POTENTIAL PYROCLASTIC DEPOSIT IN THE NEMESIS TESSERA (V14) QUADRANGLE OF VENUS.

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Introduction: As part of an ongoing analysis of volcanic and tectonic features in the Nemesis Tessera (V14) quadrangle of Venus, we have identified an anomalous unit (Figure 1), centered at 44°N, 193°E, which exhibits unusual physical features, including very high radar emissivity values. Here we assess the possibility that this is a pyroclastic deposit.

Several regions of Venus have previously been identified as potential pyroclastic flows [1]. They are characterized by feathery margins, little internal texture, and distinctive radar properties [2]. In general pyroclastic volcanism on Venus is unlikely to occur, except under very unusual circumstances, because the dense atmospheric pressure is expected to inhibit the rapid exsolution of volatiles required to create such explosive eruptions [e.g., 1,3]; most models predict that a minimum of ~1.5-5.0 wt% CO_2 is necessary to create sufficient basaltic magma disruption. If sufficient volatile levels are achieved, however, the atmospheric pressure and temperature conditions should inhibit sustained plinian eruption columns and preferentially favor column collapse to yield pyroclastic flows [1]. If the unit in Nemesis Tessera is of pyroclastic origin, this is quite significant because it indicates that unusually high volatile concentrations were present during the eruption.

Methods: For this study we used Arcview GIS software to quantify the characteristics of georeferenced, sinusoidally projected Magellan FMAP radar images (75m/pixel) and lower resolution Magellan altimetric and radiometric Global Data Records in a Lambert Conformal Conic projection. Backscatter DN values were converted to backscatter coefficient values following [4]:

$$\sigma_0 = 10^{0.02\,(\text{pixel DN} - 101)} \times (0.0118 \cos(\theta + 0.5°)/[\sin(\theta + 0.5°) + 0.111 \cos(\theta + 0.5°)]^3) \quad (1)$$

where σ_0 is the backscatter coefficient and θ is the incidence angle. An incidence angle of 35.3° was calculated using a table of latitudes versus look angles [5] and an approximate average latitude of 44°N. The average backscatter coefficient was then calculated and converted to decibels following [4]:

$$\text{value in dB} = 10 \log_{10} \sigma_0 \quad (2)$$

Altimetric and radiometric data were converted from integer pixel values (DN) to the original parameter values using equations from the Magellan GxDR disks. These data were then integrated and compared to previously identified pyroclastic flow candidates.

Results: Table 1 shows the average backscatter, altimetry, and radiometry (emissivity E, reflectivity ρ) values of: (A) the anomalous unit in Nemesis Tessera compared to (B) the surrounding plains and (C-F) previously-proposed Venusian pyroclastic flows from [2].

TABLE 1

	Location	R (km)	σ_0(dB)	E	ρ
A	44°N, 193°E	6051.94	-16.8	0.914	0.09
B	45°N, 195°E	6051.66	-18.8	0.874	0.14
C	14.9°N, 13.2°E	6052.09	-7.2	0.806	0.15
D	15.3°N, 14.3°E	6052.51	-8.3	0.871	0.11
E	16.6°N, 37.1°E	6053.13	-8.6	0.836	0.13
F	13.5°N, 37.3°E	6052.82	-7.9	0.852	0.13

Discussion: A qualitative comparison between the Nemesis Tessera feature and other previously identified pyroclastic features on Venus reveals many similarities. Their rounded geometries, feathery margins, lack of internal texture, and superficial appearance in the radar imagery are all similar. Embayment relationships indicate that the unit is superimposed upon all other units with which it is in contact, though the nature of the contacts and interactions with what are interpreted as older tectonic features suggest that spatially the unit varies in thickness. Compared with nearby plains deposits, the Nemesis Tessera unit is notably brighter. All of these characteristics are consistent with—though not uniquely so—what is expected for a stratigraphically young pyroclastic unit on Venus.

Geologically, the possible pyroclastic unit is also associated with several nearby regions of volcanic activity. It is situated on the southeast flank of a 500 km diameter topographic dome upon the apex of which a radial dike swarm is centered [6]. Several fields of small shield volcanoes are located nearby, as is a sequence of long lava flows, partially buried by the potential pyroclastic unit, which is among the stratigraphically youngest features in the region. If pyroclastic volcanism is responsible for emplacing the unit, no source vent is evident; it is possible that the materials are locally derived, implying that the vent has been buried, or perhaps they originated upon and flowed down the flanks of the large topographic dome. In any event, if the unit is indeed pyroclastic it implies that some of the youngest volcanism in the region was more volatile-rich than the earlier eruptions.

