TESTING FOR NON-VISIBLE FRACTURES ON DIONE BY IDENTIFYING POLYGONAL IMPACT CRATERS. C. B. Beddingfield[1], D. M. Burr[1], L. T. Tran[1], [1]Earth and Planetary Sciences Department, University of Tennessee, Knoxville, TN, USA (cbeddin1@vols.utk.edu).

Introduction: On the surfaces of planetary bodies, tectonism occurs due to internal and orbital stress mechanisms. Global distributions of fracture azimuths may reflect these mechanisms, providing critical information about these satellite's histories [1]. Impact craters are nearly ubiquitous on planetary bodies and commonly overprint tectonic structures. Impacts form circular impact craters (CICs) within non-fractured terrains, and polygonal impact craters (PICs), having noticeable straight rim segments, within pre-fractured terrains [2, and references therein] (Fig. 1). The straight rim segments form sub-parallel to surrounding fractures [e.g., 2 and references therein]. The crater's polygonal shape is manifested during the crater formation process. Immediately following an impact, material excavates along weak fractures, resulting in preferential expansion of the crater in directions consistent with underlying fracture orientations [3].

Relationships between PIC prominent rim azimuths and pre-existing target material fracture azimuths have been noted for other planetary bodies including Earth and its moon [e.g., 4, 5], Mars [e.g., 6, 7], Mercury [e.g., 8, 9], Venus [e.g., 10], and outer solar system icy satellites including Rhea [11], Ganymede [12], Iapetus [13,14], Enceladus [15], and Dione [16, 17].

As seen in data from the Voyager [18] and Cassini [19] Imaging Science Subsystem (ISS) cameras, Dione's surface exhibits visibly fractured terrains, termed the Wispy Terrain, and non-visibly fractured terrains, namely, the Cratered Plains and the Smooth Plains [20]. We group the non-fractured terrains into what we call the "Non-Wispy Terrain".

PICs are present in both the Wispy and Non-Wispy Terrains. This observation suggests non-visible fractures exist outside Dione's Wispy Terrain. The fractures may not be visible either due to their dimensions being below the resolution of the imagery and/or due to the presence of a regolith layer overlying these fractures.

Hypothesis: Based on the observation of PICs within Dione's Non-Wispy Terrain, we hypothesize that subtle fractures exist in Dione's Non-Wispy Terrain. If our hypothesis is supported, we will use PIC straight rim segments to map azimuths of subtle or non-visible tectonic fractures across Dione's surface.

Data and Methods: To test our hypothesis, we will collect data from PICs in both the Wispy and Non-Wispy Terrains, as well as from visible fractures in the Wispy Terrain. This project will follow a two-step approach. For Step 1, we are assessing the relationship between PIC rim and fracture azimuths in the Wispy Terrain. A statistically significant correlation would imply that PICs identified in the Non-Wispy Terrain are also controlled by pre-existing target material fractures. Thus, Step 2 is predicated on the results from Step 1. For Step 2, we will identify PICs in the Non-Wispy Terrain as a test for subtle fractures. The hypothesis will be supported if (and where) PICs in the Non-Wispy Terrain exhibit rim azimuth distributions consistent with those of nearby PICs.

Measurement and Classification Techniques: A global mosaic of Dione provided by the USGS, and multiple applications in the Environmental Systems Research Institute's (ESRI's) ArcMap software will be used to randomly select five study locations in the Wispy Terrain, and 30 in the Non-Wispy Terrain. Processing these images will be conducted with the Integrated Software for Imagers and Spectrometers 3 (ISIS 3) [21]. Images will be exported into ArcMap for measurements.

We will take crater rim azimuth measurements of the 30 impact craters closest to each study location. Because post-faulting across impact craters alters their geometries, we will disregard craters cut by faults. We will also disregard craters overprinted by other craters and craters that are too small to confidently measure (diameters ≤40 times the image resolution). In addition to the craters, for each study location in the Wispy Terrain, we will measure azimuths of the 30 closest fractures (900 total fractures). We will also disregard any fracture with a length too small to be confidently measured (lengths ≤40 times the image resolution).

To collect data of impact crater rim azimuths, the impact crater rims will first be traced by eye, using surface shadowing as a guide. The azimuths of each 1 km length of traced crater rim will then be calculated, providing an azimuth distribution for each impact crater.

To distinguish between PICs and CICs, we will test for a uniform crater rim azimuth distribution of each measured crater using a chi-squared test [22]. If the test results show a non-uniform distribution, the crater will be classified as a PIC (Fig. 1a). If the distribution is uniform, then the crater will be classified as a CIC (Fig. 1b). The most prominent rim azimuths for each classified PIC will be determined using a dip test, which is a measure of data multimodality [23].

