VOLCANIC RISES ON VENUS: GEOLOGY, FORMATION, AND SEQUENCE OF EVOLUTION, D. A. Senske[1], E. R. Stofan[1], D. L. Bindschadler[2], and S. E. Smrekar[1], [1]Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, 91109, [2]Dept. of Earth and Space Sciences, UCLA, Los Angeles, CA 90024.

Introduction. Large centers of volcanism on Venus are concentrated primarily in the equatorial region of the planet and are associated with regional topographic rises. Analysis of both radar images and geophysical data suggest that these uplands are sites of mantle upwelling [1-6]. Magellan radar imaging provides a globally contiguous data set from which the geology of these regions is evaluated and compared. In addition, high resolution gravity data currently being collected provide a basis to assess the relationship between these uplands and processes in the planet's interior. Studies of the geology of the three largest volcanic highlands (Beta Regio, Atla Regio, Western Eistla Regio) show them to be distinct, having a range of volcanic and tectonic characteristics [1]. In addition to these large areas, a number of smaller uplands are identified and are being analyzed (Bell Regio, Imdr Regio, Dione Regio (Ushas, Innini, and Hathor Montes), Themis Regio). To understand better the mechanisms by which these volcanic rises form and evolve, we assess their geologic and geophysical characteristics.

Characteristics of Major Centers of Volcanism. The geologic characteristics of the volcanic rises are shown in Table I. On the basis of the relative contributions of tectonism and volcanism, four classes of features are established. The first class contains extensive arrays of rifts that converge on highlands (Beta Regio and Atla Regio). These extensional belts are part of a system of global-scale deformation zones [7]. Geophysical data show Beta and Atla to have large geoid to topography ratios (GTR's), indicating apparent depths of compensation (ADC) in excess of 250 km [2, 4]. Significant differences between these uplands include the distribution of coronae and presence of tesserae. Coronae and tesserae are abundant at Beta but are not present at Atla. The second class of features are distinguished by the presence of large volcanoes (Western Eistla Regio, Dione Regio, Imdr Regio) with rifting being a less significant process. Compared to Beta and Atla, Western Eistla is compensated at a shallower depth (ADC ~ 200 km [6]), suggesting that the plume may be closer to the surface. Tesserae make up only a minor part of these areas with coronae being significant at Western Eistla. The third class of highlands are characterized almost exclusively by large-scale volcanism forming edifices and coronae (Bell Regio). Unlike the other rises, Bell lacks evidence for zones of rifting. On the basis of it's GTR, Bell is interpreted to be compensated at depth similar to Western Eistla [2]. The final class of rises is characterized by coronae that are interlinked or connected by linear extensional belts (Themis Regio) [8]. Due to its location in the southern high latitudes, gravity data obtain by the Pioneer Venus Orbiter (PVO) were not of sufficient resolution to determine an ADC for Themis. Likewise, ADC's have not been calculated for Dione and Imdr Regiones.

Interpretations. On the basis of geophysical and stratigraphic relationships, we suggest that the range of geologic characteristics may represent different stages in the evolution of a plume. This sequence is characterized by: (1) updoming and extension forming major rift zones (Beta and Atla). The larger GTR at Beta may indicate that it is in an earlier stage of formation relative to Atla; (2) a period where the plume is at a shallower depth with surface geology dominated by edifice construction and rift infilling (Western Eistla, Dione, Imdr); (3) continued edifice construction and relaxation of volcanoes, forming coronae (Bell Regio). Compressional ridges along eastern part of the corona, Nefertiti, in Bell Regio are interpreted to have formed by relaxation of a large volcano [8]. Within the framework of this model, Themis appears to be anomalous. In comparison to the large highlands, its formation may be related to the presence of smaller scale mantle instabilities [8]. Because of the insufficient resolution of PVO gravity data, GTR's have not been calculated for number of the volcanic rises. Data currently being collected by Magellan and those proposed to be collected when the spacecraft orbit is circularized will greatly improve estimates of ADC for structures at high latitudes. These data will provide a stronger basis for linking surface geology to dynamic processes in the Venus mantle.

References: [1] Senske *et al., J. Geophys. Res.*, 13395-13420, 1992. [2] Esposito, P. B. *et al., Icarus*, 51, 448-459, 1982. [3] Bindschadler *et al., J. Geophys. Res.*, 97, 13495-13532. [4] Smrekar S. E. and R. J. Phillips, *EPSL*, 107, 582-597,1991. [5] Kiefer, W. S. and B. H. Hagar, *J. Geophys. Res.*, 91, 403-419, 1991. [6] Grimm, R. E., and R. J. Phillips, *J. Geophys. Res.*, 97, 16035-16054, 1992. [7] Schaber, G. G., *GRL*, 499-502, 1982. [8] Stofan *et al., J. Geophys. Res.*, 97, 13347-13378, 1992.

TABLE I: CHARACTERISTICS OF MAJOR VOLCANIC RISES

Feature	Primary Processes	GTR*	Maximum Height of Rise (km)	Contribution of volcanism	Presence of coronae	Presence of Rifts	Presence of Tesserae	Regional Setting
I. Rift Dominated								
Beta Regio	Rifting & uplift >> volcanism	31	3.0	Low/moderate	Along periphery	3 major rifts	Major	Rift junction
Atla Regio	Rifting > volcanism	23	~4.0	High	None	5 major rifts	None	Rift junction
II. Volcano Dominated								
W. Eistla Regio	Volcanism > rifting	~19	2.0	High	Central part of highland	1 rift	Minor	Plains
Dione Regio	Volcanism > rifting	?	1.0	High	None	Moderate	Minor	Plains
Imdr Regio	Volcanism ~ rifting	?	0.5-1.0	Moderate	None	Moderate	Minor	Plains
III. No Rifts								
Bell Regio	Volcanism > uplift	21	1.5	High	Central part of highland	None	Minor	Plains
IV. Corona Dominated								
Themis Regio	Coronae >> uplift & rifting	?	0.5-1.0	Low/moderate	Corona chain	Moderate	None	Rift/corona chain

* From Smrekar and Phillips, Earth and Planet. Sci. Letters, 107, 582-597,1991