MAXWELL MONTES, VENUS: GEOLOGICAL UNIT MAP FROM ARECIBO AND VENERA DATA SETS AND EVIDENCE OF DEFORMATION HISTORY. R.W. Vorder Bruegge and J.W. Head, Department of Geological Sciences, Brown Univ., Providence, RI 02912 ; D.B. Campbell, NAIC, Arecibo, PR 00612.

Maxwell Montes is a pork-chop-shaped mountain range 500 by 800 km rising 11 km above mean planetary radius located in Ishtar Terra (1-4). It is characterized by high surface reflectivity and roughness (1,5) and high resolution data from the Arecibo Observatory and the Soviet Venera 15/16 spacecraft (Figure 1a, 1b) reveal the presence of parallel linear bands which have been interpreted as tectonic in origin (1-2,4,6-7). The purpose of this study is to map geological units and structures on Maxwell Montes in order to provide data to further assess its origin and style of deformation. The area mapped correlates with the high backscatter boundary evident in Figure 1a. This boundary is in the vicinity of the 6 km altitude contour.

Due to the differences in illumination directions and angles, the Arecibo and Venera data sets provide different information. The Earth-based Arecibo system illuminates Maxwell Montes from the southwest and at high incidence angles approximately equal to the latitude (60-70 degrees). These high incidence angles make the Arecibo system especially sensitive to variations in cm-scale roughness. In images obtained under these conditions, rough areas will appear bright and smooth areas will appear dark. The orbiting Venera spacecraft, however, illuminate Maxwell Montes from the east with low incidence angles (10-15 degrees). These low incidence angles make the Venera system sensitive to variations in slope, so that the slopes facing east (towards the spacecraft) appear bright in images, while away-facing slopes appear dark in images. The spatial resolution of these data sets is between 1 and 3 km. By combining these two data sets, along with the topographic data (obtained by Veneras 15 and 16 (3)), we can more fully define the nature of the surface features.

Individual map units are defined through a combination of characteristics including topography, and cm-scale roughness, which is represented in the Arecibo image as brightness. Morphological patterns, features, and textures observed in the images also help define individual units. The unit map derived from our analysis is shown in Figure 2. The 10 basic units included in the map can be divided into four general groups, based on broad similarities, as shown in the key.

Banded Units: Characterized by individually continuous parallel linear segments of high and low backscatter up to 100 km in length, the three band types are differentiated by variations in segment spacing and by broad roughness variations. Broad Bands have a wavelength of 10-15 km while Thin Bands have a wavelength less than 10 km. Compared to Maxwell in general, both exhibit intermediate roughness. The Plains Bands, however, exhibit low roughness compared to the other bands - roughness comparable to that of the volcanic plains of Lakshmi Planum. Plains Bands have a wavelength less than 10 km. We interpret all of the banded units to consist of rough ridges and smoother troughs. A simple compressional origin was suggested for these ridges and troughs based on a number of arguments, including the correlation of these features with high topography, and evidence for closure of some segments (2,7).

Complex Unit: The Dissected Terrain exhibits the most distinctively variable morphology of any unit. Very rough at the cm-scale, this terrain displays short, discontinuous bright segments (interpreted to be ridges) that intersect each other at a variety of angles. Intervening dark areas (lows or valleys) are irregularly shaped. The ridge-like components are similar to the banded terrain and thus they are interpreted to be of tectonic origin. The complexity of this morphology argues against a single, simple deformational event.

Transitional Units: Transitional in morphology between the simple Banded Units and the complex Dissected Terrain, these units exhibit extreme roughness at the cm-scale. Dissected Bands are reminiscent of the Thin Bands, exhibiting parallel bright and dark linear segments with a wavelength of less than 10 km, suggesting that these features are also compressional ridges and troughs. However, the Dissected Bands are truncated along strike at short intervals (< 25 km) by intervening fractures or faults, suggesting a more complex tectonic history than simple bands, involving shear as well as compression. The Anastomosing Bands similarly resemble Thin Bands by exhibiting parallel bright and dark linear segments with a short wavelength, again interpreted as compressional ridges and troughs. However, these Anastomosing Bands are more curvilinear than simple bands and occur in a braided pattern - again indicating a more complex history than simple compression, possibly involving shear. Broad Sigmoidal Bands resemble simple bands least of all. These features appear to be broad swells separated by thin, smooth troughs. Dark fractures or gashes are pervasive in this unit. The origin of these features is uncertain, but they may be linked to steep topographic slopes.

