EXAMINATION OF EFFECTS OF IMPACT DRIVEN TECTONICS ON SURFACE ACTIVITY OF ASTEROIDS AND ICY WORLDS. A. Manchester, G. Byers, M. Guerrero, S. McGrath, A. Nasser. Klein High School, Spring, TX

Introduction: The Klein High School Astronomy Club Research Team has studied icy moons for the past several years, and this year the team decided to use this experience to find some information we could compare to the asteroid Vesta. We chose the examination of the possible effects of impact-driven tectonics on surface activity of asteroids and icy worlds. We came to the hypothesis that large craters, left behind by equally large asteroids, could substantiate the fact that linear features on these surfaces are caused by tectonics originating from large impacts.

Experimental Setup:

1. Finding evidence of our thesis was based on observational information, so each of us using JMARS, searched our moons for visually substantial surface features
2. After finding our important features each of us attempted to find a correlation between the surface fissures and considerable sized impact tectonics
3. We attempted measurements of proximity between impact features and fissures but data was inconsistent between all the moons, specifically Enceladus.
4. In the end we observed abstracts from previous years and compared our images that provide evidence of similar features on each moon, but still found that the cause of the surface features that lie on the surface of isolated Enceladus remains unknown.

Discussion: Vesta is one of the largest objects in the asteroid belt, only second to Ceres, and was the control for testing our hypothesis. It has been theorized that the three fossa systems on the surface – Divalia, Saturnalia, and Lupercalia – were formed from a form of tectonics caused by large scale impacts, called impact based tectonics. Divalia and Saturnalia Fossae were spawned from the largest residing impact basin on Vesta – Rheasilvia Crater. Rheasilvia, the newer of the two large impact basins, is approximately 196,350 km^2 in area and spans more than half of Vesta's overall circumference. Divalia Fossae is the largest system of fossae on Vesta at 549.37 km, which is composed of a series of very long equatorial ridges that appear to be concentric to Rheasilvia Basin. Saturnalia Fossae is a slightly more obscured ridge system closer to the northern pole and is the second largest fossa system on Vesta at 344.94 km. Overlapped by Rheasilvia, the slightly smaller Veneneia Crater – at 159,043 km^2 – created Lupercalia Fossa which is the shortest of the three fossa features. All of these are highly supported in being created through impact-driven tectonics and we therefore compared the trends apparent on Vesta to prominent features on other icy moons.

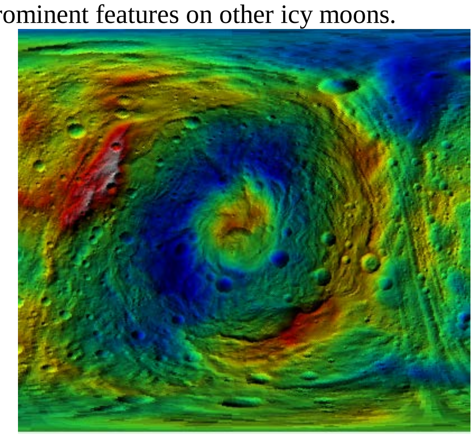

Fig. 1: Polar view of Rheasilvia crater and Divalia Fossae concentric to it. (Vesta)

The large ringed structures on the Jovian moon Callisto represent a potential substantial connection between the impact craters and the rings encircling them, where each of the four ring structures present a trend that leads us to believe that tectonics are involved in the formation of these structures. Similar to the ringed structures on Europa, there is a trend in the placement of them. On Callisto, this trend is primarily latitude. The closer the structure is to a certain latitude, the larger the number of rings around the structure. Thus we can infer that there may be a latitude on Callisto with a substantially weaker and more brittle surface that helped to cause this tectonic disturbance. While the ringed structures are certainly different from the fossa systems formed on Vesta, it is worth noting that the trend of concentric systems forming that comes with large ringed structures appears to occur with Vesta's features as well - albeit on a much larger scale.

