ANOMALOUS RADAR PROPERTIES OF MAXWELL MONTES: RESULTS FROM STEREO ALTIMETRY. F.B. Wroblewski[1,2], A.H. Treiman[2], S.S. Bhiravarasu[2], [1]Department of Environmental Geosciences, Northland College, 1411 Ellis Avenue, Ashland WI 54806; [2]Lunar and Planetary Institute, USRA, 3600 Bay Area Boulevard, Houston TX 77058.

Introduction: Positioned on the eastern edge of Lakshmi Planum, Maxwell Montes is the highest and steepest feature on Venus, and has been of significant interest for both tectonic origin and chemical properties. The Maxwell region is characterized by a "snowline" of radar properties – an elevation at which radar,backscatter, emissivity, etc. changes abruptly; see Fig. 1 [1-3]. Causes for the snowline remain ambiguous, but may result from physical or chemical alteration of the surface. Although Maxwell has previously been studied regionally, high-resolution DEMs permit analysis of individual features within the synthetic aperture radar (SAR) map [4]. Here, we mapped features in detail on Maxwell's north- and south-facing flanks, and search for trends that might be apparent at higher spatial resolution than that of Magellan altimetry and emissivity [2].

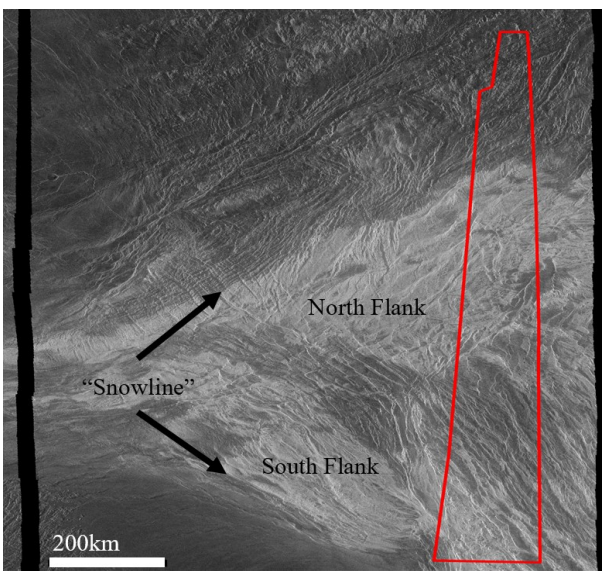

Figure 1. Magellan SAR image of western Maxwell Montes, 68.3°–64.9°N, 353.8°– 2.2°E, north to top, sinusoidal projection. Arrows mark the "snowline". North-facing flanks have higher SAR backscatter than south-facing flanks.

Methods: All data are from the Magellan Venus orbiter mission [5], obtained via USGS "Map-a-Planet" and JMARS. Elevations are from a stereo DEM [4] augmented Magellan altimetry. Images were processed and interpreted in ArcGIS and JMARS. For quantitative analysis, we derived true radar backscatter coefficient from Magellan SAR FMAP images using equation 4 of [4], by generating synthetic incidence angle images for the latitude extents covering our study area. Study areas are individual swaths free of elevation discontinuities within the DEM. The swath was divided into small polygons with relatively homogenous SAR backscatter and elevation (Fig. 2). We generated mean values of backscatter and elevation for each of these polygons, and made scatter plots as shown in Figure 3. Polygons were separated into north- and south-facing flanks based upon their position relative to Maxwell's crest along the swath.

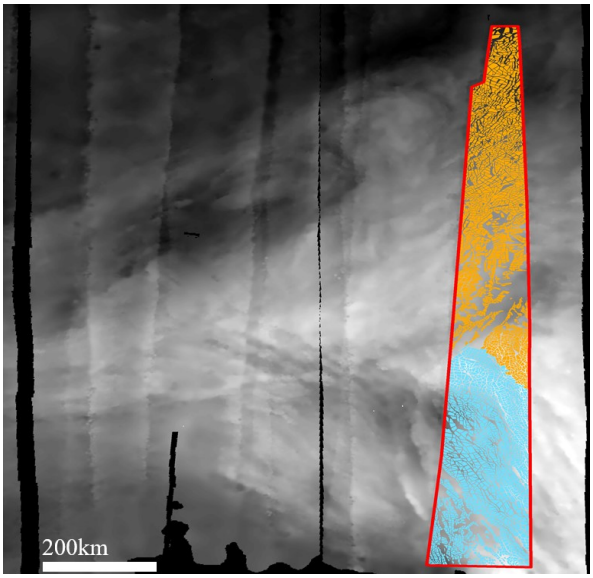

Figure 2. Stereo-derived DEM map of western Maxwell Montes, 68.3°–64.9°N, 353.8°– 2.2°E, north to top, sinusoidal projection. Red box marks the studied swath. Orange (north) and blue (south) polygons mark areas of relatively homogeneous backscatter and elevation.

"Snow:" Magellan SAR images of Maxwell Montes show a distinct "snowline" at ~ 5 km, above which SAR backscatter increases abruptly (and emissivity decreases), Fig. 1 [1-3]. In the analyzed swath, however, the elevation dependence of SAR backscatter is different on the north- and south- facing flanks. On the north flank, elevations above ~7.5 km have lower SAR backscatter values than the "snow" at ~ 5 km, but higher values for elevations below 5 km, (Figs. 1, 3). On the south flanks, however, neither emissivity nor backscatter show clear trends with elevation (Fig. 3). Surface roughness affects SAR backscatter more than emissivity (compare north flank data, Fig. 3), but roughness alone seems insufficient to explain the differences observed between north and south flanks.