Smooth Units: These units all exhibit a remarkable lack of textural contrast. Internal deformation of these units does not appear extensive due to the continuity of their surfaces. The Bright Deposits are smooth and lie on a Venera-facing slope associated with Cleopatra Patera and appear to embay surrounding ridges and troughs. Debate continues over the origin of these deposits (8), but whether they are generated volcanically or by impact, their association with Cleopatra is unquestioned. The Dark Deposits are also smooth deposits, yet they do not face the Venera system and so are dark in that imaging as well. These Dark Deposits tend to occur in topographic lows, suggesting an occurrence as soils or flows. One example of their occurrence around a circular feature (a caldera?) is evident 300 km south of Cleopatra. The Speckled deposits are found only within Cleopatra Patera. The speckled texture is quite similar to that observed in the volcanic plains of Lakshmi Planum and may represent volcanic flooding of the floor. An endogenic origin for these deposits is consistent with either an impact or volcanic origin for Cleopatra.

Discussion and Conclusions:

1) Asymmetry of Structure: The west face of Maxwell is dominated by the simple Banded Units, while the east displays the more complex, Dissected Terrain. This asymmetry is similar to that exhibited by the other linear mountain belts, Akna and Freyja (9). All three mountain belts display a topographically high range consisting of simple banded terrain, along with a foreland region exhibiting a more disrupted structure. The foreland region of Maxwell, though, appears to have even added complexity, with ridge segments being less linearly continuous than than those near Akna and Freyja (9).

2) Deformation from Gravity Slumping and/or Shear: Transitional Units display intermediate complexity and are found on the steep north and south slopes of Maxwell. Although showing continuation of some structures from the central part of the mountain, these features are remarkable for the fractures, gashes and/or faults that occur here paralleling topography. These features also parallel major shear zones mapped by previous investigators (6,10). The association of these features with steep slopes and the major shear zones suggests that their origin is linked to combined gravity slumping and shear.

3) Relation of Unit Map to Retrodeformation: Vorder Bruegge and others (10,11) have described a two-stage history of deformation for Maxwell Montes which involved the initial formation of an Akna Montes-like linear mountain belt followed by large-scale horizontal motion along strike-slip faults to produce the present morphology and topography. The unit map provides another test of this hypothesis. We have retrodeformed the unit map (Figure 2) using the offsets determined in our previous study (11). We find that the overall configuration is again similar to that of Akna Montes. Additionally, contacts that presently appear irregular or sinuous become less complex and more linear after retrodeformation. One example of this can be seen by the contact between the Broad Bands and the Dissected Terrain. Presently sinuous, this retrodeformed contact corresponds to the long linear feature labelled "D" in our previous study (11, Figure 1c,d). Thus the unit map is consistent with a two-stage history of deformation (11).

4) Two Stage History and its Consequences: Reconstructions of the morphology, topography and unit map support the interpretation of a two stage evolution of Maxwell Montes in which its initial configuration was a long linear mountain belt comparable to Akna Montes, and was later deformed into its present shape by strike-slip faulting and extensive horizontal motion. The arrangement of shear zones suggests deformation of proto-Maxwell Montes within a wedge-like region. The converging shear zones appear to be linked to the change in direction of principle stress orientation between stages of deformation. The second stage could also be responsible for the added complexity of Maxwell's foreland region, compared to Akna's. We are pesently investigating the geometry of such deformation and find that a horizontal offset of over 1000 km along this wedge is implied for the entire Maxwell structure from the Akna-like proto-Maxwell-stage to the present.

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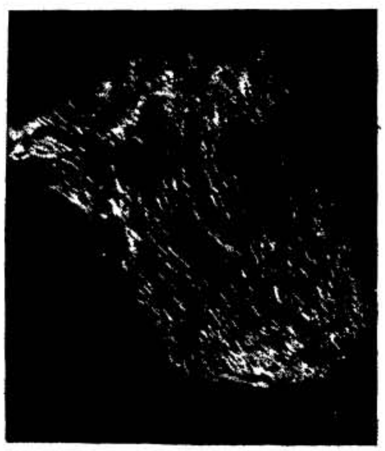
Figure 1. (a) Arecibo image of Maxwell Montes. (b) Venera 15/16 image of Maxwell Montes. Figure 2. Unit map of Maxwell Montes. See text for discussion.

1a.



1b.

2.