GEOLOGY OF THE VENUS EQUATORIAL REGION FROM PIONEER VENUS RADAR IMAGING.

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Introduction. The surface characteristics and morphology of the equatorial region of Venus were first described by Masursky *et al.* (1) who showed this part of the planet to be characterized by two topographic provinces, rolling plains and highlands, and more recently by Schaber (2) who described and interpreted tectonic zones in the highlands. Using Pioneer Venus (PV) radar image data (15° S to 45° N), Senske and Head (3,4) examined the distribution, characteristics, and deposits of individual volcanic features in the equatorial region, and in addition classified major equatorial physiographic and tectonic units on the basis of morphology, topographic signature, and radar properties derived from the PV data (5). Included in this classification are: plains (undivided), inter-highland tectonic zones, tectonically segmented linear highlands, upland rises, tectonic junctions, dark halo plains, and upland plateaus. In addition to the physiographic units, features interpreted as coronae and volcanic mountains have also been mapped. In this paper, we briefly describe the latter four of the physiographic units along with features interpreted to be coronae.

Upland rises are defined as broad, radar-dark, topographic highs containing individual peaks which are commonly radar-bright and express typically 1.0- to 3.0-km of relief (4). Two regions designated as upland rises are Bell Regio and Eisila Regio. Bell Regio is a radar-dark topographic rise on which are located four peaks, Api Mons, Nefertiti, Tepev Mons, and an unnamed peak. On the basis of the presence of both radar-bright and radar-dark flows these mountains are interpreted to be volcanoes (4,6). Gravity modeling by Janle *et al.* (7) suggests a deep apparent depth of compensation (~200 km) for this region which they interpret along with geologic mapping to indicate support of topography by dynamic processes in the mantle. The second upland rise, Eisila Regio, length of 8000 km, forms the westward extension of Aphrodite Terra. The western part of Eisila Regio is a broad radar-dark topographic rise which exhibits properties similar to the surrounding plains. Located on the crest of the high topography are two volcanic mountains, Sif Mons and Gula Mons. Flows associated with these volcanoes appear to be of limited extent, forming a thin veneer, suggesting that this region was not built up entirely by volcanic construction. On the basis of the interpretation of volcanic deposits representing a thin veneer, the presence of material on broad topographic rises similar to that on the adjacent plains, and deep apparent compensation, formation of upland rises related to doming due to thermal uplift is proposed.

Tectonic junctions are radar-bright highlands located at the convergence of three or more inter-highland tectonic zones, and are centers of volcanism possessing individual mountains typically located at the crest of a domal topographic rise. Features mapped as tectonic junctions include Beta Regio, Atla Regio, Asteria Regio, northern Phoebe Regio, the region of convergence of Ulfrun Regio and Hecate Chasma, and an elevated region southeast of Atla Regio. The largest tectonic junctions, Atla Regio and Beta Regio are broad domal topographic rises on which are located large volcanic edifices, Ozza Mons and Maat Mons in Atla Regio, and Theia Mons and Rhea Mons in Beta Regio. On the basis of geologic mapping (8,9) and modeling of gravity data (10), these regions have been interpreted to be associated with deep mantle thermal anomalies. The tectonic junctions located at Asteria Regio and northern Phoebe Regio possess characteristics similar to Beta and Atla, and may have formed in similar manners, but are smaller. The combination of inter-highland tectonic zones and tectonic junctions forms an interconnecting network extending over half the circumference of the planet.

Dark halo plains are defined as broad quasi-circular regions of very low radar backscatter located in low lying areas and extending for hundreds of kilometers (4). A radar-bright circular feature or ring, which itself has a radar-dark interior is often found in the dark material. In high resolution image data these circular features correspond to craters, several of which are located on local topographic rises and are surrounded by lobate flow deposits suggesting a volcanic origin (5). The most extensive regions of dark halo plains are located to the west of Eisila Regio and west of Atla Regio. In the region west of Eisila Regio the radar-dark material appears to embay areas of higher topography suggesting emplacement by lava flooding. On the basis of the embayment relations expressed by the radar-dark material and the presence of deposits associated with the interior craters which are interpreted to be volcanic, it is suggested that the dark halo plains are regions of smooth lava flows with the interior crater being a source region of some of these deposits.

Upland plateaus are broad, bright to mottled-bright, plateaus covering areas of hundreds of square kilometers typically bounded by steep scarps standing 1 to 2 kilometers above the surrounding plains (5). Few individual peaks are present or they are entirely absent. Central troughs similar to those associated with Beta and Aphrodite are not observed. Specific upland plateaus are located north of Asteria Regio, on the eastern flanks of Beta Regio, at Phoebe Regio, adjacent to Ovda Regio and Thetis Regio, in the southern hemisphere at Alpha Regio, and at Tellus Regio. Venera imaging of Tellus Regio shows it to possess a complex tectonic structure of intersecting valleys and ridges and is mapped as tessera (11). A comparison of radar properties indicate that both upland plateaus and tessera are characterized by high roughness, low values of uncorrected reflectivity, and that they contain a large percentage of wavelength-scale (5-50 cm) diffuse scatterers (12). On the basis of topographic signature, radar properties, and correlations with units mapped as tessera from Venera imaging, it is suggested that areas mapped as upland plateaus are tectonic units similar to tessera (5).

