CLASSIFYING VENUSIAN TESSERA BASED ON ROUGHNESS CHARACTERISTICS. J. L. Whitten[1] and B. A. Campbell[2], [1]Dept. Earth and Environmental Sciences, Tulane University, New Orleans, LA. (jwhitten1@tulane.edu), [2]Smithsonian Institution Center for Earth and Planetary Studies, MRC 315, Washington DC.

Introduction: Tesserae are a geologic unit unique to Venus, hypothesized to have formed during different climatic conditions [1]. This is partly owing to their relative age and partly to interpretations of available infrared (IR) emissivity data that infer a silicic rock type for tesserae [e.g., 2, 3], a potential indicator of the importance of water in their formation.

Tesserae materials are highly deformed rocks with complex tectonic textures. They are defined as having two or more intersecting sets of tectonic landforms (wrinkle ridges, graben, fractures, etc.) [4]. In radar data, tesserae appear bright owing to their high surface roughness at the length scale of the Magellan radar signal (12.6 cm wavelength). Tesserae surface textures, or patterns, as well as radar emissivity and IR emission data have been used to classify these materials [2, 3, 5], though there is little consistency between classification schemes. Variations in these datasets may hint at a combination of variable weathering processes and inherent differences in the original tessera rocks.

Here, we analyze NASA Magellan synthetic aperture radar (SAR) data to quantify the statistical distribution of backscatter coefficient for 22 tesserae across Venus. These results reveal information about the relatively influence of large-scale surface slopes and surface reflectivity that create backscatter patterns across the tesserae.

Data and Methodology: SAR data from the Magellan mission were used to calculate backscatter coefficient [6]. The Magellan altimetry and emissivity datasets were analyzed for completeness. Data used to determine backscatter coefficient were extracted from near the crests of ridge slopes facing away from the radar in 22 tesserae deposits: Virilis, Alpha, Sudenitsa, Tellus, Doyla, Nedoyla, Fortuna (most of it plus parts of Maxwell), Zirka, Cocomama, Pasonmana, Clotho, Cline, Athena, Anake, Nemesis, Lahevhev, Hyndla, Mamitu, Ustrecha, Zirka, Thetis (near Whiting crater), Vako Nana, Virilis, and Husbishag. Only the away-facing slopes were measured because slopes facing the spacecraft are layed-over and saturated, so they do not provide meaningful information on backscatter amplitude. Collecting data from near ridge crests also reduces the probability of sampling sediment and boulders mass wasted into the tessera valleys.

Backscatter Coefficient Trends: Backscatter coefficient values for tesserae vary from -28 dB to almost 13 dB. Almost all populations of backscatter coefficient are statistically different from one another, with the exception of the following pairs of tesserae: Anake – Athena, Husbishag – Alpha Regio, Pasomama – Alpha, Cline – Mamitu, Clotho – Sudenitsa, and Ustrecha – Zirka.

Taken as a group, the 22 tesserae measured are not well fit by the Muhlemann scattering law [7, 8] adopted for Magellan data (Fig. 1). The Muhleman scattering law was derived for the Venus disk and is therefore dominated by the low-lying smooth plains. Averaging data for each tesserae into 2º incidence angle bins further emphasizes that most tessera data plot above the Muhleman scattering law, indicating they are rougher than “average” Venus.

Several tesserae have areas that extend above 6053 km planetary radius, a conservative estimate of the lowest elevation of the “snow line” [9]. Above this planetary radius, backscatter coefficient and microwave reflectivity are very high. The cause of these high backscatter and reflectivity values is likely chemical weathering or other altitude-specific processes [9]. Thus, data points with elevations above 6053 km were not included the analysis of average tesserae backscatter behaviors owing to the dominance of dielectric constant, rather than roughness, in these areas. This decision results in the exclusion of portions of Fortuna, Husbishag, Nedoyla, Hyndla, Clotho, Doyla Sudenitsa, Tellus, Alpha and most of Thetis.

Influence of Impact Crater Ejecta: Previous studies have indicated the influence of impact crater

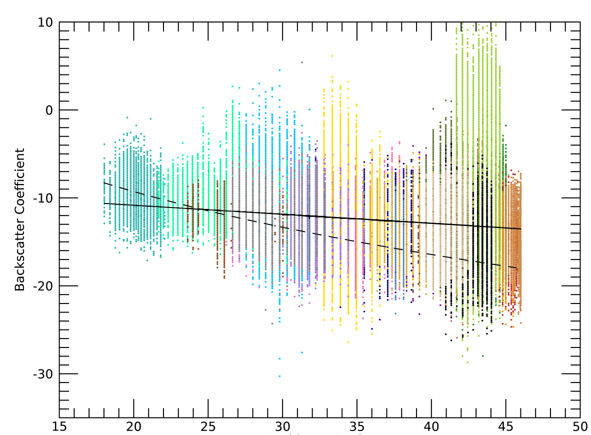

Figure 1. Backscatter coefficient values for 22 tessera sites verses Magellan incidence angle. Dashed black line shows the Muhleman scattering law for the entire Magellan dataset and the solid black line is the best fit for low elevation data.

