Comparing Cracks in Areas with Evidence of Emitted Water Vapor Near Craters on Europa and Ceres.
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Introduction: We hypothesize that Yalode Crater on Ceres and Pwyll Crater on Europa, which have informative surface features, including the width, length, and number of cracks adjacent to craters and elevation, could potentially support the existence of cryovolcanism on the extraterrestrial bodies. With further data collection, the Klein Research Team excluded width and elevation from our observations. The variations that we observed on JMARs made it impossible to gain an accurate width measurement. Elevation was considered but after further analysis, we realized the available JMARs data was also unable to give an accurate measurement for this feature. The Klein Astronomy Research Team (KART) is continuing the study of icy celestial bodies by comparing the icy moon Europa and the dwarf planet Ceres. We are doing this by measuring the length of the cracks found on both celestial objects and their correlation with adjacent craters that may contribute to water vapor found by NASA. This may provide evidence of cryovolcanism and its origin and formation on icy bodies.

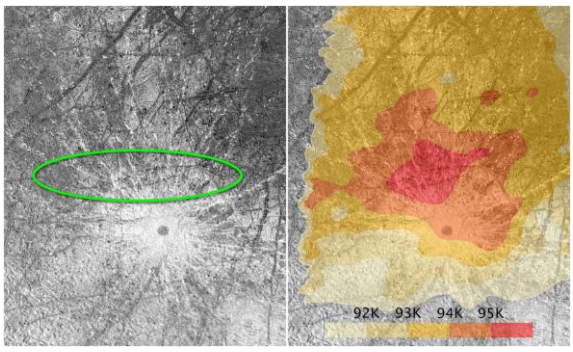

Figure 1 (left): This image shows the area of Europa from which we took data points due to its high temperature and evidence of cryovolcanism. The area is around Europa's Pwyll Crater.

Experimental Setup: We decided to collect data from cracks surrounding Europa's crater, Pwyll, which is known to be in a warm spot on Europa [Fig 1] with cryovolcanism; on Ceres, we collected data from the cracks surrounding one of its two largest craters, Yalode, a region in which water vapor has previously been detected [Fig. 2]. Our team then decided to measure data for 10 definite cracks in each region, recording the beginning and end coordinates of each crack, the length from beginning to end in kilometers, and the distance from the middle of the crack to the middle of the crater.

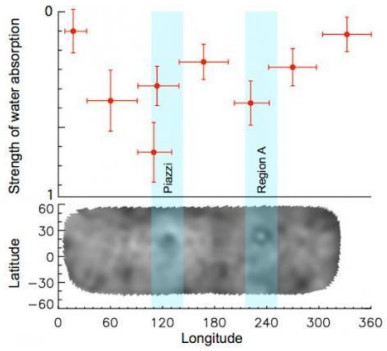

Figure 2: This diagram shows the strength of water absorption around the Yalode and Urvara craters on Ceres, the region where we collected our data.

We collected a combined amount of 20 adjacent crack measurements from both Ceres and Europa. Each crater we measured had a total of 10 length measurements. The collection procedure was as follows:

- We started with the length of the larger cracks on both icy bodies.
  We then proceeded to measure the remaining cracks from left to right and recorded the latitude and longitude of both beginning and ending points of the cracks.
- Using the measuring tool, we measured the distance (km) between the centers of the craters and the centers of the cracks.
- We compared the data collection of both Ceres and Europa using graphs
- This data collection came from the application JMARs using the Dawn and Galileo spacecraft.

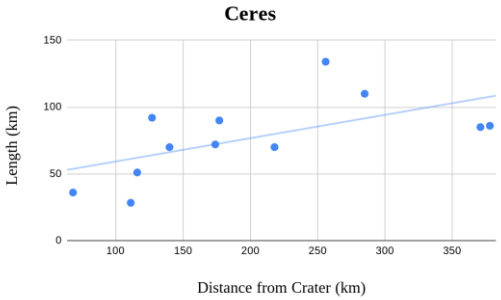

Figure 3: This graph shows the plotted points comparing the distance from the crater to the length of our ten chosen cracks surrounding Ceres' Yalode crater, and includes a line of best fit, to better illustrate the direct relationship.

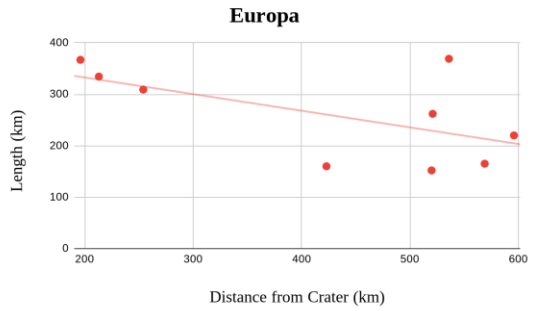

Figure 4: This graph compares the distance from the crater to the length of our ten chosen cracks surrounding Europa's Pwyll crater, including a line of best fit, to better illustrate the inverse relationship.

