IMPACT CRATERS ON TITAN: FINALIZING TITAN'S CRATER POPULATION. J. E. Hedgepeth[1], C. D. Neish[1], E. P. Turtle B. W. Stiles[2] [1]University of Western Ontario Department of Earth Sciences, London, ON (jhedgepe@uwo.ca), [2]Jet Propulsion Laboratory, Pasadena, CA.

Introduction: Saturn's moon Titan is one of the most dynamic bodies in the solar system. It is the only moon with a thick atmosphere, and like Earth's atmosphere it has an active hydrological cycle. However, the atmosphere of Titan is organic rich and rains methane instead of water. As a result, Titan's surface topography is being modified extensively by many of the same types of erosional processes seen on Earth. The methane rain creates a complex system of river networks, and the equatorial regions are covered by seas of organic sand dunes.

The extent of the endogenic and exogenic processes on Titan is best observed in its impact craters. Impact cratering is a fundamental process in planetary geology; it is a well understood process because of how pervasive it is in the solar system. Impact cratering provides important information about the composition, interior structure and surface processes that alter the solid bodies in our solar system. Here we continue the broad study of impact craters on Titan by compiling the characteristics of all known craters on Titan at the end of the Cassini mission.

At this point, there are 75 suspected impact craters that have been identified as new data has become available [1, 2, 3]. The Cassini spacecraft studied Titan and the Saturnian system starting in 2004, and acquired the last high-resolution RADAR images of Titan in April 2017. A systematic search for all of Titan's craters has yet to be performed with the completed dataset.

Therefore, in this work, we are creating a complete catalog of all the craters on Titan and characterize their morphology. We are searching the Cassini RADAR and Imaging Science Subsystem (ISS) data for impact craters, and characterize the morphology of the craters (depth and diameter) using the SARTopo dataset [4]. Finally, we are comparing the morphology to unaltered craters on airless icy worlds to determine the type and extent of processes that have modified them.

Crater Catalog: Titan RADAR data was obtained from the Planetary Data System (PDS). Only the highest resolution images are used (256 to 64 pixels per degree) with a preference for the highest resolution. The data is imported into the USGS's Integrated Software for Imagers and Spectrometers (ISIS) and eventually mosaicked together. However, before this is done, the images are compared to ensure the best image is used where datasets of differing resolution exist.

Global and polar mosaics of Titan are made using the complete SAR dataset from the Cassini mission. Once mosaicked, the files are imported into ArcGIS to map craters as shapefiles. The craters are meticulously mapped across the surface. This map is compared to the most up to date ISS mosaic, updating the crater map where necessary.

This finalized catalog of craters on Titan is imported into MATLAB as shapefiles for further analysis. Initial estimates of crater diameter and center positions are cataloged for further work.

Topographic Analysis: Our understanding of impact cratering controls how we perceive surface changes on Earth and other worlds. Therefore, constraining cratering processes informs planetary surface evolution. A large catalog of unaltered craters exists on other icy worlds that can be compared with those we see on Titan [5, 6]. Contrasting the morphology of Titan's craters to unaltered craters can constrain the processes that have altered it.

SARTopo data is a form of topographic data derived from overlying paths of radar images [4]. The data set is limited, covering only 15% - 25% of the surface, yet it is enough to constrain a large fraction of the Titan crater population. The SARTopo data is imported into MATLAB to look for overlapping topographic profiles with the putative craters in the catalog. Before an in-depth study is done, the SARtopo data is used to assess the likelihood that putative craters are indeed impact in origin. For example, SARtopo data shows that some circular features are mounds rather than impressions. Once finalized, the crater catalog and the SARTopo profiles are used to constrain the morphology (depth and diameter) of the craters.

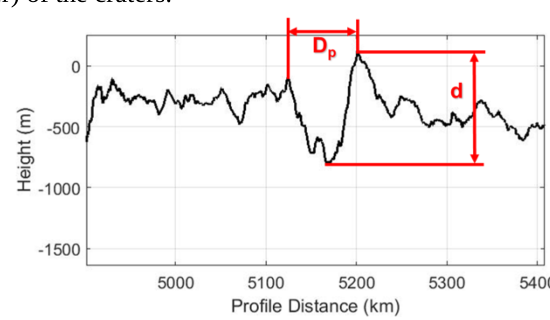

Figure 1: The peaks in topography identify the rim of the crater. The depth is found by finding the distance between the rim and deepest part of the crater floor, on the left and right of the crater.