ejecta on backscatter coefficient values. Blanketing the landscape with a thin layer of fine-grained material results in lower average backscatter, so we assessed whether observed variations could be attributed to impact crater ejecta. One notable example is at Husbishag Tesserae, where the distribution of backscatter coefficient values for tesserae within and exterior to the ejecta from Boulanger crater is different. There is a notable decrease in backscatter coefficient values, ~1.5 dB, within the impact crater parabola, which is clearly visible in the Magellan SAR images.

Classifying Tesserae: Measured backscatter coefficient distributions in the tesserae are significant and imply real differences between these deposits. Only a few processes other than surface roughness have been identified to explain backscatter variations, including high reflectivity materials at high elevations and impact crater ejecta. The remaining variations in backscatter coefficient are interpreted to be due to decimeter-scale roughness variations. Calculating the deviation of tesserae from a mean backscatter coefficient value allows a classification to two major types (Fig. 2). There is no obvious spatial clustering of these two classes of tesserae, with each class occurring across a wide range of latitudes and longitudes.

Many tesserae that have been classified as smoother than average (blue, Fig. 2) also correspond to deposits that have positive detections of superposed impact crater ejecta. For example, Alpha Regio, Virilis and Tellus tesserae, in addition to Husbishag, have all been identified as having superposed parabolic impact crater ejecta [10, 11]. Thus, the detected changes in roughness revealed by changes in backscatter coefficient are influenced by secondary processes unrelated to the original tesserae materials.

Even so, anomalous radiophysical behaviors were detected. Husbishag Tesserae is one such example. These tesserae have one of the largest ranges in backscatter coefficient, even after accounting for the influence of the superposed parabolic ejecta materials. This large range in backscatter indicates that the tesserae materials in Husbishag have a large range in decimeter-scale roughness. On the other hand, there are tesserae with relatively consistent backscatter values (e.g., Cocomama, Zirka, and Ustrecha).

Our classification of tesserae, based on decimeter-scale roughness, may be correlated with the larger-scale morphology of these deposits. Many researchers have shown that few-km scale morphology of tesserae varies within and across tesserae [e.g., 12, 13]. Backscatter coefficient distributions shows that morphologic variations also occur at small scales, and indicate the influence of impact crater ejecta on regional and global tesserae properties.

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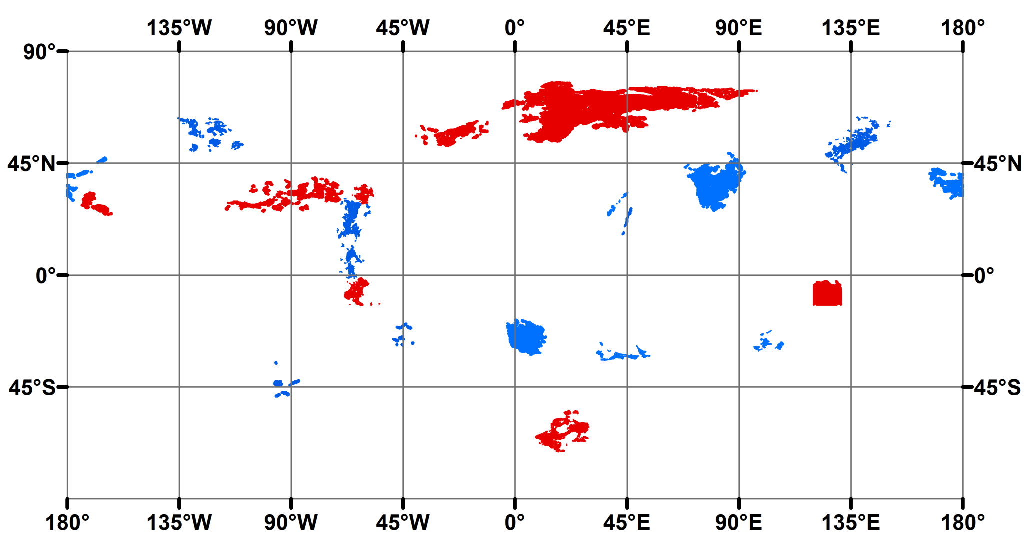

Figure 2. Classification of 22 tesserae based on decimeter scale roughness inferred from backscatter coefficient values. Red polygons denote tesserae that are rougher than average and blue polygons indicate tesserae that are smoother than average.