DISTRIBUTION AND VOLUME OF IMPACT-GENERATED SEDIMENT ON VENUS. T. M. Ganey[1], M. S. Gilmore[1], and J. Brossier[1], [1]Department of Earth and Environmental Sciences, Wesleyan University, 265 Church St., Middletown CT 06459 (tganey@wesleyan.edu)

Introduction: The high temperature of the Venus surface prohibits fluvial processes in the current era. The generation of sediment today therefore is limited to weathering via chemical reactions, mass wasting, volcanic output, deflation and physical communition via impact [1]. Of these, impact-derived sediment is predicted to be dominant. Sediment sinks for Venus include aeolian bedforms and lithification. Dunes, yardangs, and microdunes are rare in the Magellan data at 100 m/pixel [2,3], although Fresnel reflectivity data suggests widespread distribution of aeolian features [4].

Previous estimates of the volumes of impact-generated sediment suggest that it far exceeds the sediment recorded in aeolian landforms. Here we reevaluate these estimates by calculating the volumes of impact sediments and observed aeolian landforms using a variety of techniques. We plot the distribution of impact-derived sediment on Venus which allows us to predict the regions on Venus that are most likely to be sediment sources. Our estimates of impact-derived sediment are greater than has been reported in the literature for the post-Magellan era and confirm a large discrepancy between the volume of sediment sources and aeolian landforms. We suggest locations on Venus that have witnessed concentrations of impact-derived sediment and warrant further scrutiny as possible locations for aeolian landforms in Magellan data and higher resolution radar images provided by future missions [5].

Methodology: The surface of Venus is dominated by volcanic plains that are presumed basaltic and have weathered under a dominantly CO_2 and SO_2-rich atmosphere. The ~900 craters on Venus correspond to an average surface crater retention age of 0.5-1 Ga [6]. Forty-nine of these craters are surrounded by a parabola-shaped ejecta deposit opening westward that is likely derived from impact materials of the largest craters (>11 km diameter); impact materials reach and are carried and distributed by the westward winds at 50-70 km altitudes [7]. A variety of preservation states of these deposits shows that they are removed with time by surface winds with velocities on the order of 1 m/s [8].

We produce model parabolic ejecta deposits ("parabolas") as shapefiles for each crater >11 km diameter (n=581) using ArcGIS 10.6 (ESRI) (Fig. 1). For the 49 visible (radar-dark) parabolas, shapefiles are mapped as semi-ellipses with the dimensions reported in [7]. For other craters, parabolas are modeled after the method described in [9] which calculates a linear relation between the parabola area (A, km^2) and the crater diameter (D, km) derived from the 49 parabola craters. We calculate the thickness of parabola deposits after [10] as a function of the radial distance from the crater center. Deposit volumes are calculated by multiplying by the pixel size, which varies as a function of latitude (~0.2 km at poles to 4.6 km at equator). We then sum all pixels to create a cumulative thickness/volume map of sediment directly deposited on every location on the planet.

Thickness and Volume of Impact-derived Sediment on Venus: Thickness values range from a few microns to a maximum is 875 meters found at Mead crater. The cumulative global volume map contains values between 2×10^{-9} m^3 and 17.5 km^3 (Fig. 1) and yields a total volume of impact-derived sediment for craters >11 km of 2.9×10^5 km^3. We can make a rough approximation of the transportable fraction by dividing the transportable volume from [11] by this cumulative volume which yields ~29% of all sediment or a volume of 8.4×10^4 km^3.

By dividing this volume by the surface area of Venus we can estimate the thickness of a global layer of sediment. If the distribution of sediment is uniform across the surface, this layer would be 63 cm thick.

This preliminary estimate yields a sediment accumulation rate of 5.8×10^5 m^3/year, or 1.2 nm/year assuming a 500 Ma surface age. This is 3 orders of magnitude larger than a global estimate of 0.01 nm/year of sediment production via erosion on Mars during the Amazonian epoch [12].

Volume of Known Aeolian Features: Two prominent dune fields are identified on Venus [2]: Aglaonice field and Fortuna-Meskhent field (Fig 1). Yardangs of comparable planimetric form and spacing are identified southeast of Mead crater [2]. Occurrences of possible microdunes are detected in the southern hemisphere near the craters Stowe, Guan-Daosheng, and Eudocia [3].

Our first aeolian volume estimation follows the methodology of [13] wherein field area is multiplied by an average dune height of 200 m. For Aglaonice, the dune volume is 258 km^3, while the volume is 3424 km^3 for the Fortuna-Meskhent field. Using a similar assumption, the yardang volume for the Mead field would be 8000 km^3. We do not calculate volumes for microdune fields, as the 200 m average height cannot be assumed to apply. Under these assumptions, the total volume of known dune and yardang fields is ~11680 km^3.

