FRACTURES, SCARPS, AND LINEAMENTS ON CALLISTO AND THEIR CORRELATION WITH SURFACE DEGRADATION. R. Wagner[1], G. Neukum[1], R. Greeley[2], J. E. Klemaszewski[2], and the Galileo Imaging Team, [1]DLR, Inst. of Space Sensor Technology and Planetary Exploration, Berlin, Germany, e-mail: Roland.Wagner@dlr.de; [2]Arizona State University, Dep. of Planetary Geology, Tempe,Az.

Introduction: Tectonic features on Callisto are found (1) preferentially in large multi-ring structures, or (2) in several areas in its dark, cratered plains units outside the large multi-ring structures [1, 2]. In this latter case, tectonism is represented by *fractures*, *scarps*, and *albedo lineaments*. In this paper, we will mainly concentrate on tectonic features outside the large multi-ring structures and investigate (1) their spatial distribution, as seen on high resolution images returned by the Galileo SSI camera, (2) their preferential orientations, (3) their correlation to tectonic features found on lower resolution Voyager images, (4) their time-stratigraphic position, and (5) their correlation to surface degradation processes.

Target areas: High-resolution views of Callisto's surface which essentially reveal tectonic features studied in this paper were obtained during Galileo's orbits C9, C10, and C20. In these target areas, stereo data could be used. Red-blue anaglyph images were constructed to aid in the evaluation of these data.

Geologic units and crater ages: In orbit C10, an area originally termed *smooth plains* [3] was targeted at 270 m/pxl and 68 m/pxl (SSI target areas 10CSSMTHPL02 and 01). The area appears bright and smooth in Voyager-1 images. It was interpreted as either a volcanically resurfaced area [3], or as a degraded palimpsest [1]. The higher resolution SSI data showed a rough and knobby surface instead. No evidence is found for volcanic resurfacing in this area, but some more or less concentric scarps indicate an impact origin, most likely a degraded palimpsest. From measurements of the crater distributions, cratering model ages are 4.2±0.05 Gyr in model I [4] and 4.3 Gyr (uncertainty range 4.56 Gyr to 2.1 Gyr) in model II [5], while the surrounding cratered plains have ages of about 4.2 to 4.25±0.05 Gyr in model I, or 4.3 to 4.5 Gyr in model II. Hence the stratigraphic position of the degraded impact structure is close to the base of the system defined by the Asgard impact [6].

In orbit C20, a dark patch interpreted as dark volcanic flow [1] was targeted for high resolution at 430 m/pxl and 108 m/pxl (SSI target areas 20CSDRKFLO02 and 01). Both observations could not reveal features unequivocally indicative of volcanism [7]. The dark "flow" is located close to a bright area which appears smooth at Voyager resolution but turned out to be rough and knobby in the SSI frames, comparable to the C10 "smooth plains". Also comparable to these plains, concentric structures indicate a degraded multi-ring structure about 150 km in diameter, probably a palimpsest [8]. From measurements of the superimposed crater frequency we derived average ages of 4.1±0.06 Gyr in model I [4] and 3.7 Gyr (uncertainty range 4.56 to 1.26 Gyr) in model II [5] for both the degraded palimpsest and the dark "flows". Both geologic units hence can be put into the Asgard time-stratigraphic system. The surrounding cratered plains have ages of 4.3±0.05 Gyr (model I) and 4.54 Gyr (model II; range 4.56 - 3 Gyr).

Stereo data are also available from craters Har and Tindr, imaged in C9 at 143 m/pxl and C10 at 390 m/pxl. Both craters could be dated at 4.07 Gyr (model I) versus 3.32 Gyr (model II; range 4.55 – 1.05 Gyr) for Har, and 3.87 Gyr (model I) versus 1.35 Gyr (model II; range 3.77 Gyr – 0.31 Gyr) [9] for Tindr.

Major trends of tectonic features: An anaglyph image and a structural map of the C10 smooth plains target area is shown in *figure 1*. Preferential trends of structural elements in this area are ENE-WSW, and a trend orthogonal to this direction (NNW-SSE). A N-S to NE-SW trend is less common. In the Har-Tindr area which is located about 600 km south of the "smooth plains", the ENE-WSW trend is also confirmed in lineaments. In the area of the degraded palimpsest imaged during orbit C20, trends of NW-SE to ENE-WSW, as well as orthogonal to these directions, are common.

Trends of tectonic features in Voyager context: Systems of albedo lineaments and fractures were confirmed from Voyager imagery by different investigators [1] [2]. Lineament trends in the sub-jovian hemisphere (images by Voyager-1), and in the anti-jovian hemisphere (imaged by Voyager-2) were determined [2]. These larger regions also encompass the higher resolution target areas imaged at orbits C9, C10 and C20. Preferential trends measured on Voyager data are NW-SE to NNW-SSE, and NE-SW to ENE-WSW [2]. These trends agree very well with those found in the higher resolution areas. Hence it seems clear that albedo lineaments mapped in Voyager images are real phenomena and not artifacts caused by viewing geometry.

