**THE EFFECT OF EXISTING GEOLOGIC FEATURES ON THE FORMATION OF EUROPA'S CHAOTIC TERRAINS.** J. E. Hedgepeth[1] and B. E. Schmidt[1], [1]Georgia Institute of Technology (School of Earth and Atmospheric Sciences 311 Ferst Drive Atlanta, GA 30332, jhedgepeth3@gatech.edu).

**Introduction:** Where there is water, there is possibly life. This makes icy satellites particularly interesting to planetary scientists. The discoveries of global oceans on Enceldus [1] and Europa [2-4] have profound implications on the search for life beyond Earth and raise many interesting questions regarding how these bodies may become habitable. Europa has a radius 6 times larger than Enceladus, and its surface is arguably far more interesting due to global scale evidence for recent dynamic overturn [5-8]. While there is debate as to how to uniquely classify chaotic terrain, these are regions of lumpy, disrupted matrix material formed from the preexisting surface by an endogenic process [5-6,8]. They are complex yet fascinating because they indicate that Europa may have active cycles that may make it possible for life to thrive [7-8]. These regions may be evidence of subsurface activity facilitating mixing with the surface. Previous attempts have been made to model their formation, but they are largely lacking [5]. Recent findings support the hypothesis that these terrains may arise from subsurface water lenses that form underneath the surface, between the deeper ice and the upper 3 km of the ice, facilitating ice-water interactions and giving rise to the distinct morphologies of chaos [8]. Models such as this work to explain how individual chaos terrains may form, but the diversity of chaotic terrain have yet to be fully explained.

**Scientific Objectives**

The purpose of this research is to study the effect of the existing geologic terrains on the formation of chaotic terrain. It may be that different forcing events lead to the diversity of chaotic regions, but we hypothesize that similar processes occur in each case. Using Earth as an analogue to Europa, glacier fracture and hydrodynamics can be considered analogous to ice dynamics on Europa. Glacier flow and calving rates are largely dependent on the surrounding geologic parameters such as the fjord shape and size [9-10]. We hypothesize that the geological units (i.e. ridges, troughs, etc.) that exist prior to the forcing event that drives chaos formation play a significant role in the how the terrain will deform and disrupt.

Europa's surface is full of different geologic features. In addition to the chaotic terrains it has craters, planes, bands, and ridges [6]. Our objective is to consider both conceptually and with qualitative analysis of the forces acting on different surface units as chaos terrain forms in order to understand how these feature are affected by subsurface activity. For example, Greenberg et al. [10] postulate that root like structures beneath ridges would take longer than the thinner surrounding terrain to melt so that icebergs are more likely to be ridged than plainer (Figure 1) . Schmidt et al 2011 studied the relationship of background terrain and chaos for Conamara Chaos [7]. We extend this work.

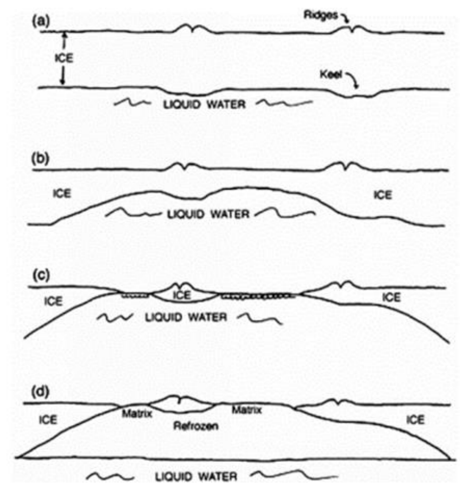


Figure 1: Greenberg et al. (1999) [10] postulates that ridges have root like features that last longer before fully melting.

**Technical Approach & Methodology**

We use archival image data generated by NASA's Galileo Project obtained using the Solid State Imaging (SSI) camera on the Galileo spacecraft from the Planetary Data System (PDS).

