VIRTIS EMISSIVITY OF ALPHA REGIO TESSERA, VENUS. M. S. Gilmore[1], N. Mueller[2] and J. Helbert[2], [1]Dept. Earth and Environmental Sciences, Wesleyan University, 265 Church St. Middletown, CT 06459 USA, mgilmore@wesleyan.edu, [2]Institute for Planetary Research, DLR, Berlin, Germany.

Introduction: The discovery that emission from the Venus surface can be detected through atmospheric windows provides an opportunity to assess surface composition. Observations of the venusian surface from Galileo NIMS [1] and Venus Express VIRTIS [2,3] show that the emissivity at ~1µm from tessera terrain is lower than the (presumably basaltic) plains. This observation is consistent with a felsic composition for tessera [e.g., 4]. However, surface emission is also dependent on grain size and surface roughness, which are difficult to deconvolve from the signal. Here we examine emissivity over a special area in Alpha Regio tessera which may provide some controls on elevation and roughness effects.

Previous work has recognized plains materials (lava flows, vents) within western Alpha, that have been deformed and uplifted to the level of the remainder of the plateau [5]. The Magellan-scale deformation of the western margin is morphologically similar to the remainder of Alpha, containing structures of similar size and rms slopes [6]. Thus, western Alpha provides an example of known plains materials (again, assumed basaltic) that are deformed to the same level as adjacent tessera terrain of unconstrained composition. We hypothesize that because of the similar roughness, elevation and location of western Alpha and the remainder of Alpha, any regolith-forming processes will contribute equally to the emissivity of both terrains and thus any residual emissivity differences between them are due to inherent material characteristics such as composition or grain size.

Methods: The VIRTIS instrument observed much of the Venus southern hemisphere through the atmospheric window at 1.02µm [e.g., 2]. The data are processed as described in [7], and are reported here as the ratio of local radiance to the global radiance (emissivity ratio). The VIRTIS image is integrated over several Earth years, yielding a product with a pixel size of 50 km. However, blurring by the atmosphere causes each pixel value to contain a contribution from neighboring pixels. To minimize this effect, we drew the boundaries for each mapped unit at least 75 km from the unit boundaries observed in the Magellan SAR image.

Results: Four units were mapped in the Alpha region: Alpha tessera (the main body of the plateau), western Alpha, plains (surrounding Alpha), and Eve corona. None of these units are observed to contain materials of high radar reflectivity as is seen elsewhere at higher elevations. VIRTIS emissivity ratio values for each unit are plotted in Fig. 1, where the plains have the highest mean emissivity ratio (1.04±0.02), followed by Eve (1.02±0.02), western Alpha (1.01±0.02), and the tessera, respectively (0.95±0.02). These differences are statistically significant as determined by the Mann-Whitney U-test.

The mean emissivity ratio for tessera is 9% lower than the smooth plains, with almost no overlap in the data values. Eve and western Alpha values are similar to the smooth plains at 7% and 6% higher than the tessera average. Errors in the Magellan altimetry introduce a potential bias in the emissivity retrieval over tessera that is estimated to be <3%. This is less than the ratio differences measured here.

Discussion: The macroscale roughness of western Alpha and Alpha Regio are similar, yet yield different emissivity values. Due to the shared structural elements, location and elevations, we expect both areas to be subject to a similar aeolian environment, where each would either trap sediments or experience deflation. We also expect that the terrains will have suffered similar mass wasting processes. Thus, the differences between the terrains are unlikely to be due to meter-km scale topography, or differences in the accumulation of aeolian sediments or production of regolith. We now examine other factors which may contribute to the emissivity differences.

Primary Composition. One micron emissivity is positively correlated to ferrous mineralogy [e.g., 4]. If it is assumed that materials with the highest radiance values have real emissivities ≤ 1 [7], the radiance values of Alpha tessera correspond to surface emissivity values of 0.4 - 0.5. This is consistent with felsic lithologies such as granites and anorthosites. This emissivity range may also be consistent with mafic materials that have a lower Fe^{2+} content than the basalts of the plains. Such compositions are associated with ultramafic and primary magmas or highly oxidized lavas. Many of the weathering products of felsic and Mg,Ca –rich mafic lavas (e.g., sulfates, carbonates) would also be expected to have lower emissivities than the weathering products of Fe-rich mafic lavas (e.g, hematite). Alternatively, the tesserae may comprise metamorphic or sedimentary rocks encompassing a range of compositions.

