A REASSESSMENT OF VENUS’ TESSERA CRATER POPULATION AND IMPLICATIONS FOR TESSERA DEFORMATION. R. P. Perkins¹, M. S. Gilmore¹, and R. R. Herrick², ¹Dept. of Earth and Environmental Sciences, Wesleyan University, 265 Church St, Middletown, CT 06459 (rperkins@wesleyan.edu), ²Geophysical Institute, University of Alaska Fairbanks, 903 Koyukuk Dr, Fairbanks, AK 99775

Introduction: The heavily deformed tesserae are the stratigraphically oldest materials on Venus [1]. The 80 craters recognized on the tesserae corresponds to a surface age that is 1.4x the average surface age of Venus [2]. However, craters may be more difficult to identify in the rough tessera fabric, as evidenced by the paucity of craters < 8 km in diameter compared to the volcanic plains. Here we investigate the possibility that crater-like features (CLFs), circular to semi-circular features ubiquitous in tessera terrain, may be unidentified tessera craters. This study considers 97 crater-like features proposed by [3] and [4]. The results of these analyses are then discussed in relation to the surface age of tessera terrain and the duration of deformation in the tesserae.

Hypothesis: If our analysis suggests that a greater number of crater-like features are possible unidentified tessera craters, then may alter the age of the tessera and the earliest geologic evolution of Venus. As felsic (and more necessarily water-rich) compositions have been suggested by low NIR emissivity tesserae data [5, 6], tesserae age constrains the extent and duration of a liquid water ocean at some point in Venus’ past, as well as constraints on the last instances of deformation recorded in the tesserae.

Identification of crater-like features: We examined 97 crater-like features identified from morphological surveys in Magellan FMAPS of all tessera terrain [3] and the tesserae covered by SAR stereo data (~ 20% of the planet) [4]. These were assessed using 5 criteria:
1) Is there a visible rim?
2) Is there a visible wall?
3) Is there a central peak?
4) Is the radar backscatter coefficient ratio < 1?
5) Are there no similar neighbor features?

Criterion 4 is a measure of the ratio of the radar backscatter coefficient of the empirically-derived hummocky ejecta radius for Venus craters [7] to the radar backscatter coefficient of the background terrain using ENVI [8]. Crater-like features with radar backscatter coefficient ratios < 1 are interpreted to have more radar-bright hummocky ejecta areas than background terrain, taken as a proxy for ejecta.

A “yes” for every category in the criteria translates to a point value of 1, except for category 5, of which a “yes” translates to a point value of 0.5. This allows the positive features (presence of rim, wall, central peak, ejecta) to be weighted more heavily than the absence of features. To be considered a crater, a CLF must score positively in at least one of criteria #1-3. This yields a range of values for CLFs from 1 to 4.5. We recalculate those total scores as integers from 1 to 8, with 8 being equal to 4.5, 7 being equal to 4, 6, being equal to 3.5, and so on.

Figure 1: All 14 possible craters proposed by this study with criterion scores (upper right). The white scale bar is equal to 50 km.

Results: Fourteen of the analyzed 97 crater-like features possess at least one positive criterion demarcating it as a possible crater (Fig. 1). We can add these 14 to the total to calculate an estimate of crater density, where N is the number of craters and a is the square area, in km² (Eq. 1).

\[
d = \frac{N}{a} \tag{1}
\]
Prior work reports a global crater density of 2.09 craters/10^6 km², where tessera craters have a density of 2.26 craters/10^6 km² [9]. The addition of all 14 proposed possible craters yields a crater density of 2.66 craters/10^6 km². This gives our upper-bound estimate a 58% higher crater density than the global average.

The inclusion of all 14 possible craters increase the crater age of tessera slightly. If the average crater age is 400 Ma [11], this gives a new tessera crater age of 632 Ma. If the average surface crater age is 750 Ma [10], this expands the tessera crater age to 1.1 Ga, placing the last primary phase of tessera deformation in the latest 20% of the geologic history of Venus.

**Tessera strain rates:** We now consider the effect of our updated crater-like feature population on several previous studies that have considered the age and deformation history of the tesserae [9, 11].

Previous work held that the number of visible undeformed craters is dependent on the strain rate, where the strain rate prior to tessera crater retention has to be high enough to deform all craters to a state where they are unidentifiable, taken as 50% strain [11]. We can utilize the equations of [11] to calculate strain for a population of craters on a certain area, where we increase the original baseline of 80 tessera craters to our updated 94 tessera craters over the tesserae surface area of 35.33x10^6 km² (Eq. 2, 3, 4).

\[
P = e^{\left(-\frac{\tau_d}{\tau_c}\right)}
\]

\[
\tau_d = \frac{\epsilon_d}{\epsilon_{xx}}
\]

\[
\tau_c = T/f_s N
\]

The probability that a crater is completely deformed, or “erased” as a function of strain rate is given by Eq. 2, where the probability \(P\) is an exponential function of the crater destruction time \(\tau_d\) (with \(\epsilon_d\) being the amount of strain needed to erase a crater, set by [11] as 0.5, and \(\epsilon_{xx}\) being the strain rate) divided by the average time interval between impacts \(\tau_c\). The authors of [11] assumed two endmembers of surface deformation where the surface area \(f_s\) is set to 0.1, or 10% of Venus’ surface that is actively deforming as well as 0.001, or 0.1% of Venus’ surface area actively deforming. \(T\) is the Venus surface age. \(N\) changes depending on the number of craters considered: all 940 craters in the global database (including the 80 baseline tessera craters) and the 14 possible craters added, giving a total of 954 craters.

For an \(f_s\) of 0.1, adding 14 craters increases the tessera crater age resulting in a revised lower bound on strain rate of \(~10^{-16}\) s⁻¹, which is similar to, but lower than the strain rates reported for 940 craters. (Fig. 2). This still represents an elevated strain rate relative to the current strain rate of \(10^{-18}\) - \(10^{-17}\) s⁻¹ [12]. If \(f_s = 0.01\), present-day strain rates are allowed for the tesserae.

![Figure 2: Plot of strain rates (in strain rate/s⁻¹) for the total crater population of Venus. Solid lines indicate \(f_s = 0.1\) and dashed lines indicate \(f_s = 0.01\).](image)

We have measured the semi-major and semi-minor axes of the 14 possible craters, finding 13 of 14 to show some signs of compressional strain ranging from 2% to 56%. We take 13/94 to represent the duration of compressional deformation, coming to about ~14% of the age of the tesserae. Based on stratigraphic position of tessera structures [1], this corresponds to the earliest phase of tessera deformation. The presence of deformed craters would indicate lower strain rates than those prescribed above.

**Conclusions:** We use morphological criteria to examine 97 crater-like features previously reported by [3, 4], finding 14 possible new tessera craters. The addition of these features to the present tessera crater population increases the age of the tesserae by 18% more than the present tesserae age, which still constrains tessera formation to the last ~1 Ga of Venus history. Most of the CLFs show some signs of compressional strain, corresponding to a duration of ~14% of the updated tesserae age and may record the earliest tesserae deformation.