Tectonic features and surface degradation: There is little or no evidence for tectonic movements. Parts of the degraded palimpsest in C20 data could have downdropped and have been covered with the dark blanketing material. Some of the scarps seen in the C10 “smooth plains” could represent either normal faults or the remains of a crater rim. The tectonic features provided zones of weaknesses along which the bright material disintegrated, most likely by a process involving sublimation degradation [10]. Cracks formed in the bright material and became wider with time. Eventually a rough, hummocky or knobby surface formed with isolated, oblong hummocks, or groups of hummocks. These hummocks can have spatial extents of several 100 m or several kilometers. *Figure 2* shows a detailed view of the oblong form of these hummocks in the C20 degraded palimpsest.

Summary: The following origin is possible for the lineament and fracture system: (1) reactivation of old zones of weaknesses created by an early period of tidal despinning [11], or global expansion [1]. Tectonism was still active in the time-stratigraphic Asgard system. It is not clear whether surface degradation is a process which has been active until recent times, or whether it has ceased in the past. Some large, bright craters, such as Burr, appear pristine and hence were not affected by erosion and degradation largely. In cratering chronology model I [4], these craters can be up to several billions years old, hence degradation could have ceased in the past. In model II [5], however, these fresh craters are only several hundred millions of years old, and erosion could very well have been active in more recent times.

References:

[1] Schenk P. M. (1995) *JGR, 100,* 19,023–19,040. [2] Wagner R. and Neukum G. (1994) *Bull. Astron. Soc. Am., 26,* 1162. [3] Bender K. et al. (1997) *U. S. Geol. Surv. Misc. Inv. Series,* Map I-2581. [4] Neukum G. et al. (1998), *LPSC XXIX*, abstr. #1742 [CD-Rom]. [5] Zahnle K. et al. (1998), *Icarus, 136*, 202-222. [6] Wagner R. et al. (1998), LPSC XXIX, abstr. #1918 [CD-Rom]. [7] Greeley R. et al. (2000), *Planet. Space Sci., 48*, 829-853. [8] Wagner R. et al. (2000*), LPSC XXXI*, abstr. #1826 [CD-Rom]. [9] Wagner R. et al. (1999), *LPSC XXX*, abstr. #1818 [CD-Rom]. [10] Moore J. M. et al. (1999), *Icarus, 140*, 294-312. [11] Melosh H. J. (1977), *Icarus, 31*, 221-243.

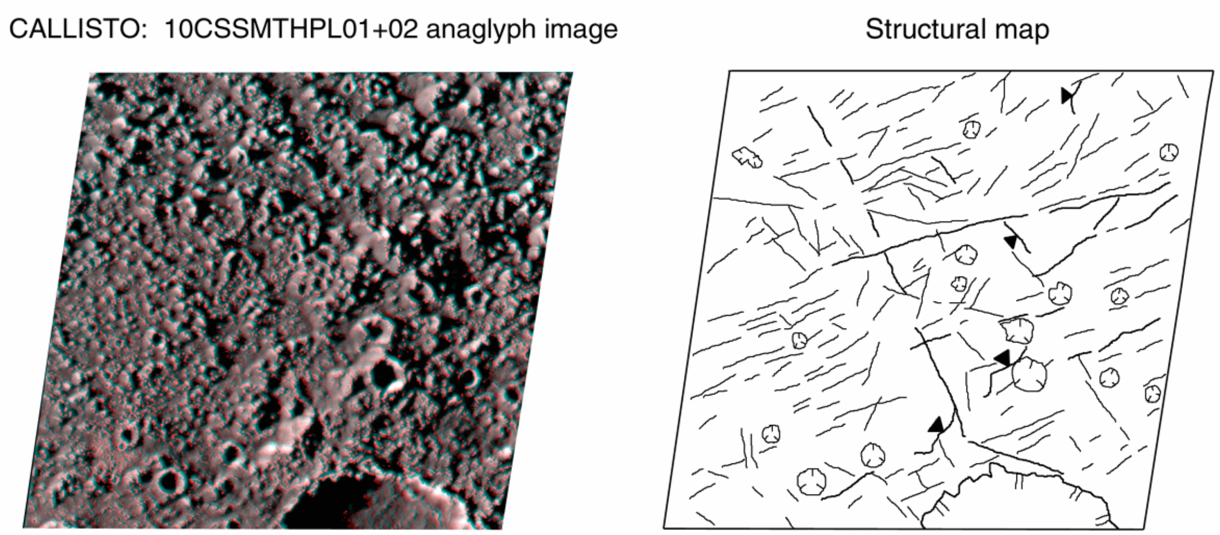

Figure 1: Anaglyph image and structural map of SSI target area 10CSSMTHPL01 and 02. Frames are in Mercator projection. Lines represent fractures and lineaments (thick lines: prominent features), triangles indicate scarps.

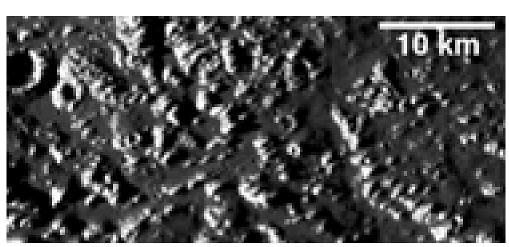

Figure 2: Detail of the C20 degraded palimpsest