Calculating the Global Budget of Impact-Derived Sediment on Venus

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Impact Crater Deposits

Most (if not all) of the sediment on the surface of Venus is thought to be derived from impact cratering. When an impactor collides with the planet, sediment is ejected into the Venusian atmosphere where it is carried west by strong zonal winds. Eventually, particles fall to the ground where they are emplaced in large, parabola-shaped deposits. Because the resurfacing rate of the planet is so low, over 500 craters are still detectable on the surface of Venus. Of these craters, 49 retain their parabolic ejecta deposits (Figure 1). The sediment contained in these deposits is thought to contribute to dune fields and aeolian features on Venus (Figure 2).

Despite knowledge of the production of impact-derived sediment, the global volume of sediment on Venus is still unknown. Preliminary estimates suggest the total amount of material is on the order of 10^4 km^3 (Basilevsky et al., 2004; Melosh & Schaller, 1996) but these calculations often only account for the fraction of transportable sediment. Here we present a method for calculating the total budget of sediment on Venus and mapping the locations that have seen the most sediment produced over the past 500 million years.

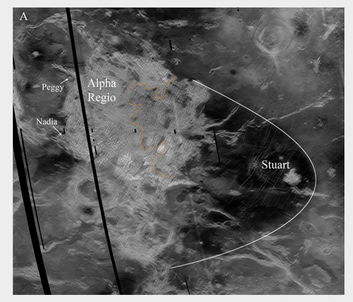


Figure 1: Crater Stuart and its radar-dark parabolic ejecta deposit (Campbell et al., 2015)

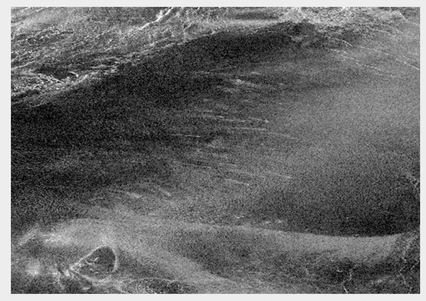


Figure 2: Synthetic aperture radar image of the Fortuna-Meshkenet dune field. Dunes appear as white streaks in the center of the figure.

Modeling Thickness and Volume

- We use existing ArcGIS maps of parabolic ejecta deposits. These files map deposits by dividing each parabola into thousands of equally-spaced points. Each point has a unique latitude and longitude and may therefore be assigned different values of thickness and volume.
- We calculated deposit thickness for all data points in every parabola using the following equation derived by McGetchin et al. (1973): $t = 0.14{R_c}^{0.74}(\frac{R_c}{R})^3$
- These thickness values were converted to seven ArcGIS rasters (grids of pixels) in order to visually display contours of constant deposit thickness.
- The seven thickness rasters were summed to create a map of global cumulative thickness using the “Mosaic to New Raster” tool.
- Sediment volume for each data point was then calculated by multiplying its thickness value and its surface area.
- Volume rasters and a cumulative volume map were created in the same manner as the thickness maps, and global sediment volume was calculated by summing the volume contained in each data point.

Sediment Maps

- We have produced thickness and volume maps for all parabolas on Venus which include isopach contours showing regions of constant ejecta thickness/volume.
- A sum of all the thickness maps and a sum of the volume maps (Figure 3) were also created. These maps display cumulative ejecta thickness or volume over the entire planet.
- From the cumulative volume map, have calculated the global volume of impact-derived sediment on Venus to be a minimum of **~2.9 x 10^5 km^3.**

