EQUATORIAL DISTRIBUTION OF CHAOS AND LENTICULAE ON EUROPA.

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Introduction: Chaos on Europa is defined as large, irregularly-shaped regions containing a hummocky matrix material and commonly containing linear-textured polygonal blocks [1, 2]. Lenticulae are subcircular features ranging from 5 to 25 km in diameter which are inferred to be genetically related and can be divided into three major classes: domes, upraised features which generally do not disrupt the pre-existing terrain; spots, smooth, low albedo areas that subdue or conceal pre-existing terrain); and pits, lenticulae that have disrupted the pre-existing terrain with a chaos-like matrix material, henceforth called micro-chaos. It has been proposed that the analogous deformational style and close association of chaotic regions and lenticulae suggest these features may be different scale manifestations of a similar formational process [3]. Chaos and lenticulae have been suggested to form through diapirism and partial melting [4, 5], volcanic flows [6], or an ocean directly melting through to the surface [7]. Analysis of the global distribution of chaos and lenticulae may serve to constrain the possible internal processes at work in the formation of these features.

In this analysis, we focus on the equatorial distribution of chaos and micro-chaos lenticulae to study their relationships and update previous findings [3]. We have mapped several regions at different longitudes near Europa's equator and compare the data for these regions to assess any longitudinal variations in feature size distribution. We also address the issue of mapping images with resolution differences and the potential variations, as inferred in the data of [8].

Procedure: Galileo has provided images of chaos and lenticulae features on the regional map scale, approximately 200 m/pixel, at several locations around the globe. We have also mapped two regions at high resolution, ~25 m/pxl. The images used, global location, image resolution, and statistics are listed in Table 1. The images vary in solar incidence angle which is acceptable because 1) albedo is not part of the mapping criterion to identify micro-chaos or chaos and 2) we have been able to study some regions at varying phase angle to test our mapping techniques. Our mapping criteria for all images is as follows: a chaos or micro-chaos feature must have disrupted the pre-existing terrain and have an identifiable hummocky matrix material. Highly ambiguous features were not mapped. We digitally measured the surface area of each feature and then converted this into equivalent circular diameter.

For the E17 Regional Mapping (01) image mosaic and the high resolution images, we have separated features into two categories: full and partial. A "full" feature appears wholly within the mapped area, while a "partial" feature extends beyond the mapped area and thus its size measurement is a minimum estimate. This test will demonstrate any effects on the size frequency distribution due to inclusion of both partial and full features. In the analysis of data sets for the other studied regions, we have combined full and partial features.

Analysis: The histograms in Figure 1 show the size frequency distribution of chaos and micro-chaos features. The maps generated of regions can be found in [3] and Figure 2. Analysis of Table 1 and Figure 1 has revealed that the mode in feature size is most intrinsically related to the dominant feature size, which corresponds to the peak in the size frequency histograms. We see main peaks in all of the regions near 9 km in equivalent circular diameter, except in the E4 high-resolution region, where the peak is near 4 km. Based on these peaks, it is apparent that there is overall a preferred size for micro-chaos and chaos features near the equator with a characteristic size scale of ~ 9 km in average diameter.

Why does the E4 region differ? It is worthwhile to consider that the 4 km peak in the histogram might be due to the higher resolution of those images allowing for better identification of smaller features. However, the E11 high resolution region has both a peak (8 km) and a mean (8.5 km) similar to the low resolution imaged regions. Furthermore, the E11 high resolution region is adjacent to the E15 RegMap02 imaged region, which also has a peak at 8 km (and a mean of 7.2 km, even smaller than that of the high resolution region), supporting the accuracy of our mapping at varying resolutions. Also note that the minimum feature size and the mode in most of the images, both high and low resolution, is similar; these results thus suggest that resolution differences are negligible. This suggests that the mapping in the high resolution is accurate and reflects a true difference in lenticula size in this region and that the E4 high resolution region is located in an area where feature size is potentially smaller overall than the other equatorial regions studied. Due to the deficit of 200 m/pxl or better images in that quadrant of Europa, further testing of this is difficult.

There is a potential discrepancy in the data set due to the difference between measuring full and partial features. Because the mean feature size is more sensitive to larger features, the size frequency distribution is more likely to be skewed by very large features that extend beyond the map, rather than by image resolution differences. For example, the addition of 10 partial features to the 336 full features in the E17 RegMap would increase the mean by 1 km. However, we can not ignore these partial features, as most chaos features are large and generally extend beyond mapped regions. Thus we must caution that measurements which include partial features list the *minimum* averaege feature size. Global coverage of Europa will ultimately resolve this problem.

Discussion: The competing models for the origin of chaos and lenticulae each make predictions for the size range of features. The whole-shell melt-through model [7] interprets chaos and micro-chaos lenticulae as an analog to the floating, and foundering of terrestrial ice blocks in the arctic regions. Because the only controls on the size of a feature are variations in the thickness of the ice lid and the amount of heat input, [7] suggest that chaos and micro-chaos lenticulae should exhibit a continuum of feature sizes, with no lower limit. This does not match the observations. Even in the high resolution images, full features are no less than 1 km in diameter. While features < 5km in diameter are clearly observed in all of the images, and comprise the mode for most of the regions, a distinct peak in the size distribution is found in all of the regions studied.

