WHERE ARE THE MISSING TESSERA CRATERS ON VENUS? R. P. Perkins and M. S. Gilmore, Dept. of Earth and Environmental Sciences, Wesleyan University, 265 Church St, Middletown, CT 06459 (rpperkins@wesleyan.edu)

Introduction: The tessera terrain of Venus is widely held to be older than the smooth basaltic plains which comprise most of the surface due to observed embayment relationships [1].

Tesserae contain a higher proportion of craters with diameters > 16 km compared with the smooth basaltic plains, lacking craters with diameters < 8 km, with the general consensus being that there is an inability to accurately identify craters at such small diameters [2]. This concern holds also for larger craters that may be unrecognized in or deformed by tessera structures.

Crater-like features have been identified and evaluated as possible missing tessera craters [3]. A qualitative criteria was developed that considered the presence of a crater rim, visible crater walls, a central peak for diameters greater than 10 km, flooding of the floor due to volcanism, presence of ejecta, and presence of similar “neighbor” features. A small number of features were found that could be reclassified as craters [3].

Recently processed Magellan stereo data has made it possible to further investigate the distribution of crater-like features on tessera terrains [4]. To this end, we focus on developing a robust pipeline of crater morphometry and ejecta radar backscatter measurements taken of the known population of roughly 80 tessera craters [5], creating power-law functions of crater diameter versus depth and ejecta backscatter value that will aid in the detection of yet-unidentified tessera craters.

Background: Prior work has examined crater morphometry through power-law functions describing depth and continuous ejecta radii as a product of crater diameter [6]. The crater depth function will be used to compare calculated depths of all known Venusian craters to our measured values. As we seek to use the latter function to collect average radar backscatter coefficients from all tessera craters, we hypothesize that because smaller craters are relatively younger, we expect radar backscatter coefficients of their corresponding continuous ejecta radii to be higher, due to younger craters having radar-bright, “fresh” ejecta deposits.

Methods: To aid in the detection of possible tessera craters from yet-unidentified crater-like features in recently processed stereo data [4], two separate parameters are considered: the depths of craters in km and the average radar backscatter value of the continuous ejecta flow radius in decibels (dB) of craters in left-looking Magellan synthetic aperture radar (SAR) imagery.

Crater depth. As detailed in previous work [6], there exists a power-law function that describes crater depth as a function of diameter for Venus’ crater population. Digital elevation models (DEM) of prominent tessera craters were utilized from the work of [7]. A program developed in Python can read a crater DEM and, starting from the center coordinate pair of the crater, take a measurement of 100 elevation values out to 1 crater radius, iterating the process 360/θ times, averaging the points to create a mean crater depth for all radial profiles.

\[
\begin{align*}
x_2 &= x_1 + r \sin \theta \\
y_2 &= y_1 - r(1 - \cos \theta)
\end{align*}
\]

Equation 1: Given an initial coordinate pair \((x_1, y_1)\) and an angle \(\theta\), we can find a new coordinate pair \((x_2, y_2)\), used in this study as the endpoint of a radial profile starting out from the crater’s center coordinate pair as defined by radius \(r\).

An angle \(\theta\) can be defined by the user, effectively allowing any number of radial profiles to be generated (Eq. 1). For the preliminary results of this study, \(\theta\) is set to 1°, producing a total of 360 unique radial profiles and crater depths. The total number of crater depths are then averaged.

Figure 1: Gilmore crater (left) with a radial profile outlined in red. Units are in pixel coordinates. To the right is the topographic profile. Y-axis is in meters. X-axis is in pixel coordinates.

Continuous ejecta radii. Depending on whether the crater diameter is > or < 20 km, a power-law function describes the relationship between diameter and the continuous ejecta flow radius [6]. We can delineate a region from which to sample the radar backscatter of the ejecta in units of decibels (Fig. 2), producing our own power-law function between crater diameter and the average backscatter value. We take images from the USGS Map-A-Planet 2 database and import them into ArcMap, converting image xy coordinate points from meters to decimal degrees using the Venus 2000 geographic coordinate system (GCS). The following ArcMap geoprocessing tools create an image of crater latitude values: “Project Raster,” “Raster To Point,” “Add XY Coordinates,” and “Point To Raster.”
Making sure that the latitude raster and the original raster (in DN values) are projected in the same coordinate system, we import both images into ENVI, exporting them to IDL variables, utilizing commands that create an array of \( \sigma_0 \) values (Eq. 2), then converting \( \sigma_0 \) values to decibels (Eq. 3).

![Figure 2: Continuous ejecta flow region around Zhilova crater, mapped using ENVI. The outer circle indicates the area of maximum continuous ejecta flow as derived by [6], while the inner circle depicts the idealized area of the crater (53.3 km in diameter). The reticule is used to confirm crater center coordinates consistent with [8].](image)

\[
\sigma_0 = 10^{0.0118 \cos(\phi + 0.5^\circ) / \left[ \sin(\phi + 0.5^\circ) + 0.111 \cos(\phi + 0.5^\circ) \right]^5}
\]

Equation 2: Radar backscatter coefficient \( \sigma_0 \) in terms of the original stereo raster (DN values) and the incidence angle (\( \phi \)) raster calculated from a best fit approximation with latitude values. Taken from [9].

\[
dB \text{ value} = 10 \log_{10} \sigma_0
\]

Equation 3: Conversion of the radar backscatter coefficient \( \sigma_0 \) to decibel (dB) values.

**Preliminary results and discussion:** Crater depth generally increases with growing diameter up to 40 km (Fig. 3). After that point, crater depth declines, which may be explained by the structural collapse of large craters [10] and/or by impact melt infilling. Studies of the \(~100 \text{ km diameter crater Joliot-Curie, analyzed here, indicate post-impact deformation and volcanism affecting morphology [7].} \]

We compare modeled depths of all Venusian craters using a power-law function developed by [6] to measurements of 12 tessera craters. While any conclusion is qualified by these limitations, but we can report promising agreement with the prior study. The relative greater depth of 6 of our measured tessera craters indicates that plains craters may be significantly shallower than tessera craters. Earlier studies [7, 11] have looked into dark-floored Venusian craters as likely sites of up to hundreds of meters of volcanic inflow, indicating a possible shallowing mechanism for plains craters relative to tessera craters.

We hypothesize that smaller craters are “fresher” and thus predict a negative correlation between crater diameter and average radar backscatter coefficient, however, we see no such trends so far (Fig. 4).

![Figure 3: Crater depths measured using the method described with the observed crater diameter (orange triangles) plotted with the calculated depth of every Venusian crater (blue) using the power-law function derived by [6].](image)

![Figure 4: Radar backscatter coefficient as a function of crater diameter.](image)


**Acknowledgments:** Travel funds to present this research were provided by the NASA CT Space Grant.