Figure 1 illustrates how the depth and profile diameter are determined. The rim of the crater creates a peak in the topography which gives rim-to-rim distance, needed to find the crater diameter. The depth is found by taking the difference between the rim height and the lowest point of the crater floor. However, the depth is determined and averaged for the left and right of the crater to account for fluctuations in local topography.

At this point, the profile diameter is converted to the actual crater diameter because the profile does not typically go through the center of the crater (Figure 2). Simple geometry can easily convert the profile distance to find the radius for each rim, but in averaging these radii to find a diameter the crater is falsely assumed to be a perfect circle. A theoretical assessment is done to consider all the possible crater center points for a circle with a varying radius (Figure 3). However, it is important to realize that the crater center position dictates radii measurements. Previous estimates of crater centers have had very imprecise results that can significantly skew diameter estimates (at least 5+ km).

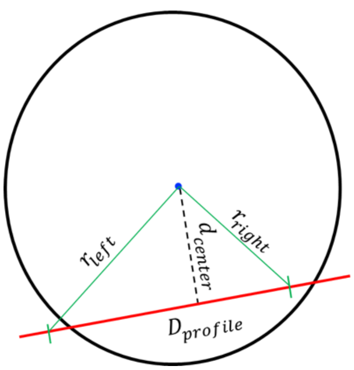

Figure 2: An illustration of a hypothetical crater fit (black) with a SARtopo profile (red) cutting through the edge of the crater. The actual topography will not fit a perfect circle and the left and right radii (green) will likely differ.

Results: Initial results show several craters have larger diameters than previously estimated. For example, Sinlap was originally listed with a diameter of 82 ± 2 km [1], while our results indicate that it is 89 ± 2 km. Several factors may have contributed to these differences. The biggest aid in this investigation is the SARtopo data that gives much more precise constraints on the crater rim, which are often difficult to pinpoint from radar data alone. However, the center of Sinlap crater was significantly misrepresented along with several others. This may be due to error or changes in the georeferencing. This example highlights the importance of this new analysis is in our understanding of the formation and modification of craters on Titan.

Currently, 11 crater depths and diameters have been measured (Figure 3). More data is available for other craters, but further analysis is required to constrain their morphology.

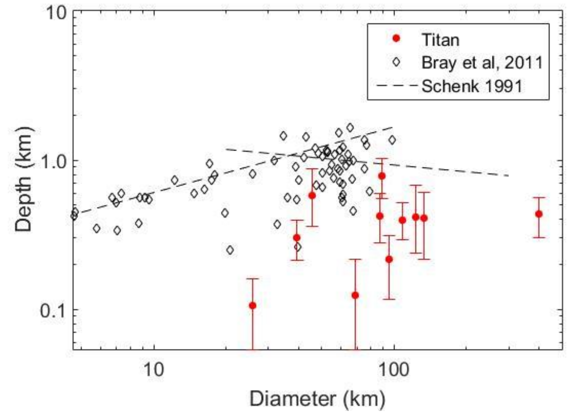

Figure 3: A plot of the depth-to-diameter ratio of craters on Titan (red) compared to craters on Ganymede (diamonds [5] and dashed line [6]) modified from Neish et al. [7].

Discussion: Once completed, the catalog of Titan craters will reflect the complete range of depths and diameters for certain to probable impact craters on that world. Thirty-one of the previously reported craters have some amount of SARtopo data in their region. The initial results (Figure 3) suggest that the significance of erosion is higher for smaller craters, as suggested by Neish et al. [8]. Smaller craters have smaller initial depths, so less crater erosion and infill is needed to significantly reduce the relative crater depth.

Most crater depths on Titan are much less than those of similarly sized craters on Ganymede. Nevertheless, it is interesting to note how many large craters (≥100 km) exhibit the same depth. Rather than being an effect of erosion, this may be indicative of endogenic processes (e.g. viscous relaxation) taking control. Previous works has suggested relaxation should not play a significant role in the modification of Titan's craters, but recent findings suggest it could be playing a moderately important role under the right conditions [9].

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