Weathering. Contemporary chemical weathering is predicted to correlate with elevation on Venus [e.g., 10], however, there is no systematic correlation between emissivity and altitude in the data presented here

(Fig. 2). Emissivity does correlate to stratigraphic age of the four units (from oldest to youngest: tessera, western Alpha, plains and Eve). Although the limited data on weathering at Venus conditions suggests that 10s of microns of weathering products can be produced on time scales much less than the average crater age of the planet [e.g., 11], we cannot exclude a weathering mechanism that operates on a long (~1 Ga) time scale.

Another alternative is that tessera are mafic but contain different weathering products because they were witness to a different weathering regime. This is supported by the following: the stratigraphic position of the tessera suggests that they were present prior to and during the eruption of the plains lavas. The wavelength of deformation of the tessera requires their formation in an era of enhanced heat flow [12]. In the catastrophic models of plains formation, the eruption of the plains is predicted to modify the climate by increasing atmospheric temperature and SO_2 content [13], which could lead to enhanced weathering.

Grain size. It is well known that reflectance decreases (emissivity increases) with increasing grain size for powdered samples [e.g., 8]. This effect has also been documented for whole rock samples where reflectance decreases with increasing microscale roughness [9]. Thus, the tessera could have a lower emissivity due to a smaller grain size or lower roughness at the micron scale. If we assume that the plains are basaltic, with textures similar to those seen at the Venera sites, this would require that the tessera, if igneous, to have undergone faster cooling that the plains lavas or have a different porosity, which is due to volatile content, degassing history and cooling rate.

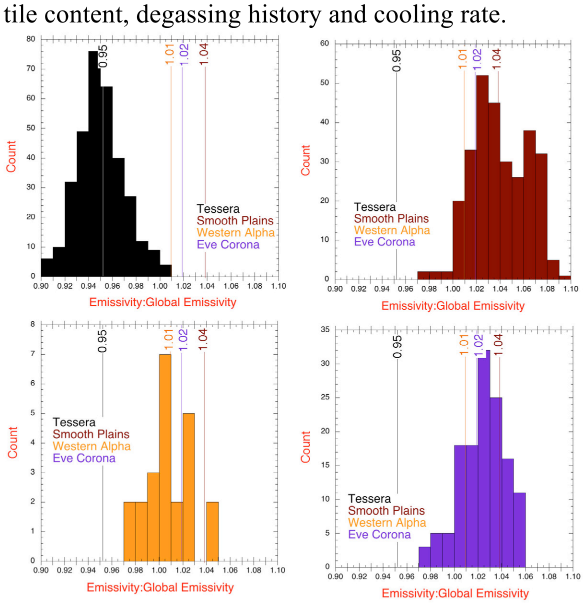

Fig. 1. Histograms of VIRTIS emissivity ratios for each mapped unit. Mean (=median) values are plotted.

Conclusions: We find that Alpha tessera has different emissivity compared to materials in western Alpha with similar macroscale roughness and similar environmental conditions. This implies that the low emissivity of Alpha with respect to plains materials is inherent to the rocks of Alpha, where: 1) tesserae have a different (more felsic, less ferrous) primary (or secondary) composition, or 2) tesserae are mafic and have experienced a different weathering regime than the plains, because they were witness to an ancient climate, or are older, or have some other characteristic to make them differently susceptible to weathering, or 3) tesserae have a different primary grain size: if igneous, they could be glassy, or have higher porosity, or 4) they could be non-igneous materials.

The data here show that the emissivity differences between tessera and plains observed globally reflect real differences in material properties. While the data are consistent with some mafic mineralogies, they would require that mafic materials have undergone a different geological history than the plains. The tessera remain a key target to understand the evolution of Venus.

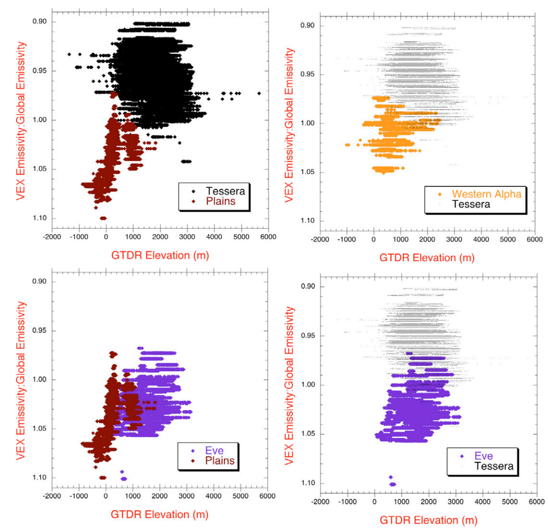

Fig. 2. VIRTIS emissivity ratio vs. Magellan elevation.

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