Distribution of Normal Faults Not Evenly Distributed Across Dione. D. V. Miller[1], J. P. Kay[1], and P. Schenk[2], [1]The College of William & Mary, Williamsburg, VA, 23185 (dvmiller@email.wm.edu), [2]Lunar and Planetary Institute/USRA, Houston, TX, USA.

Introduction: We identify and map Dione's visible tectonic features, many of which are likely normal faults. We create cross-sections and topographical profiles and calculate the average surface topography of the moon. Using the lengths of these faults and a topographical model, we intend to infer the elastic thickness of Dione's ice shell and gain insight into the formation of the moon's Wispy Terrain, a heavily deformed region located on the trailing hemisphere. This terrain consists primarily of a network of extensional tectonic faults and its absolute age remains uncertain.

Background: Dione is a small moon orbiting Saturn with a density of 1480 kg m^3 and a radius of 561 km [1]. This density is about 1.5 times that of liquid water which suggests that Dione consists of a dense core with a thick ice shell [1]. The surface is most heavily cratered on the moon's trailing hemisphere, with other moderately and lightly cratered terrain spread throughout the surface as well [2]. Dione also has heavily fractured areas that appear as wispy lines that can span up to hundreds of kilometers. This Wispy Terrain suggests some form of previous tectonic activity [3]. The terrain's network of extensional fractures spans across nearly an entire hemisphere and is of uncertain absolute age [4]. The Wispy Terrain may also be indicative of previous endogenic activity [4]. The moon's surface is covered in many different tectonic and other features, and for this study, we identified and investigated primarily normal faults.

Methods: This study required mapping and quantitative analysis components which are outlined below.

Imagery and Mapping. Surface imagery of Dione was accessed from the publicly released Cassini ISS missions global mosaic. An image containing all surface features was used for mapping Dione's tectonic features. Features were mapped using ArcGIS Pro by creating a new vector feature class and carefully aligning the position of each tectonic feature using the base map for guidance. Figure 1 shows the completed map with all identifiable tectonic features outlined. The majority of features are found on Dione's trailing hemisphere in the Wispy Terrain, though there are indicators of tectonic activity throughout most of the moon's surface. Following our analysis of the surface imagery, we imported several Digital Elevation Models (DEMs) into the ArcGIS project. Each DEM only covers a small portion of the moon's surface, so these were mosaiced together to create a layer that covered the majority of Dione's area. Some regions, particularly those closest to the poles, did not have DEM data available or only had data with a very low resolution, which would compromise our high-resolution data in other regions. This mosaiced DEM layer was then used to generate cross-sections of the features mapped in the previous step.

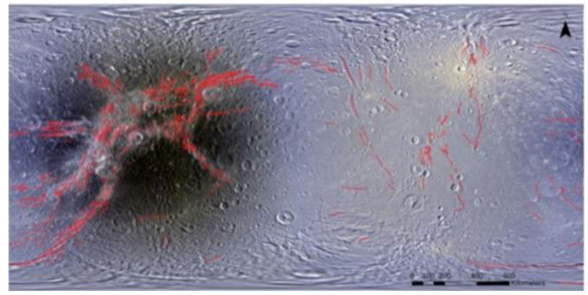


Figure 1: Imagery of Dione's surface with all features identified in a vector dataset.

Calculations and Modeling. We generated cross-sections for tectonic features that we believed to be normal faults using our DEM layer. The goal was to use this data and apply the same method used by Dr. Nimmo and Dr. Schenk in their 2005 study exploring normal faulting and implications for ice shells on Europa [5]. We identified hanging walls and foot walls in each of the observed features to determine offset. When those were identified, we added them to our list of potential normal faults. Several examples that we have found are shown in Figure 2. These features vary in both length and location across the surface. We created cross-sections of the structures we believed to be normal faults in ArcGIS Pro and exported these for further analysis in Microsoft Excel. We drew 6 profiles evenly spaced apart for each feature in order to calculate the average surface topography in each region (Figure 3). Our initial cross-sections covered too much distance, so we determined that using shorter cross-sections and

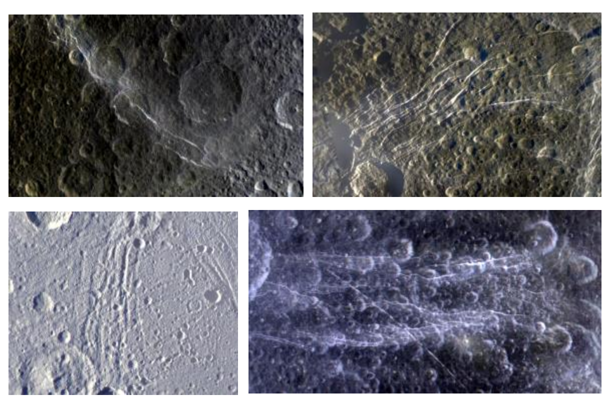


Figure 2: Examples of tectonic features found on Dione's surface.