Interpretation: Origins for the "snowline" on Maxwell have been controversial [2, 6-12], but are most commonly ascribed to the presence of semiconductor compounds, either precipitated from the atmosphere (e.g., Te, PbS, BiTe) [7,8,13], or produced by surface-atmosphere chemical reactions (e.g., FeS_2) [9,10,13]. As proposed so far, these processes do not explain the decline in SAR backscatter above ~7.5 km, nor the differences in radar properties between north and south flanks.

In general, the differences in radar properties could represent different materials or atmospheric conditions. Given that Maxwell is a complex mountain range with several structural trends [14], it is possible that it exposes a variety of rock types that reacted differently with Venus' atmosphere; e.g., granitic versus basaltic rock. Or, it is possible that atmospheric precipitates or reaction products vary with temperature (i.e. elevation).

The atmospheric conditions might also be different on either side flanks of Maxwell. Venus' atmosphere has downwelling polar vortices [15], which could induce equator-ward meridional flow at low elevations [16]. If such a flow impinged upon Maxwell, it might experience orographic lift causing a "shadow" effect of precipitates or reactants, with differing conditions on either flank.

Conclusion: Our results confirm earlier reports of the "snowline" on Maxwell Montes [1-3]. Within the analyzed swath, the zone of high backscatter (the snow) appears consistently on north flanks at ~5 km elevation and continues up to ~7.5 km. Above that, backscatter drops to intermediate values. On south-facing flanks there is no clear relationship between radar properties (backscatter or emissivity) and elevation. By using the high-resolution stereo DEM, we have demonstrated that there are more relationships between radar properties and elevation on Maxwell than had been noted before [2]. These data confirm that the relationships between elevation and radar properties are different on Maxwell than on equatorial highlands, such as Ovda Regio [17]; and confirm that the differences must relate either to different rock or atmosphere compositions (Fig. 3). Regardless, the findings of this study reveals the ambiguous nature of Maxwell's processes, and warrants further study of this region on Venus.

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References: [1] Pettengill G.H. et al. (1992) *JGR* 97, 13091-13102. [2] Klose K. et al. (1992) *JGR* 16353-16369. [3] Campbell B. et al. (1999) *JGR* 104, 1897-1916. [4] Herrick R.R. et al. (2012) *EOS* 93, 125-126. [5] Saunders et al. (1992) *JGRP* 97, 13,067-13,090. [6] Pettengill G.H. et al. (1992) Science 272, 1628-1631. [7] Brackett R.A. et al. (1995) *JGR* 100, 1553-1563. [8] Kohler E. et al. (2015) *LPSC* 45th, Abstr. # 2563. [9] Fegley B. et al. (1997) *Venus II*, 591-636. [10] Fegley B. & Treiman A.H. (1992) *Venus and Mars: Atmos., Iono., and Solar Wind Int.*, 7-71. [11] Arvidson R. et al. (1994) *Icarus* 112, 171-186. [12] Wood J.A. & Klose K.B. (1991) *LPSC* 12th, 1521-1522. [13] Pettengill G.H. (1996) *Science* 272, 1628.-1631. [14] vorderBrugge R.W. et al. (1990) *JGR* 95, 8357-8381. [15] Garate-Lopez I. et al. *Nature Geosci.* 6. NGeo 1764. [16] Lebonnois S. et al. (2016) *Icarus* 278, 38-51. [17] Treiman A.H. et al. (2016) *Icarus* 280, 172-182.

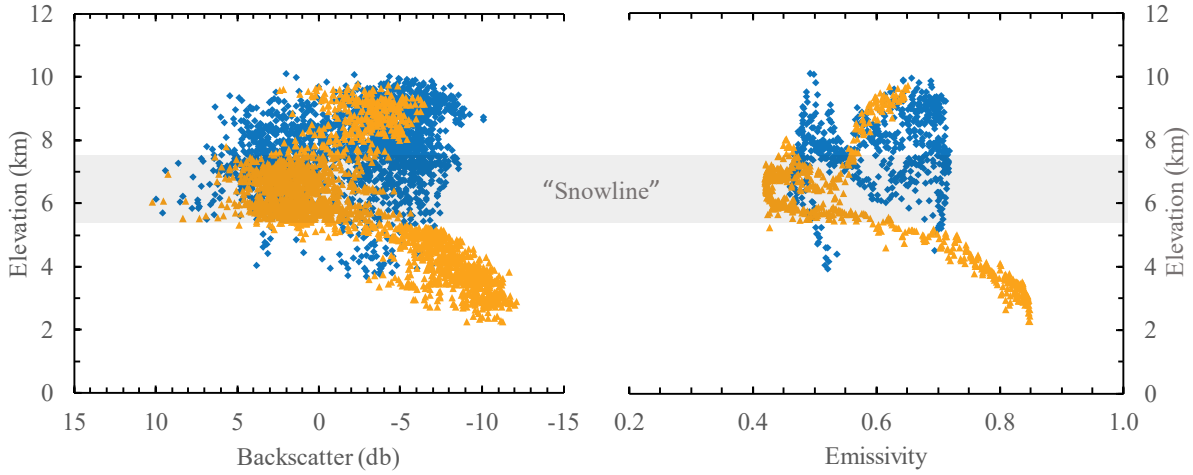

Figure 3. Magellan SAR backscatter (left) and microwave emissivity (right) vs. elevation in the studied swath of Maxwell Montes (Fig. 1), with the "snow zone" (5 – 7.5 km) in gray. Orange and blue symbols represent data points (i.e. polygons, see Fig. 2) for north and south flanks, respectively.