The diapiric model [4] suggests that diapirs tend to produce sub-circular features which have a preferred size and regular spacing and which may merge to form larger features [9]; this is because plumes of similar sizes and starting depths will be initiated by thermal or density instabilities. The regular spacing of the convecting cells creates the regular spacing of the features, and the regular size of surface features would be caused by the consistent size of the rising diapirs. Our results are most consistent with a diapiric model for the formation of chaos and lenticulae. The dominant peaks in the histograms suggest that features are generally ~ 9 km in diameter, with a statistical variation of ~ 5 km. Because the mapped features are stratigraphically young based on embayment, cross-cutting, and overprinting relationships, we can also conclude that the observed 9 km feature size is the "production size" of these features, and not related to degradation.

Conclusions: Our mapping of chaos and micro-chaos-lenticulae in the equatorial region of Europa suggests the following conclusions: 1) there is a dominant chaos and lenticula size of ~ 9 km in equivalent circular diameter. This is supported through analysis of both high and low resolution imaging data. 2) Differences in the peak size of features is more likely due to local variations in the Europan surface and internal processes than any biases based on image resolution and phase angle.

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	E4 highres (5N, 337W) 25 m/pxl	E11 highres (35N, 87W) 30 m/pxl	E17 RM01 (0, 225W) 225 m/pxl	E15 RM02 (13N, 78W) 234 m/pxl	E14 wedges (14S,180W) 230 m/pxl	E11 RM01 (5S, 237W) 220 m/pxl	E6 DrkLin (8N, 274W) 180 m/pxl
Total number	18 (9)	17 (6)	346 (336)	253	228	46	132
Minimum	1.0 (1.7) km	1.5 (2.0) km	2.3 (") km	1.6 km	3.1 km	3.2 km	1.8 km
Maximum	23.5 (8.3) km	24.2 (9.1) km	223 (52) km	29.8 km	83.4 km	15.2 km	16.3 km
Mean	4.8 (4.4) km	8.5 (5.7) km	9.5 (8.5) km	7.2 km	14.4 km	8.3 km	7.0 km
Median	3.3 (3.6) km	8.0 (5.5) km	6.6 (6.4) km	6.0 km	11.2 km	7.8 km	6.7 km
Mode	*3 - 4 (") km*	*9-11 (5-7)km*	*4 - 6 (") km*	*4 - 6 km*	*6 - 8 km*	*4 - 8 km*	*4 - 6 km*
Peak of graph	*4 km*	*8 km*	*7 km*	*8 km*	*11 km*	*8 km*	*7 km*
Areal density	42%	68%	26%	37%	10%	44%	24%

Table 1: Statistics for the studied equatorial regions. The relevant image observations are: E4 Dark Material 02 high resolution, E11 Morphology 01 high resolution, E17 Regional Map 01 and Near-Term 01, E15 Regional Map 02, E14 Wedges 01, E11 Regional Map 01, and E6 Dark Lineaments 01. All data are for full and partial features combined. Data for the E4 high-resolution, E11 high-resolution, and E17 RegMap01 also includes the data for the full features only, denoted within parentheses in the table. Where the full feature data and the full and partial feature data are the same, a quotation mark is indicated. Areal density is the amount of the surface in each mapped region that is comprised of chaos and micro-chaos lenticulae. It is apparent from comparison of Table 1 and Figure 1 that the mode in feature size is most indicative of the dominant feature size, represented by the peak in the size frequency distribution histograms.

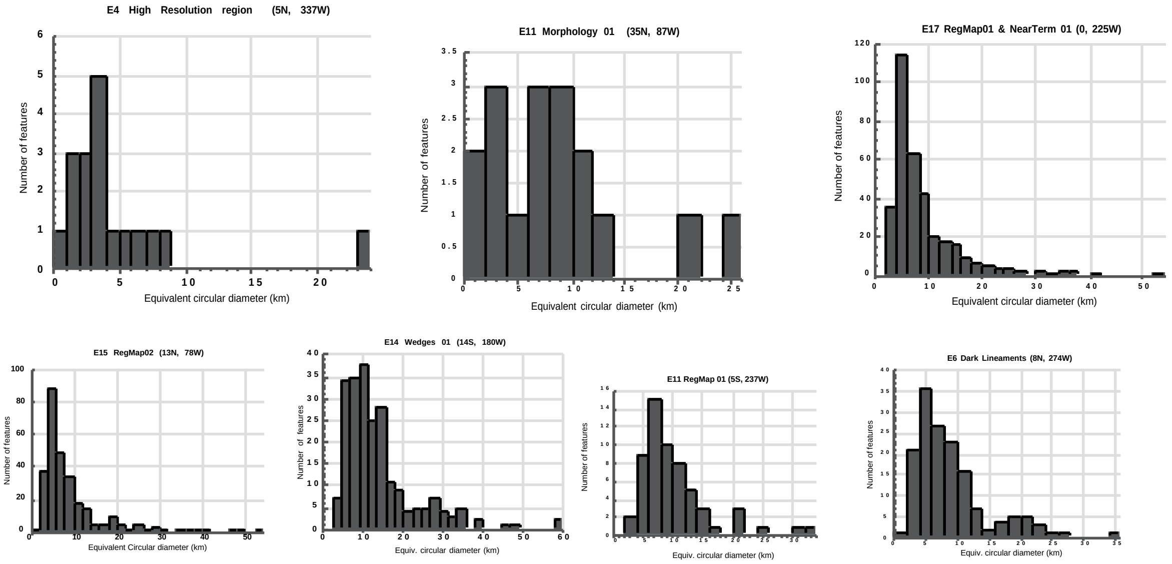

Figure 1. Histograms of size frequency distribution for the studied regions. Number of features vs. equivalent circular diameter in kilometers.