Within the PV data **coronae** are characterized by locally elevated topography, narrow radar-bright discontinuous rims, and radar-dark interiors (13). Similar characteristics are observed for coronae mapped in Mnemosyne Regio from both Arecibo and Venera radar images (14). On the basis of this characterization, two large circular features interpreted as coronae are identified in the area imaged exclusively by PV. The first, Pavlova, is located in eastern Eisila Regio (15° N, 40° E), is elliptical with dimensions of 525 km x 370 km, and is characterized by a 50-km wide discontinuous rim which exhibits 200 to 600 m of relief. The discontinuous part of the rim corresponds with flanking topographic depressions mapped as very dark that are similar to units mapped elsewhere as volcanic plains and suggests that lava flows have breached the rim. The second (840 km diameter) corona is located to the south of western Eisila Regio (2.0° N, 355.0°). Like Pavlova, this structure is characterized by a discontinuous rim which is radar-bright and elevated to the south while the northern rim possesses no topographic relief and is mottled dark (5). Stratigraphic relations between the rim and radar-dark interior deposits suggests lava flooding, forming plains, has occurred in the interior of this structure. From this analysis, we find that the number of large coronae in the equatorial region to be much less than in the northern high latitudes (14,15).

Discussion and Conclusions. On the basis of variations in structure and morphology, the physiographic units are divided into three distinct longitudinal zones: upland rises (330° to 55°), tectonically segmented linear highlands-upland plateaus (55° to 145°), and inter-highland tectonic zones-tectonic junctions (145° to 315°). The zone of upland rises contains the two highland structures of Bell Regio and Eisila Regio whose volcanic nature has been previously established (4,6,7). Eisila Regio is characterized by three distinct regions, western Eisila with its volcanic peaks Sif Mons and Gula Mons, central Eisila with the volcanic peak Sappho (16,17), and eastern Eisila Regio with its corona structure, Pavlova. Detailed analysis of western Eisila Regio suggests that the volcanoes and their deposits represent a thin veneer of material superimposed on a broad topographic high. In addition, ridges in the lowlands along the eastern flanks of western Eisila Regio are interpreted to be normal faults (18) whose relation to high topography is consistent with a model of uplift under extension (19). This arrangement of structures and association with volcanism in western Eisila suggests formation by doming associated with thermal uplift. A similar model has been previously proposed for Bell Regio (6,7). The region of tectonically segmented linear highlands and upland plateaus is made up of the highlands of western Aphrodite and Tellus Regio. Previous studies of the tectonically segmented linear highland of western Aphrodite show it to be characterized by bilaterally symmetric topography and an en echelon central trough offset in a right lateral sense along cross-strike structural and topographic discontinuities (CSD's) (20,21). The structure of western Aphrodite is similar to that of terrestrial mid-ocean ridges, and has on this basis been interpreted to be a site of possible spreading (20,21). The upland plateaus of Tellus Regio and the units flanking northern Aphrodite form a second distinctive set of highland features in the equatorial region (13). The location of an upland plateau adjacent to Thetis Regio, a region interpreted to be the site of crustal spreading (20,21), suggests two possible models for formation of this upland plateau: 1) the plateau is a preexisting old crustal block; doming and rifting analogous to that of old terrestrial continental crust, followed by spreading as suggested by Head and Crumpler (20), have split the block and formed the intervening high topography associated with Thetis: 2) the upland plateau originated by crustal spreading. In this second model, developed by Sotin *et al.* (22), an increase in mantle temperature and associated production of thicker crust created the high topography in central Thetis Regio. The region of inter-highland tectonic zones and tectonic junctions has previously been described as zones of extension (2). Unlike the upland rises and tectonically segmented linear highlands, which are predominantly linear features striking east-west, the inter-highland tectonic zones have a variety of orientations forming an interconnecting radial pattern between tectonic junctions (13). The presence of a bilaterally symmetric topographic rise with a central trough offset along CSD's suggests that the inter-highland tectonic zone of eastern Aphrodite is a site of rifting and possible crustal spreading (23). This and other inter-highland tectonic zones converge at tectonic junctions. Two of these junctions, Beta Regio and Atla Regio, have been interpreted to be associated with deep mantle thermal anomalies (5,9,10).

The highlands in the equatorial region of Venus form a near-global network of volcanic centers and interconnecting tectonic zones, composed of several distinctive terrain types. The relationship between tectonic junctions and inter-highland tectonic zones suggests that the junctions are nodal points of the network. The inter-highland tectonic zones which extend to the north and do not connect with tectonic junctions die out in this direction. In some places in the equatorial network crustal spreading may be occurring (inter-highland tectonic zones) (23) whereas at other places (tectonic junctions) hot spots and thermal uplift activity is apparently occurring. These characteristics and correlations suggest that both vertical thermal uplift and lateral movement are occurring in the Venus equatorial highlands. In contrast to the equatorial region, the northern high latitudes are characterized by several broad zones of compression forming highlands and orogenic belts (24,25).

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VENUS GRAVITY: MEASUREMENTS, REDUCTIONS AND RESULTS; W.L. Sjogren, Jet Propulsion Laboratory

This presentation will include a description of what gravity data are and how gravity data measurements are obtained. There will be a brief discussion of the error sources that corrupt the raw data and how Magellan data will be superior to the previous Pioneer Venus data set.

A summary of present data coverage and what will be obtained by Magellan will be shown. The various reduction techniques using spherical harmonics, line-of-sight profiling and direct mass estimates for local feature modeling will be described. The published results from these various approaches will be summarized and inferences suggested. There'll be a list of things we hope to resolve in the MGN extended mission with new high resolution data. For the consciencious participant at this conference, he would be in good shape to ask intelligent questions if he reads the Venus V-gram #14, May 1988.