For example, we retrieved images S0449974326 and S0449974300 to create a complete image of Murias Chaos, informally known as the "Mitten". The images were combined for further analysis (Figure 2). We first begin to characterize the surface prior to the chaotic formation using the features within the chaotic terrain and around it. Using the Galileo images and Figueredo et al. [11] mapping of Murias Chaos contains we have identified five major geologic units: 1) Ridged band material, 2) Degraded plain material, 3) Complex ridge material, 4) Lineated band material, 5) Ridged plain material.

Figueredo et al. [11] identifies regions north and a small region south of the Mitten. That may be indicative of a large degraded plain region or that degraded plains are commonly localized. However, there is no significant evidence of other degraded planes in this

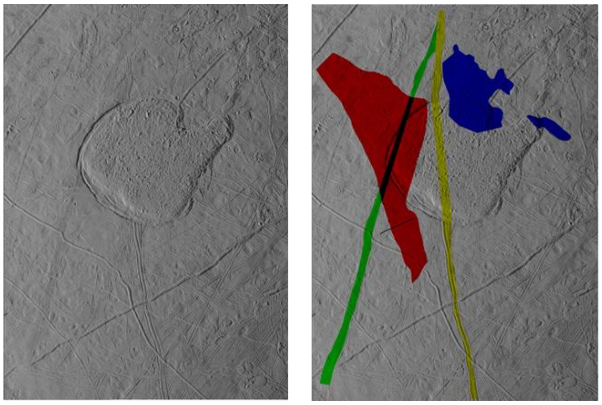

Figure 2: Murias Chaos (the Mitten) shown on the left, and a map of terrain types of the original terrain before and after chaos formation using Figueredo et al. [12] and Figueredo & Greeley [6] mapping criteria (middle and right). Ridged band material is shown in red, degraded plains material is shown in blue, complex ridge material is shown in yellow, and lineated band material is shown in green. All other terrain is left blank (white) to represent ridged plain material, the predominant surface feature.

region. This type of smooth, calm region seems unlikely and uncommon. Figueredo et al. [11] classify the degraded planes south of the Mitten as also wedged next to mass wasting terrain (from the elevated chaos material) indicating it may not be degraded plains after all. For these reasons, we present a conservative view for the amount degraded terrain.

The ridged band material is the largest geologic unit, aside from the ridged plain material. At the top of the band, two different bands can be seen to come together. On the left, the bands are at an angle of ~20 degrees from the N-S axis. On the right, the bands are ~45 degrees and the ridged plains exhibit the same orientation. This indicates that this location was experiencing two different orientations of stresses all of which meet at the top left of the chaos region. This may have resulted in this region being weaker than the surrounding terrain. It may have been prone to disruption by the formation of a subsurface lens due to this weakening [8]. Figueredo et al. [11] produced a DEM model to create a 3D mosaic of Murias Chaos. The DEM shows uplift of the Mitten consistent with the Schmidt et al. suggestion that matrix material becomes thickened with respect to the background from infilling of disaggregated matrix material with water from below and subsequent. We can infer, from the uniformity of the surrounding terrain, that original surface was not previously elevated and might have undergone melting that then refroze to elevate the region. Using this knowledge, we can consider whether the surrounding terrain features might have influenced the formation of the chaos region (e.g. creating an outer boundary or affecting the local stress-strain ).

We will present further analysis to include a simple force balance to better consider the effect of these features on the formation of the Mitten, and we will compare the iceberg like structures in the chaotic material with the surroundings. We will repeat this geologic analyses for other high profile chaotic terrains (Table 1). Using a larger sample size we can compare the main geologic features of each terrain and identify how they compare to one another. Finally, a general review of past postulated models can be considered for each terrain as well to identify which best predict the observed geomorphology.

| Chaos | Latitude-N (degrees) | Longitude-E (degrees) |
|---|---|---|
| Arran | 14 | 80 |
| Narbeth | -26 | 273 |
| Conamara | 11.9 | 271.1 |
| Rathmore | 26.3 | 73.9 |
| Thera Macula | -40 | 180 |
| Thrace Macula | -40 | 200 |

Table 1: Position of Chaotic Terrains to be studied.

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