

VARIATIONS IN THE RADAR PROPERTIES OF TESSERAE ACROSS VENUS AS OBSERVED WITH MAGELLAN DATA. J. L. Whitten¹ and B. A. Campbell², ¹Tulane University, Dept. Earth and Enviro. Sciences, New Orleans, LA 70118 (jwhitten1@tulane.edu), ²Smithsonian Institution, National Air and Space Museum, Center for Earth and Planetary Studies, Washington DC, 200013.

Introduction: Tesserae are the oldest terrain type on Venus [1] and cover 7.3% ($33.2 \times 10^6 \text{ km}^2$) of the surface area of the planet [2]. Generally, tesserae are regions of high standing topography. Tesserae are identified by their complex morphology, which involves at least two sets of intersecting tectonic structures (e.g., graben, ridges, fractures) [3] (Fig. 1). Their high degree of deformation, which created areas of increased surface roughness, leads to a radar-bright appearance of tesserae in the Magellan SAR data and often enhanced Fresnel reflectivity.

Despite decades of study, the composition, formation, and age of tesserae is not well constrained. Tesserae have been variously hypothesized to be composed of highly deformed basalts [4] and more felsic materials, such as granite or anorthosite [5, 6]. If tesserae are composed of granite, that could imply a more substantial role of water in the early history of Venus [7]. The degree of uncertainty associated with compositional measurements of the surface are large enough to encompass both basalts and granites [8]. Similarly, the formation of tesserae remains uncertain. For example, certain hypotheses suggest tesserae form at locations of mantle downwelling [9], while other theories propose tesserae as the sites of mantle upwelling [10, 11]. The age of the tesserae is also still a topic of debate. While it is agreed that this terrain type is the oldest on Venus, researchers still debate whether tesserae are all one age [12, 13] or if tesserae are the oldest materials regionally [14, 11], and each deposit of tessera is a different age (directional vs. nondirectional geologic history).

The paucity of definitive measurements of the tesserae lead to these large gaps in understanding the evolution of Venus. Here, we analyze the Magellan synthetic aperture radar (SAR) and Earth-based radar datasets to more specifically constrain the radar properties of tesserae. The range in radar brightness across the tesserae has not been quantified, and could provide important information about the distribution of crater ejecta or locally-derived regolith, as well as inherent differences in original tessera materials. This is a first and fundamental step to addressing the much larger questions about tesserae, including their composition and formation mechanism(s).

Methodology: We quantify radar brightness variations across tesserae by calculating the backscatter coefficient [15] of backslopes (slopes that are facing away from the Magellan spacecraft) using Magellan SAR

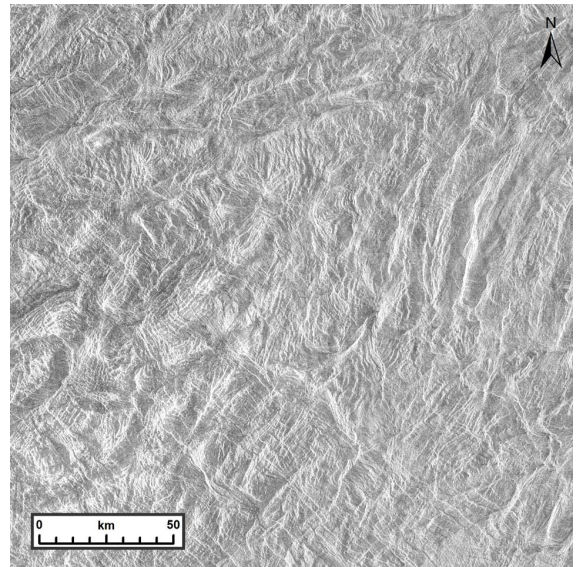


Figure 1. Example of highly deformed tessera morphology from Alpha Region. Base map: Magellan SAR left look, 75 m/pixel.

orbital datasets and Earth-based radar collected with the Arecibo telescope. Magellan SAR data (12.6-cm) have a linear HH polarization and are sensitive to slopes on the order of tens to hundreds of meters. The pattern of backscatter coefficient variations in each tessera deposit are compared with the presence of various geologic landforms, such as impact craters and volcanic structures. Fine-grained particles in distal impact crater ejecta or erupted during volcanic activity can modify surface roughness [e.g., 16, 17]. For example, these particles can smooth the surface by infilling small-scale topographic lows and cracks. Identifying where impact craters or volcanic eruptions have modified the radar surface properties of tessera will enable identification of more “pristine” regions to determine natural variations in tessera material properties.

Discussion: There are substantial backscatter coefficient variations both within and between tesserae (Fig. 2). Backscatter coefficient values across the surface of Venus vary from -28 dB to 13 dB. Some variations, such as those observed in Alpha Region, Virilis Tesserae, and Tellus Tessera, can be correlated with impact craters and their predicted ejecta deposits [18] (low backscatter variations, warmer colors in Fig. 2). These detections of crater ejecta have been validated with Earth-based same-sense polarization radar (circularly polarized signals that are sensitive to surface roughness variations on

the order of centimeters to decimeters) data where coverage overlaps (e.g., Alpha Regio) [16].

