EPSC Abstracts
Vol. 6, EPSC-DPS2011-259, 2011
EPSC-DPS Joint Meeting 2011

The identification of chaotic terrain on Europa

C. Neish, L. Prockter and G.W. Patterson
The Johns Hopkins University Applied Physics Laboratory, USA (catherine.neish@jhuapl.edu / Fax: +001-443-7788939)

Abstract

Chaos is one of the dominant terrain types on Jupiter's moon Europa. However, the determination of its total areal extent has been hindered by the lack of global images of Europa at suitable resolutions and incidence angles. In this work, we determine that high incidence angle (> 75°), not high resolution, is the primary observational requirement for observing chaos in spacecraft imaging data. These recommendations will guide observational strategies for future missions to Europa and other icy bodies, such as Triton and Pluto.

1. Introduction

A large fraction of Europa's surface consists of an unusual type of terrain known as chaos. Regions of chaos appear as disrupted areas of Europa's surface, consisting of plates of pre-existing crustal material, with a lumpy matrix between the plates [e.g., 1]. Chaotic terrain likely comprises more than a third of Europa's surface area [2]. However, the determination of its total areal extent has been hindered by the large variability in viewing geometries available in the global imaging data from the Galileo mission.

As first noted by Hoppa et al. [3], the identification of chaotic terrain on Europa is highly dependent on observational parameters such as resolution and incidence angle. Higher resolution images allow for the identification of smaller patches of chaotic terrain, which may be indistinguishable from the surrounding terrain in lower resolution images. Images taken at high incidence angle (near Europa's terminator) also reveal more chaos than those taken at low incidence, as they highlight the textural differences between the chaos and the surrounding terrain. Hoppa et al. [3] found seven times more regions of chaos in one area when the resolution was increased by a factor of 3.6, and as much as 33% more regions of chaos in two areas when the incidence angle was increased from 75° to 82°.

In this work, we seek to quantify the relative importance of resolution versus incidence angle in chaos identification. We also seek to extend the areal coverage examined by [3] by degrading high-resolution images in regions where image overlap is not available. The ultimate goal of this work is to provide appropriate viewing geometries for identifying chaos in future missions to Europa and other icy bodies, such as Triton and Pluto.

2. Method and Results

2.1 Resolution

To determine the effects of resolution in chaos identification, we mapped chaos in several regions imaged at medium resolution during the Galileo mission (< 300 m/pixel). Guided by the geologic maps of Figueredo and Greeley [4], we mapped areas of chaos in a region of E15REGMAP02 (from 10 to 55°N, centered at ~80°W) and E17REGMAP01 (from -70 to 20°N, centered at ~225°W). Both of these regions were imaged at high incidence (i > 70°). For each chaos region, we determined its latitude, longitude, and area. We then artificially degraded the high-resolution images to a lower resolution (1000 m/pixel). A second team member then independently identified regions of chaos in these degraded images.

The results of this analysis indicate that (a) larger chaos areas (> 1000 km^2) are preferentially observed at lower resolution, but that (b) the majority of chaos is still identified in these low resolution, high incidence angle images (Figure 1). The total area of chaos observed in E15REGMAP02 at 260 m/pixel (71,000 km^2) is 42% higher than the total area of chaos observed at 1000 m/pixel (41,000 km^2). The total area of chaos observed in E17REGMAP01 at 230 m/pixel (74,000 km^2) is only 9% higher than the total area of chaos observed at 1000 m/pixel (67,000 km^2).

2.2 Incidence Angle

To determine the effect of incidence angle in chaos identification, we compared images taken at similar resolutions, but different incidence angles. Murias Chaos (22°N, 84°W) is one example of chaos that has been imaged at a variety of incidence angles and resolutions. In particular, it was imaged at low resolution (1000 m/pixel) and low incidence angle (i = 27°), allowing for comparison to the degraded image produced using the technique described above (Figure 2). In this case, incidence angle appears to be the dominant factor in identifying regions as chaos. At lower incidence, relative albedo differences dominate the image. The textural differences needed to identify chaos can only be seen at high incidence.