Our second volume estimate uses wavelength-to-height ratios from terrestrial and martian dune studies to approximate venusian dune height. Wavelength-to-height ratios on Earth range from 12:1 to 24:1 [14] and 20:1 on Mars [15]. The spacing of Aglaonice and Fortuna-Meskhent dunes and Mead yardangs are given by [2]. Each value was converted to an average height via the ratios above and multiplied by the surface area of the parent field. Volumes span between 2600–7600 km^3 (12:1), 1500–4500 km^3 (20:1), and 1300–3800 km^3 (24:1).

Since yardangs are erosional features, the volume of sediment for this field is better calculated as the volume removed, not the volume deposited. Length-width-height ratios for yardangs are given as 10:2:1 and 9.9:2.7:1 in [16] and [17], respectively. The Mead yardangs have lengths of 25 km and widths of 0.5 km; they do not obey the ~10:2 length-to-width ratio but are within the length-to-width range of 3:1 to 50:1 for mega-yardangs given by [18]. We use the length-to-height and width-to-height ratios separately to estimate yardang heights of 185-2525 m. An upper and lower bound for the field volume using these two heights gives removed volumes 7400 km^3 and 101,000 km^3. Using this approach, we calculate the highest total volume of aeolian sediment to be 7900–104,700 km^3, which is roughly half of the total volume of available impact-derived sediment (2.9×10^5 km^3) we have calculated.

Location of Additional Possible Aeolian Features: The volume map can be used to identify concentrations of impact sediment associated with so-called "crater farms" (Fig. 1). Two are of particular note because they are also associated with radar-dark (recent) parabolas: Greenaway and the Stanton-Isabella regions. These should be primary targets for future radar sensors.

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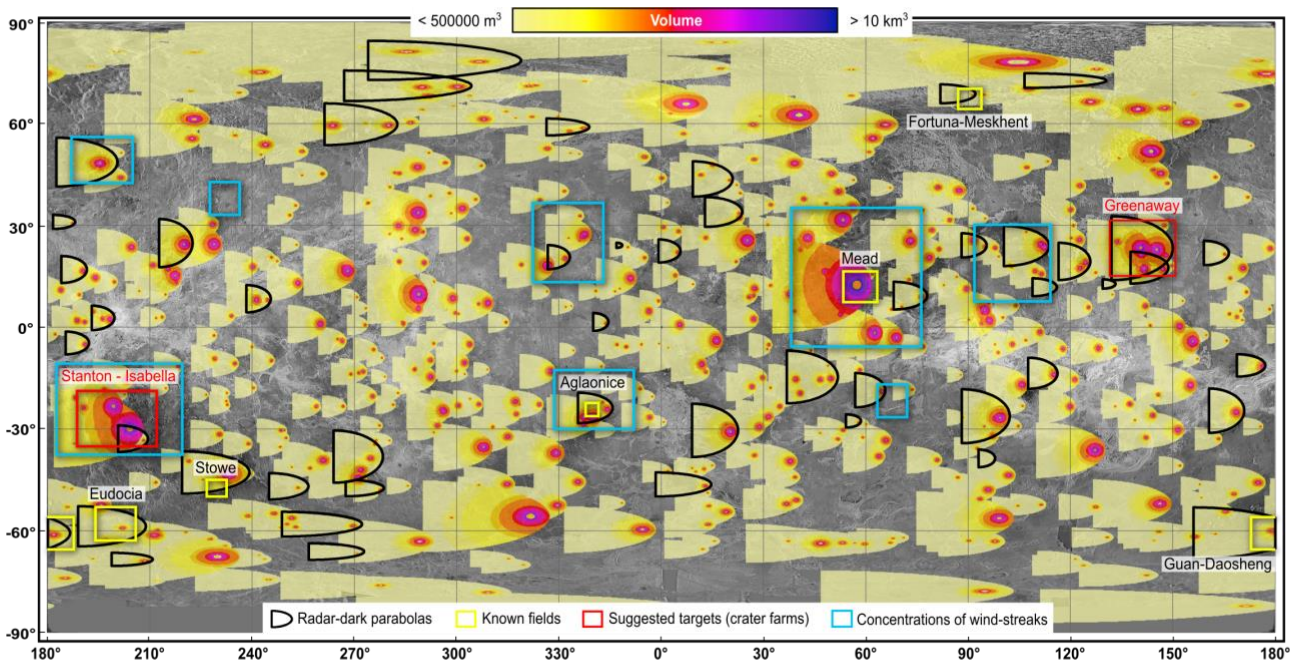

Figure 1 – Cumulative volume of impact crater-derived sediments on Venus. Wind streak locations derived from [2].