Other variations, such as those observed in Sudenitsa and Fortuna tesserae, can be attributed to high reflectivity materials atop Beta Regio and Maxwell Montes (high backscatter coefficient values, cooler colors in Fig. 2). Other backscatter coefficient variations within individual tessera cannot easily be attributed to geologic landforms. We hypothesize that these variations are due to inherent differences in the original composition or to the surface evolution of those local tessera materials.

The backscatter coefficient values were compared between tesserae as well. There is observable variation amongst the different tessera, but there is no obvious trend with latitude or longitude (Fig. 2). For example, the tesserae (from north to south) of Hyndla Regio, Nedoya and Doyla at $\sim 295^\circ\text{E}$ vary from north to south, with the highest backscatter coefficient values in the southernmost Doyla. Moving northward the lowest backscatter coefficient values are in Nedoya and more intermediate values are calculated for Hyndla Regio. Then, immediately adjacent to Hyndla, Beta Regio has extremely high radar backscatter coefficient values. Cocomama, the southernmost tessera mapped so far, is one of the most radar-bright mapped tesserae and Tellus is one of the darkest. Not enough mapping has been completed in the tesserae surrounding Mead crater (270 km, 12.5°N , 57.2°E) to determine whether ejecta from this impact event has been preserved in tesserae.

Summary: Magellan data show that the tesserae vary substantially in their radar properties, both within

an individual tessera and also between tesserae. Some, but not all, of these variations can be attributed to local geologic landforms and their associated processes, such as impact craters. These remaining backscatter coefficient variations suggest that the original materials that comprise the tesserae varied in some way, either by composition, grain size, formation process or due to the local geologic processes active in that region of Venus, to cause such different expressions of radar properties. To fully constrain tesserae composition additional datasets are needed from future missions.

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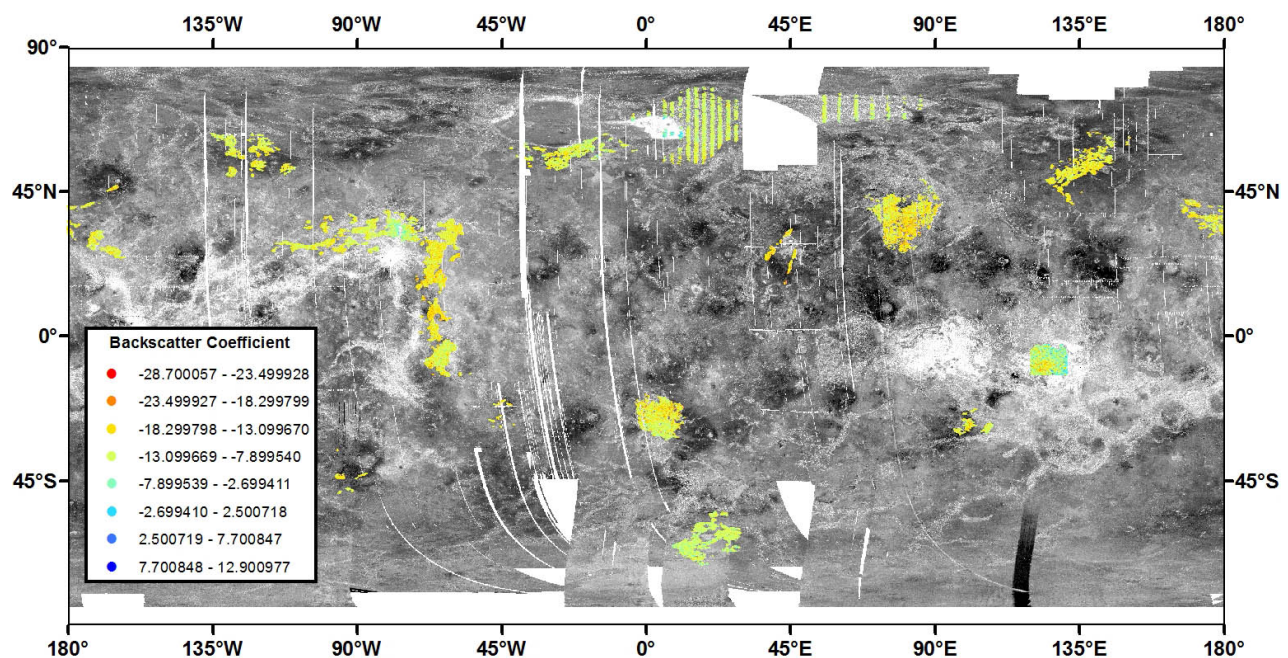


Figure 2. Distribution of tesserae backscatter coefficient values (colorful dots) across Venus. Note variations between and within different tesserae (e.g., Sudenitsa, Alpha, Cocomama, Tellus). Base map: Magellan SAR left and right look data.