminiscent of e.g. lunar craters [1]. During the entire Galileo Jupiter orbit tour from 1996 to 2002, spanning a total of 34 orbits, the Galileo SSI camera was targeted to selected features on each one of these two satellites. In this paper, we will address (1) geology, (2) stratigraphy and (3) ages of craters observed by the SSI camera on the outermost Galilean satellite Callisto.

**Data base and procedure:** Geologic units identified in selected impact features were (1) mapped as members of each respective crater formation, based on albedo and morphology, and (2) the frequencies of superimposed craters were measured in order to derive a relative age sequence. Each crater formation was referred to a time-stratigraphic system defined by giant impacts which, from oldest to youngest, created the basins Asgard, Valhalla, and Lofn [2]. Absolute ages for each formation or member were obtained from two cratering chronology models for the Jovian system [3, 4, 5]. In one model [3], impacts are believed to stem mainly from asteroids, with a Late Heavy Bombardment period as on the terrestrial planets, since the shapes of crater size distributions on e.g. the Moon and on the Galilean satellites are very similar. In another model [4] (and its update [5]), craters are assumed to have been created mainly by impacts of comets with a more or less constant impact rate. The large basin Valhalla on Callisto has been assigned a nominal age of about 2 Gyr in both versions of the comet impact model [4][5].

**Target areas:** We focused our investigation on the following impact features: (1) Dome crater Har and regular crater Tindr, observed in Callisto flybys C9 and C10 (143 m/pxl and 390 m/pxl respectively); (2) dome crater Doh (C10; 90 m/pxl); (3) bright ray crater Bran (C20 and C30, 610 and 640 m/pxl).

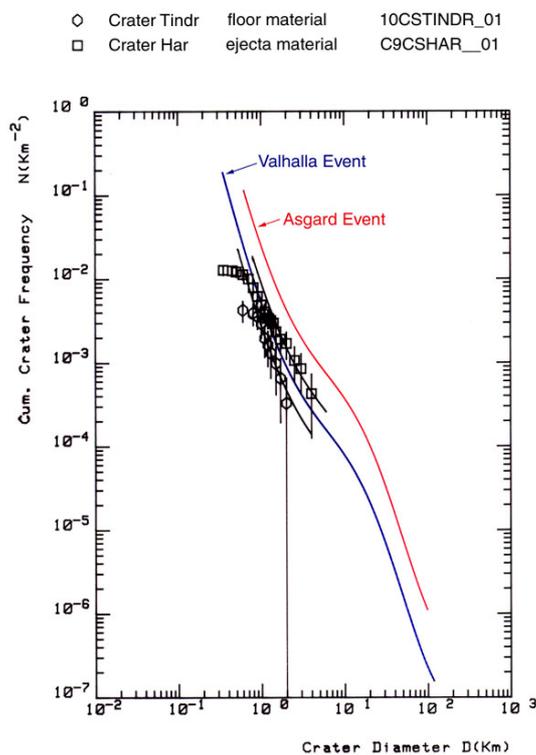
**Geologic units:** The dome crater Har (45 km diameter) and the regular crater Tindr (73 km diameter) are close neighbors. Secondary crater clusters and chains from Tindr overlap the older crater Har. Continuous ejecta, secondary craters, crater floor material, and two units associated with a central pit

were mapped in crater Tindr. Dome crater Har features a continuous ejecta blanket, floor material, and the central dome material. Dome crater Doh is characterized by smooth or knobby materials on the floor, dissected material surrounding the dome, and the central dome material itself. The actual diameter of Doh is larger than 55 km. The actual crater rim is degraded more or less, and the dissected unit represents the rim of a central pit with the dome in its center. Bran is a large (ca. 150 km) bright ray crater with a morphology reminiscent of palimpsests in places, i.e. a bright, smooth unit. Its rim, and an inner ring surrounding are degraded. The strongly asymmetric configuration of its ejecta suggest an impact at a low angle.

**Results:** Stratigraphically, Har can be placed between the Asgard and Valhalla impact events, while Tindr formed after Valhalla, at a time comparable to the formation of the youngest basin Lofn. Cumulative frequency diagrams of these two craters, and their relative ages in comparison to the ages of two major basins on Callisto, are shown in figure 1. The cratering model of Har age is 4.1 Gyr [3], or 3.32 Gyr [4] respectively, while the model age for Tindr is 3.87 Gyr [3], versus 1.35 Gyr [4]. Bran and the multi-ring basin Valhalla are comparable in their model ages (about 4.0 Gyr [3], or about 2 Gyr [4, 5]). Different crater morphologies in two closely spaced craters (older dome crater, younger regular crater) suggest either a change in rheology with time, or water ice or slush being concentrated in pockets in the subsurface [6]. The cratering model age of dome crater Doh, however – 3.86 Gyr [3], versus 1.25 Gyr [4] – is lower than that of Har, inferring that dome craters could still form at later time. In terms of the updated cometary impact model [5] there is not much change in model ages between the older version [4] since Callisto's surface is generally assumed to be "old" (>> 3.5 Gyr). It must be kept in mind, however, that cometary impacts produce a strong apex-antapex asymmetry in crater frequency [5]. In this view, the two basins Valhalla and Lofn are assumed to be of the same age since Valhalla is more densely cratered but located closer to the apex point of orbital motion than Lofn, as discussed by [5]. Hence, Tindr with a similar distance to the apex as Lofn is also about the same age as this basin and as Valhalla. On the other hand, the dome crater Doh with a crater frequency comparable to Tindr must be older than due to its greater distance from the apex

point. In the context of the asteroid impact model, the cratering rate is the same on all longitudes, and crater frequencies are directly comparable independent of geographic position [3, and references therein].

**References:** [1] Passey, Q. R., and E. G. Shoemaker, in: Satellites of Jupiter (D. Morrison, ed.), UofA Press, Tucson, p. 379-434, 1982. [2] Wagner, R., et al., LPSC XXIX, abstract 1918 [CD-Rom], 1998. [3] Neukum, G., et al., LPSC XXIX, abstract 1742 [CD-Rom], 1998. [4] Zahnle, K., et al., Icarus 136, 329-347, 1998. [5] Zahnle K. et al., Icarus 163, 263-289, 2003. [6] Greeley, R., et al., Planet. Space Sci. 48, 829-853, 2000.



**Figure 1:** Cumulative frequencies of dome crater Har and regular crater Tindr. Curve shown is the crater production function for Callisto [3], fitted to the measured crater size distributions. The diagram shows the age sequence from the older Asgard basin (only curve shown) to Har, Valhalla basin (only curve) to the younger crater Tindr.