Results and Discussion When plotting the points comparing the distance of chosen cracks from craters to the length of the cracks, we can see that the variables are directly related on Ceres [Fig. 3] and inversely related on Europa [Fig. 4]; this means that Ceres' cracks are larger the further they are from the Pwyll crater, while Europa's cracks are smaller the farther they are from the Yalode crater. This could be due to the fact that Yalode on Ceres is next to the Urvara crater, which may affect the nearby cracks; Ceres is also in the asteroid belt and is more likely to come in contact with objects that deform its surface and may alter the number and size of cracks. Europa's Pwyll crater, on the other hand, is not surrounded by any craters that may skew the data. It is also important to note that the Pwyll is in a "warm spot" [Fig.1] of Europa, while Ceres does not have warm spots and its water vapor is hypothesized to be due to sublimation from its icy surface, rather than cryovolcanism; Europa has photo evidence of emitted water vapor [Fig. 5], while Ceres only has detected traces of water vapor sublimation on its surface.

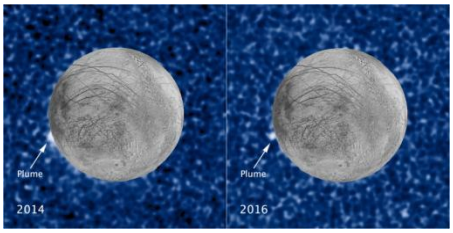

Figure 5: Photo evidence of cryovolcanism on Europa.

The size of the cracks themselves, regardless of distance from craters, vary drastically between the two chosen icy bodies, with Europa's largest measured crack surpassing the largest crack on Ceres by over 200 kilometers. This is similar to an observation made in a past Klein abstract comparing Europa and Enceladus, where the width of cracks was compared to the area of nearby craters and geysers; in this abstract, it was found that Europa's cracks were larger around big craters and smaller around small craters, while Enceladus had an inverse relationship between the size of the cracks and size of the craters- similar to Ceres' having smaller cracks closer to its crater. It was suggested that this could be due to more powerful forces such as greater tidal forces or interior thermal forces, which we can take into consideration when observing the differences between Europa and Ceres' cracks. Europa, like Earth, has an iron core and thus a heated interior, which is most likely its cause of cryovolcanism. Ceres, on the other hand, has an ice core, which means that its water sublimation is most likely not due to heat; this leaves us with the possibility of tidal forces, or, more likely, ice on the surface being sublimated, since tidal forces on Ceres are very minuscule and interior heat is generally necessary for cryovolcanism. Thus, there is more evidence to support the idea that Ceres' water vapor is not due to cryovolcanism, but rather comet-like sublimation when dust is removed to expose the icy surface beneath. However, this then leads to further questions. If sublimation is occurring from exposed ice, how does one explain the data showing water vapor near the Yalode and Urvara craters [Fig. 2]? Are there other places on Ceres with water vapor evidence that is not being taken into account?

Acknowledgments: Special Thanks to Mrs. Carol Benignus for being the advisor for our project. Special Thanks to Mr. Jon Benignus for sponsoring our Astronomy Club.

References: [1] Potter S. et al. 2016, "NASA's Hubble Spots Possible Water Plumes Erupting on Jupiter's Moon Europa." NASA: 16-096. https://www.nasa.gov/press-release/nasa-s-hubblespots-possible-water-plumes-erupting-on-jupitersmoon-europa [2] (2017) https://photojournal.jpl.nasa.gov/catalog/PIA21444 [3] Williams, Dr. D. 2018. "Jupiter Fact Sheet." NASA. https://nssdc.gsfc.nasa.gov/planetary/factsheet/jupiterfact.html [4] Kohler, S. 2015. "Geysers from the Tiger Stripes of Enceladus." NOVA. https://aasnova.org/2015/10/02/geysers-from-the-tigerstripes-of-enceladus/ [5] 2006. Science, Vol. 311. https://web.mit.edu/wisdom/www/porco-enceladus.pdf [6] Thompson, J. 2017. "The Moon with the Plume." NASA. https://solarsystem.nasa.gov/news/13020/themoon-with-the-plume/ [7] 2010. "Zooming in on Heat at Baghdad Sulcus." NASA. https://www.jpl.nasa.gov/spaceimages/details.php?id=PIA12448 [8] http://ciclops.org//view_media.php?id=17625&js=1 [9] NASA, 2014 "Water Detected on Dwarf Planet Ceres" https://science.nasa.gov/science-news/science-at-nasa/2014/22jan_ceres