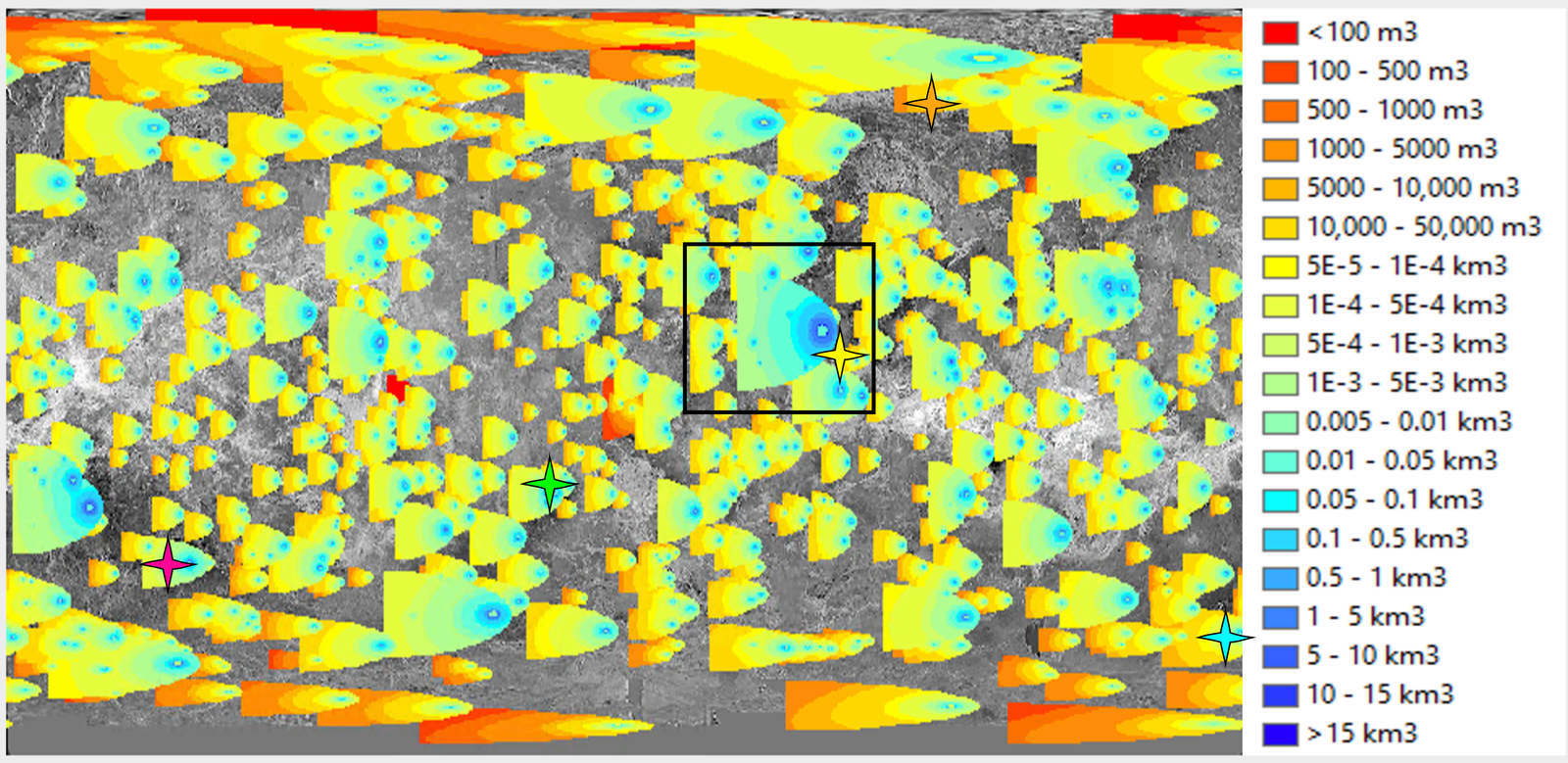


Figure 3: Map of the cumulative volume of impact-derived sediment on the surface of Venus. Black rectangle notes the area displayed in Figure 4. Locations of dune fields identified by Rader et al., 2019 shown with stars: Fortuna-Meshkenet in orange, Mead in yellow, Aglaonice in green, Stowe in magenta, and Guan Daosheng in blue.

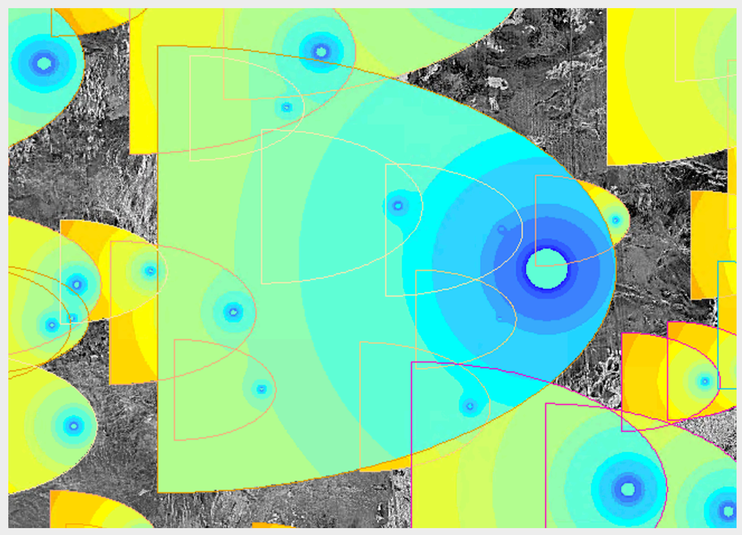
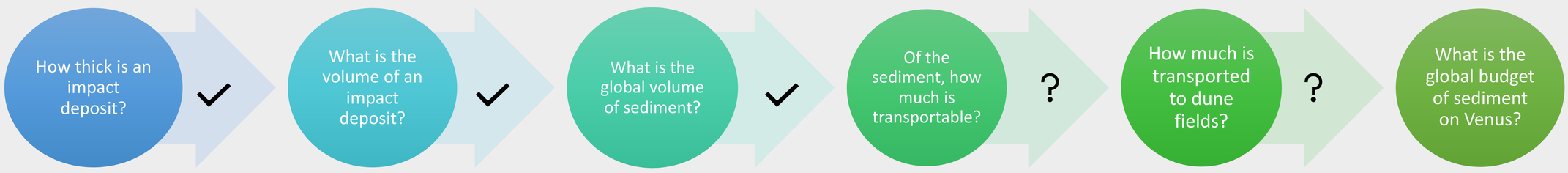


Figure 4: Cumulative sediment volume map of Mead Crater and surrounding field, including parabola outlines. Volume contours are the same as in Figure 3.

❖ Conclusions

- Our preliminary calculation of the total volume of sediment on Venus is significantly larger than previous estimates.
- The sediment accumulation rate on Venus is 5.8 x 10^5 m^3/year (1.26 nm/year in thickness), which is an order of magnitude larger than to the current estimate of 0.01 to 0.1 nm/year of sediment production on Mars (Golombek & Bridges, 2000).
- Known Venusian dune fields are associated with areas that have historically contained high volumes of sediment, according to our volume maps.

Project Trajectory



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Acknowledgements

Special thanks to my advisor, Dr. Martha Gilmore, for her guidance and willingness to work remotely this summer, even when it meant teaching me GIS through a Zoom call. Additional thank you to the Wesleyan Research in the Sciences program and to Dr. Jeremy Brossier for his valuable collaboration and use of the data that are the basis of this project. Lastly, I thank Hunter Vannier and Haley & Gilligan Brumberger for their company and for making the most of an unusual summer.