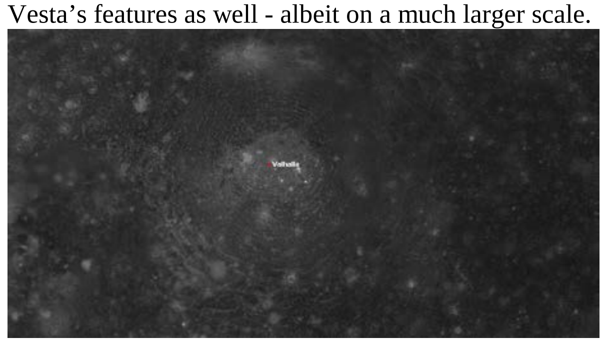

Fig. 2: Valhalla basin, a Large Ringed Structure, with 6 concentric rings to the epicenter. (Callisto)

On Europa many of the Linea systems such as Minos, Drumskinny, and Harmonia were existing across Europa without any place of origination, but as we looked deeper into the geography of Jupiter's moon we notice that there are traces of water ice surrounding the surface of the moon. Many scientists have hypothesized that there is an ocean that exists below the surface of Europa which may result in the movement of the ice plates on the surface. One of the reasons for the different ridge systems to not have an originating feature is because with the movement of the ice plates on the moon. Some of the impact features could have progressed from one position to another over the course of many years. Another reason is that in the originating impact feature there could be a buildup of ice inside of the crater/point of impact which might cover up the feature completely making it basically invisible to the satellite imaging the moon.

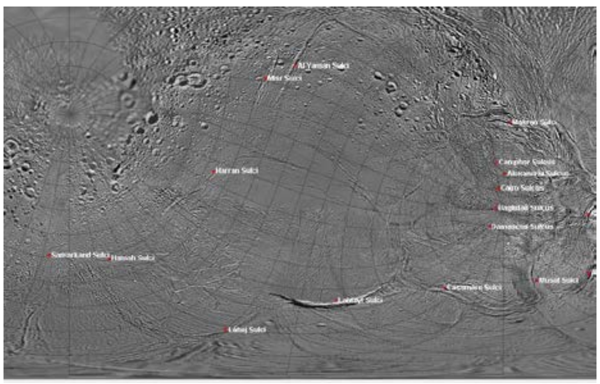

Fig. 3: View showing the dichotomy of Enceladus, with the north and south pole having craters and sulcus systems respectively.

For the study of Saturn's icy moon Enceladus, we chose four specific sulci near the moon's southern pole which included the Baghdad Sulcus, Damascus Sulcus, Cairo Sulcus, and the Alexandria Sulcus, also known as "The Tiger Stripes". During observation we realized that there is a stark difference between the location of impact craters and the Tiger Stripes. There is a substantial cluster of craters that lie at the northern pole of Enceladus but there is no evident correlation directly with the tiger stripes near the south pole. Therefore, our current lack of connection between the tiger stripes and impact tectonics helps to further compare the possible subsurface ocean of Europa and a possible subsurface ocean on Enceladus. The Linea on the surface of Europa visually compare to the tiger stripes, in that they are similarly spaced. Additional data from other research states that the reason for the icy plumes that lie on the tiger stripes, and the ridges on Europa could be from heat fluxes from possible oceans beneath their thin icy surfaces.

Results and Conclusions:

The results of our setup were conflicted. Initially starting out with Vesta, the imagery available to us for proper measurement and data collection for Saturnalia and Lupercalia fossae gave way to unclear numbers, however careful observation and existing data on the structures allowed for proper data collection. When comparing our selected moons to Vesta's structures, the "ripple" effect observed on Vesta's surface was in some form recreated on Europa and Callisto with the Large Ringed Structures, which we have previously hypothesized to be the result of some form of impact-caused tectonics. However, on Enceladus the results did not end up showing any correlation in regards to impact-based tectonics. With Enceladus's most prominent features being separated from the impact basins, it was not evident that these features would have been directly related to an impact but rather other activity on or slightly below the surface as supported by the unique cryovolcanism that exists on the surface. Another possibility for Enceladus is that this cryovolcanism exists in the same regions as the tiger stripes, exhibiting activity around this region of the moon. This could have led to the erosion and weathering of any evidence of impact craters on the surface; otherwise there is another force under the surface of that region causing not only the tiger stripes but also the cryovolcanism that exists there. Overall, the data we collected from these icy worlds gave unclear results, aside from the observation of trends on the topography of their surfaces.

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