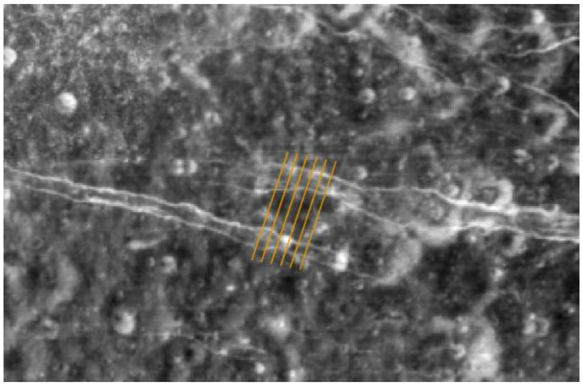
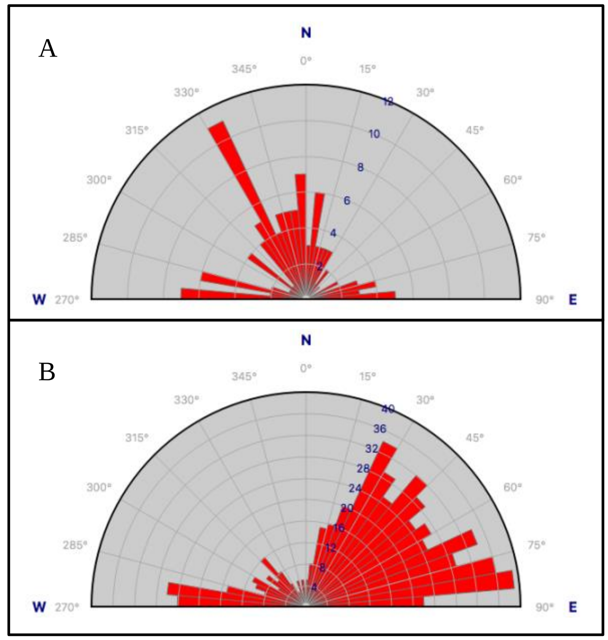


Figure 3: An example of the cross-sections initially drawn for the surface topography calculations. These were found to be too long so additional cross-sections covering just one tectonic feature were created.

focusing our analyses on small features would provide more precise results. The 6 cross-sections for each feature were all graphed and used to determine the average terrain of Dione.

Observations: Mapping the tectonic structures on Dione resulted in several observations about the moon's surface. One of the primary observations is the distinction between the moon's hemispheres. In total, we have identified 723 potential normal faults. Of those, 608 are in the Western Hemisphere and 115 are in the Eastern Hemisphere. The trailing hemisphere is dominated by the Wispy Terrain which results in a much higher concentration of tectonic structures. Structures can be found throughout the entirety of the moon's surface, but only appear in such high densities in this region. The structures in the Wispy Terrain appear to be extensional, and it is possible that there are exposures of water along normal fault scarps in the region. The structures throughout the moon's surface vary in length. We found that the average length of the features was approximately 41 km for the trailing hemisphere and 60.4 km for the leading hemisphere. We can see from Figure 4a and Figure 4b that there are two trend directions in each. In the trailing hemisphere a small NW trend and a W trend. In the leading hemisphere, we see a dominant NE trend and a smaller E-W trend.

Discussion: The purpose of this research is to develop an understanding of Dione's ice shell by determining the elastic thickness of the moon. We are also hoping to formulate a hypothesis for how and when the Wispy Terrain was formed. This project still requires further analysis, especially quantitatively to determine the surface topography of the moon. We also have to develop a means of distinguishing the various structures on the moon. Once we do this, we can create a vector layer of just the normal faults on the moon. By developing an understanding of Dione's ice shell, we can better understand other bodies' ice shells and what



Figures 4a and 4b: Rose diagrams showing the trend directions of features in each hemisphere (4a = leading, 4b = trailing).

effects they may have on the tectonic history and surface of these bodies. The biggest question this research has left us with is the history of the Wispy Terrain. Similar structures and regions have been observed on other bodies, such as the Tiger Stripes on Saturn's moon Enceladus. This research will help us identify and better understand the shear modulus and driving stresses on bodies with ice shells.

References:

[1] Thomas (2010) *Icarus, 208,* 395-401. [2] Goff-Pochat and Collins (2009). [3] Kirchoff and Schenk (2010) *Icarus, 206*, 485-497. [4] Hirata (2016) *JGR Planets, 121*, 2325-2334. [5] Nimmo and Schenk (2005) *Journal of Structural Geology, 28*, 2194-2203.