Analysis of the physical properties of the proposed pyroclastic unit using available remote sensing information reveals that, when compared with surrounding units and the Nemesis Tessera quadrangle overall, the unit has an intermediate to low backscatter coefficient, high emissivity and RMS slope, and low reflectivity (Figure 1). The deposit is clearly very rough at the meter scale, with RMS slope values exceeding those of the surrounding plains units considerably, as well as those exhibited within Nemesis Tessera (bright band cutting NE-SW across NW part of region shown in Figure 1). The reflectivity and emissivity values in general suggest competent rock surfaces rather than enhanced dielectric properties or porous material [e.g., 2]; when compared with the surrounding plains, the unusually high emissivity may derive in part from the unusually rough surface of the proposed pyroclastic deposit [7].

The basic geological observations (feathery edges, mantling appearance, association with young volcanic features, etc.) do not seem consistent with lava flow emplacement, nor are the remote sensing properties described above (very rough surface characterized by competent rock) consistent with an unconsolidated aeolian deposit. Taken together, however, the basic characteristics of the unit are consistent with the interpretation that it is pyroclastic in origin. These characteristics also closely resemble those associated with materials interpreted as pyroclastic units elsewhere on Venus—with one exception. Other units interpreted as possible pyroclastic deposits have high backscatter coefficients—though not anomalously so compared to the average for the latitudes where they have been identified—whereas sampling of single pixel values for the unit in Nemesis Tessera reveals values significantly lower than the ~ -13 dB value characteristic of Venus at an incident angle of ~35 degrees [7]. This requires further examination using regional averaging methods rather than point sampling, but our initial interpretation is that the low backscatter derives from the presence of parabola-related deposits from the crater Yablochkina, which may serve to reduce the roughness at the radar wavelength. These deposits appear to depress the backscatter value through the region where they are found, and it is worth noting that the proposed pyroclastic deposit's backscatter value is significantly higher than that of the surrounding plains, suggesting that it is relatively rougher at 12.6 cm wavelength in spite of the parabola-related mantling deposit.

Overall, based on our analysis to date of the appearance, geological associations and remote sensing properties, the characteristics of the anomalous feature are most consistent with a pyroclastic origin. The existence of a pyroclastic flow is highly significant because it required unusual amounts of volatiles to form, and further studies are underway to assess the implications this may have for the evolution of volcanism in the local region.

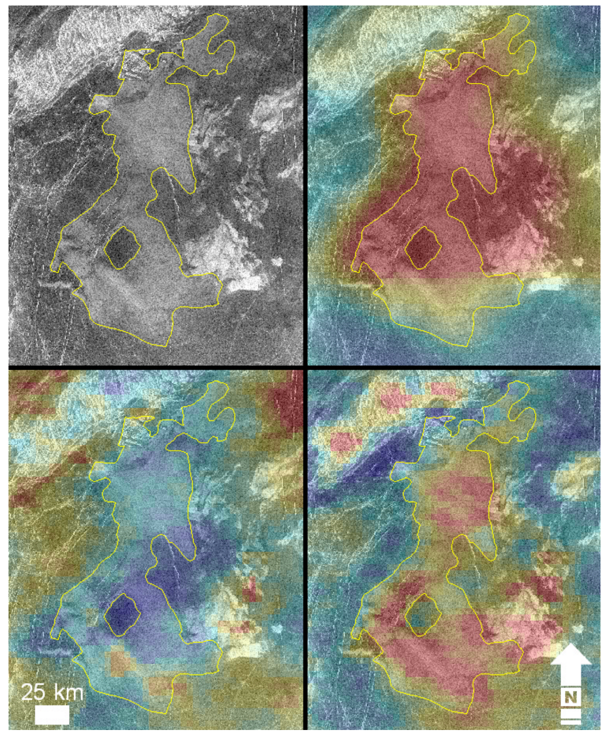

Fig. 1: Physical properties of the anomalous unit. Clockwise from top left: (a) SAR image (b) emissivity: values range from .800-.951. (c) RMS slope: values range from .5°-11°. (d) reflectivity: values range from .05-.34. For colored figures, blue denotes relative low values while red denotes relative high values.

References: [1] Grosfils, E. B. et al. (2000) in *Environmental Effects on Volcanic Eruptions*, 113-142. [2] Campbell, B.A. et al. (1998) *LPSC*, #1810. [3] Garvin, J.B. et al. (1982) *Icarus*, *52*, 365-372. [4] Lancaster, M.G. et al. (1995) *Icarus, 118,* 69-86. [5] Campbell, B. A. (1995) *USGS* Open-File Report 95-519. [6] Doggett, T. C. and Grosfils, E. B. (2002) *LPSC*, #1004. [7] Ford, J. P. et al. (1993) JPL publication 93-24.