MAXWELL MONTES, VENUS: ITS RADAR "SNOWLINE" IS NOT AT A CONSTANT ELEVATION – IMPLICATIONS FOR ITS ORIGIN. A. Strezoski[1,2] (astrezoski@alaska.edu) and A. H. Treiman[1] (treiman@lpi.usra.edu), [1]Lunar and Planetary Institute (USRA), 3600 Bay Area Blvd., Houston, TX 77058. [2]University of Alaska Anchorage, Department of Geological Sciences, 3211 Providence Dr., Anchorage, AK 99508.

Introduction: The heights of Venus' tallest mountain range, Maxwell Montes, have greatly different radar properties than do lower elevations (and the rest of the planet). Maxwell's heights have greater radar reflectivity and lower radar emissivity, and the boundary between high and low is a sharp 'snow line' at ~ 4.5 km elevation [1-3]. The causes of the 'snow line,' the unusual radar properties at elevation, are not known [4-9]; the main two hypothesis involve rock-atmosphere interaction to form metal or semi-metal compounds. On one hand, rock and atmosphere might react chemically to create semiconductor compounds (pyrite, magnetite, etc.) [5,7]. On the other hand, the heights' surface could be coated by metallic 'frost' (compounds with Te, Pb, Bi, etc.) precipitated from the atmosphere [4,6,8,10]. In this work, we test these hypotheses by determining the spatial distribution of the 'snow line' across Maxwell Montes.

Methodology: All data used here are from the Magellan orbiter mission around Venus. Our primary source was SAR (synthetic aperture radar) left-look maps (FMIDR), which have spatial resolutions as good as 75 m per pixel. Elevations are from Magellan altimetry. We also used Magellan maps of Fresnel reflectivity and emissivity. These data are all available in public record, and were explored using JMARS GIS system (Univ. Arizona) and accessed via the USGS Astrogeology USGS 'Map-a-planet' website [11]. These datasets were imported into and processed in ArcGIS©, with careful attention to artifacts and missing data.

Results: '*Snow line' elevation:* To determine the relationship between snowline location and elevation, we manually traced the 'snow line' location on the Magellan SAR mosaic (Fig. 1a). Then, we retrieved Magellan altimetry along that perimeter (Fig, 1b). That graph shows that the elevation of the 'snow line' varies regularly along Maxwell's south, west, and north sides, and irregularly along its west side. Surprisingly, the elevation of the 'snow line' is not constant – it lies at ~4.2 km at Maxwell's SE corner, and at ~8 km along Maxwell's northern slopes. We tested this the variation in 'snow line' elevation by tracing a contour of Fresnel reflectivity (~0.35), and find that it conforms to the elevational trend in SAR reflectivity. The irregular variation along Maxwell's western front can be ascribed to its steep topography, and thus likely spatial misregistration of SAR and altimetry values.

Discordance at Highest Elevations: Radar emissivity at Maxwell's highest elevations is lower than just above the 'snow line' [2-5], and this effect is mirrored to some extent in SAR and Fresnel reflectance. To explore this, we examined reflectivity, emissivity, and elevation against distance along several traverses that cross Maxwell's highest points (Figure 2). The nominal expectation is that reflectivity and emissivity should vary inversely (Kirchoff's law).

For the most part, emissivity and reflectivity exhibit the expected inverse behavior. Figure 2 shows (as noted elsewhere [2-5]) that Maxwell's surfaces above ~7 km have lower reflectivity (and higher emissivity) than at lower elevations above the 'snow line.' On Profile 2 (Fig. 2), starting at ~600 km in distance, reflectivity increases with elevation then rapidly drops past ~7 km of elevation. Past the highest elevations, when elevation drops to ~7km (~1300 km distance), reflectivity follows the elevation trend once again. Profile 1, however shows significant divergence from the expected inverse