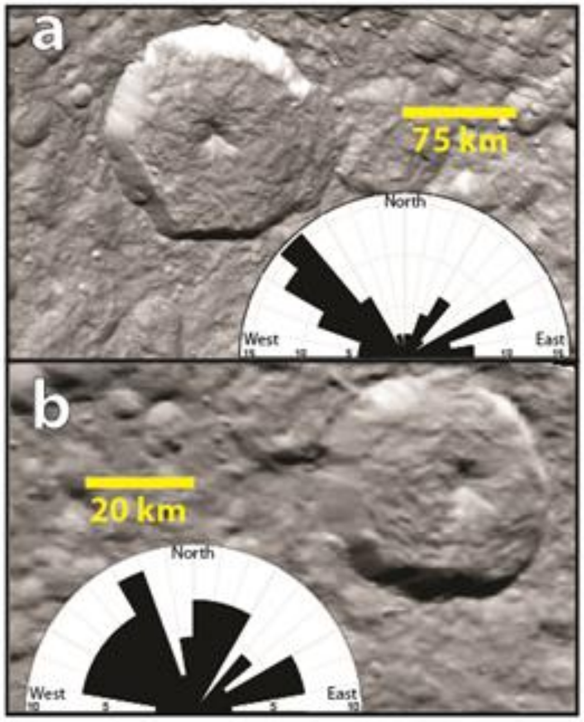

Figure 1: Two impact craters on Dione with the associated rose diagrams of their rim azimuth distributions. The rose diagrams were created using the Stereonet 7 software. (a) A 150 km diameter PIC (image N1507742406_2). (b) A 45 km diameter CIC (image N1665975217_1).

Analysis Techniques: Our azimuthal data are circular, defined as data without a designated zero for which the designation of high and low values is arbitrary [24]. For this reason, common statistical tests, used for linear data, cannot be used on our data. Instead, specialized circular statistical tests must be applied [24].

For Dione's Wispy Terrain, we will investigate if a statistical similarity exists between PIC prominent rim azimuths and surrounding fracture azimuths. To determine if the data in each study location follow a circular normal distribution, we will apply the Watson's goodness of fit test [24, 25]. If the data follow a circular normal distribution, then the Watson-Williams two-sample test [26] will be used to compare fracture trends and prominent PIC azimuths. The Watson-Williams test is analogous to the linear t-test, and is used to determine if two sets of data are statistically different. If the data do not follow a circular normal distribution, we will use the non-parametric Watson-Wheeler two-sample test [27], analogous to the linear Mann-Whitney U test.

If the statistical test results show a similarity between PIC prominent rim azimuths and fracture azimuths in each study location in the Wispy Terrain, then the interpretation that PIC rim azimuths are controlled by surrounding fracture azimuths is supported. For PICs in the Non-Wispy Terrain, we will perform statistical tests to determine if rim azimuth distributions of each PIC are consistent with the nearest PIC. As in the analysis done on PICs within the Wispy Terrain, we will determine whether or not the data follow a circular normal distribution and then use the appropriate test (as described above) to compare rim azimuths among nearby PICs. Similar azimuths for crater rim segments of nearby PICs would support the hypothesis for a given study location.

Possible Implications: Knowledge of Dione's global fracture azimuth distribution would provide substantial information on Dione's orbital and/or geologic history. Findings in support of the hypothesis would imply that Dione experienced more tectonic activity than previously thought. Findings that do not support the hypothesis would imply that tectonic activity was strongly concentrated within the Wispy Terrain.

References: [1] G. Collins et al. (2009) *Planetary Tectonics, 264-350*. [2] T. Öhman et al. (2005) *Impact Tectonics, 131-160.* [3] D. Eppler et al. (1983) *GSA Bull. 94, 274-291.* [4] E. Shoemaker (1962) *Physics and Astronomy of the Moon, 283-359.* [5] C. Fulmer and W. Roberts (1963) *Icarus 2, 452-465*. [6] R. Leighton et al. (1969) *Science 166, 49-67.* [7] A. Binder and D. McCarthy (1972) *Science 176, 279-281.* [8] C. Wood et al. (1977) *LPS 8, 3503-3520.* [9] H. Melosh and D. Dzurisin (1978) *Icarus 35, 227-236.* [10] M. Aittola et al. (2010) *Icarus* 205, 356-363. [11] B. Smith et al. (1981) *Science 212, 163-191.* [12] P. Thomas et al. (1998) *Icarus 74, 554-567.* [13] C. Porco et al. (2005) *Science 307, 1237-1242*. [14] T. Denk et al. (2005) *LPS 36, 2262.* [15] P. Helfenstein et al. (2005) *Bul Amer. Ast. Soc. 36, 36.01.* [16] J. Plescia (1983) *Icarus 56, 255-277*. [17] J. Moore (1984) *Icarus 59, 205-220*. [18] B. Smith (1982) *Science 215, 504-537.* [19] C. Porco et al. (2006) *Science 311, 1393-1401.* [20] K. Stephan et al. (2010) *Icarus 206, 631-652.* [21] J. Anderson et al. (2004) *LPS 35, 2039*. [22] J. Burt et al. (2009) *Elementary Statistics for Geographers*. [23] J. Hartigan and P. Hartigan (1985) *Ann. of Stat., 70-84.* [24] S. Jammalamadaka and A. Sengupta (2001) *Topics in Circular Statistics*. [25] E. Gumbel et al. (1953) *J. Amer. Stat. Assoc., 48, 131-152.* [26] G. Watson and E. Williams (1956) *Biometrika, 43, 344-352.* [27] J. Zar (1999) *Biostatistical Analysis, 640*.