What then is the lowest resolution for which it is possible to identify chaos, even at high incidence angles (i > 75°)? In the degraded images of E15REGMAP02 and E17REGMAP01, most large regions of chaos were identified at 1 km/pixel. In actual Galileo images, Thrace Macula is identifiable as chaos in a region imaged at only 1.5 km/pixel (Figure 3). Incidence angle therefore seems to be more important than resolution in the identification of large regions of chaos.

3. Summary and Conclusions

Large incidence angle, not high resolution, is the primary observational requirement for identifying chaos on Europa. If the majority of Europa were to be imaged at high incidence, at varying resolutions, we would underestimate the amount of chaos by at most ~ 40%. These recommendations will guide future exploration of not only Europa, but other icy bodies, such as Triton and Pluto. Indeed, 'knobby materials' have been mapped at high incidence in Voyager images of Triton [5] with morphologies intriguingly similar to Europan chaos.

Acknowledgements

Thanks to T. Becker at USGS for assistance in the construction of the E17 mosaic.

References

[1] Collins, G. and Nimmo, F.: Chaotic terrain on Europa, In: Europa, Pappalardo, R., McKinnon, W., and Khurana, K. (Eds.), The University of Arizona Press, 2009.

[2] Riley, J., Hoppa, G., Greenberg, R., Tufts, B.R., and Geissler, P.: Distribution of chaotic terrain on Europa, Journal of Geophysical Research, Vol. 105, pp. 22,599 – 22,615, 2000.

[3] Hoppa, G., Greenberg, R., Riley, J., and Tufts, B.R.: Observational selection effects in Europa image data: Identification of chaotic terrain, Icarus, Vol. 151, pp. 181-189, 2001.

[4] Figuerdo, P. and Greeley, R.: Resurfacing history of Europa from pole-to-pole geological mappin, Icarus, Vol. 167, pp. 287-312, 2004.

[5] Croft, S., Kargel, J., Kirk, R., Moore, J., Schenk, P., and Strom, R.: The geology of Triton, In: Neptune and Triton, Cruikshank, D. (Ed.), The University of Arizona Press, 1995.

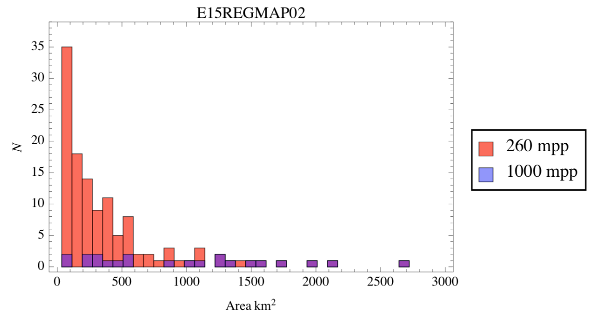

Figure 1: Chaos identified in a region of E15REGMAP02. Most large areas of chaos (> 1000 km^2) are observed even at low resolution. Two areas of chaos > 3000 km^2 are not included in this plot, but were observed at both resolutions.

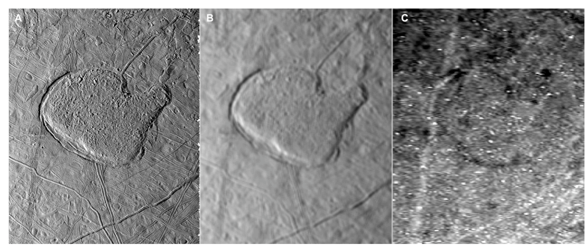

Figure 2: (a) Image of Murias Chaos as seen by Galileo at 270 m/pixel and i = 75°. (b) Same image of Murias Chaos, degraded to 1 km/pixel. (c) Image of Murias Chaos taken by Galileo at 1 km/pixel and i = 27° (25ESGLOBAL01). Given the relatively high albedo of this feature, it is practically unrecognizable at this low incidence angle.

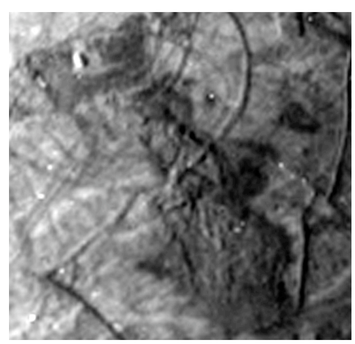

Figure 3: Thrace Macula is recognizable as chaos even when imaged at 1.5 km/pixel in this high incidence angle (> 75°) image (14ESGLOCOL01).