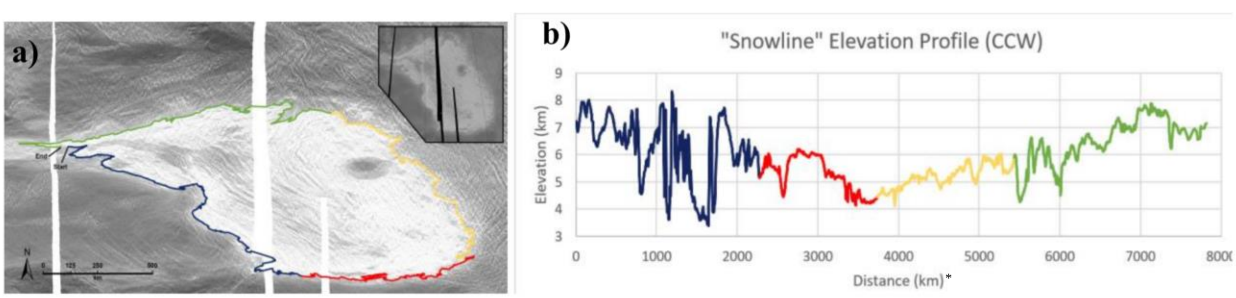

Figure 1. (a) Left-look SAR image of general study area on Maxwell Montes. Blue, red, yellow, and green lines represent individual sections of the 'snow line.' Each line segment has a corresponding section in profile graph (b), respectively. North is up. (b) Profile graph of the snowline on Maxwell Montes. Elevation is plotted against distance. *Distances in ArcMap are about twice the actual values.

behavior. Starting at ~700 km along the profile, reflectivity does not increase at a similar rate of elevation (~9 km elevation), and remains relatively low until ~1100 km, just past the highest elevations.

Discussion: '*Snow line' Elevation:* Neither of the main hypothesis for the origin of the 'snow line' imply that its elevation should vary with latitude (or longitude); both hypotheses as now presented assume that the 'snow line' represents an isotherm [4-7], and that chemical reaction or atmospheric precipitation are responses to crossing that temperature. If the 'snow line' represents an isotherm, our results imply that temperatures at a set elevation on northern Maxwell are ~30 K higher than to the SE (applying Venus' mean lapse rate of ~7.7 K/km [12]); this seems unlikely. If the 'snow line' need not be isothermal, and it represents precipitation from the atmosphere, one can interpret its variation in elevation as representing a 'snow shadow' with winds blowing from the SE or S [13]. If the 'snow line' represents chemical reaction between atmosphere and rock, the 'snow shadow' concept could still apply. Or, variations in radar properties could represent different rock types, with the reactive rock exposed at lower elevations to the SE.

Discordance of Elevation & Reflectance: The drop in reflectivity at the highest elevations in Figure 2 suggests an absence of metal or semimetal in or on the rocks. Provisionally, we interpret this discrepancy to indicate that Maxwell is composed of several different rock types.

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References: [1] Treiman A. et al. (2016) *Icarus*, 280, 172-182. [2] Klose K. et al. (1992) *JGR*, 97(E10), 16353-16369. [3] Brossier J. & Gilmore M.S. (2021) *Icarus* 355, 114161. [4] Fegley B.Jr. et al. (1997) 591-636 in Bougher S.W. et al. Eds., *Venus II: Geology, Geophysics, Atmosphere, and Solar Wind Environment*. University of Arizona Press, Tucson, AZ. [5] Wood J.A. (1997) 637-665. in Bougher S.W. et al. Eds., *Venus II: Geology, Geophysics, Atmosphere, and Solar Wind Environment*. University of Arizona Press, Tucson, AZ. [6] Port S.T. et al. (2020) *Icarus* 336, 113432. [7] Semprich J. et al. (2020) *Icarus* 346, 113779. [8] Pettengill G.H. et al. (1988) *JGR* 93, 14881-14892. [9] Gilmore M.S. et al. (2017) *Space Sci. Rev.* 212, 1511–1540. [10] Schaefer L. & Fegley B.Jr. (2004) *Icarus* 168, 215-219. [11] https://astrogeology.usgs.gov/search?pmi-target=venus [12] Seiff A. et al. (1980) *JGR* 85, 7903-7933. [13] Lebonnois S. et al. (2021) *Icarus* 314 (2018) 149–158.

Figure 2. (a) Map of profile lines. North is up. (a, b) Profile graphs of emissivity, reflectivity, and elevation plotted against distance from (a) 6º 17' 53.7" W, 66º 45' 6.5" N to 11º 30' 33.4" E, 65º 35' 21.4" N and (b) 5º 33' 16.7" W, 64º 21'24.3" N to 13º 58' 15.5" E, 64º 21' 12.8" N. Emissivity and reflectivity values are scaled such that EMISSIVITY=(actual value*10 000)+1 and REFLECTIVITY=((actual value*200)+1)*50. Equations are from [11]. *Distances in ArcMap are about twice the actual distance.