REGIONAL GEOLOGY OF THE BETA-PHOEBE REGION ON VENUS. J. B. Garvin and J. W. Head, Dept. of Geological Sciences, Brown Univ., Providence, RI 02912, and A. T. Basilevsky, Vernadsky Institute, USSR Academy of Sciences, Moscow, USSR.

The planet Venus is dominated by extensive rolling plains (65% of surface area) which serve to separate and isolate the highlands and lowlands. Of the three major highland regions on Venus, the Beta-Phoebe area is the most fully characterized, on the basis of the wealth and variety of data available -- Earth-based radar images (Arecibo, Goldstone), Venera lander panoramas (Veneras 8-14 landed east of these highlands), and complete Pioneer-Venus orbiter radar coverage. Neither Aphrodite nor Ishtar Terrae are covered as well as the Beta-Phoebe region; there has yet to be a lander mission to either of these highlands, though the Vega landers are targeted for an area near Aphrodite. The data available for Beta-Phoebe and the surrounding plains spans several orders of magnitude in resolution, from cm-scale in the Venera panoramas to several km-scale in Earth-based radar backscatter images, to 30-100 km in Pioneer-Venus maps of radar roughness (α^0), reflectivity (ρ), and altimetry (z). This affords us an opportunity to analyze the geology of the region from the surface (Venera panoramas) and from afar (radar), and allows us to assess how representative the Venera lander sites are of the high plains and lower highlands for this part of Venus. In addition, the entire Beta-Phoebe area can be compared with planet-wide radar properties. This type of study is similar to that performed for regions on the Moon; radar, high- and low-resolution orbital images, and surface photos were correlated for several areas near the Apollo landing sites by Moore et al. {1,2}.

Earth-based radar observations of Venus identified the Beta highlands, even in low-resolution backscatter images, because of the extremely high backscatter of its elevated (~5 km) summit regions. The reflectivity of such regions (e.g., Theia Mons) is 0.28 ±0.07 {3}, which suggests the occurrence of extremely dense materials (>3 g/cm^3) likely to be enriched in high dielectrics {3, 4}. Recent high-resolution backscatter images from Arecibo show details at scales of 2-3 km. Such images reveal structures which strikingly resemble vast lava flows, rift zones, and a possible summit caldera (Theia Mons) {5}. These discoveries are not suprising as the Venera 9 and 10 spacecraft acquired γ-ray spectrometry data from the eastern flanks of Beta which indicated basaltic compositions {6,7}. In addition, the Venera 10 panorama showed that there are semicontinuous, platy exposures of bedrock at the surface of Venus which morphologically resemble eroded pahoehoe lava flows {6,7,8,9}. In order to interpret the regional geology of the Beta-Phoebe region and the plains to the east, we have produced maps of the PV radar properties for the region {10,11}and have statistically analyzed small (200 x 200 km) areas around the Venera 9-14 lander site coordinates. Table I summarizes the averaged radar characteristics. While such averages (and standard deviations) are useful, the spatial distribution of radar properties is especially useful in examining how extensive a type of surface is likely to be {10,11}.

Since all of the Venera sites fall in an elevation interval from 0.9 to 2.1 km, we will focus on the spatial distribution of roughness, reflectivity, and model density {5} in the region at these elevations. The more elevated regions show the most distinctive radar backscatter patterns, and are more extreme (higher α^0,ρ) in their PV radar properties. The high plains in the Beta-Phoebe region are concentrated around the Beta and Phoebe highlands, and serve to connect the smaller highland regions together. They are replaced by lower plains and lowlands to the east of Beta, but continue to the southeast (where V11-14 landed). The roughness pattern in these plains is variegated, but is dominated by surfaces with 3^0 to 4^0 RMS slopes. Isolated clusters of high (>5^0 RMS) roughness terrain occur predominantly around the most elevated highlands -- areas near V9 and those containing V12 are examples. Frequently, the high roughness patches are low in ρ (density <2g/cm^3), perhaps reflecting an appreciable soil-cover or substrate, or possibly due to an artificial lowering of the measured ρ because of a high degree of small-scale (cm) roughness. Clusters of very smooth (1-2^0 RMS) terrain occur mostly south of Phoebe and are usually ringed by increasingly rougher terrain. A small region at 4^0N, 300^0E shows this pattern of gradational roughness, and could represent an impact structure or small volcano -- this feature shows up as a bright-haloed circular structure with a dark interior in Arecibo images {12}. The terrain around Beta Regio is typically 3-4^0 or more in roughness, with rougher areas occurring at higher elevations. The Venera 9 region is probably representative of locally blocky areas which have roughnesses above 4^0 (e.g., VL-1 on Mars and average lunar mare), but is <u>not</u> typical; the Venera 10 area (roughness 3-4^0) is <u>most</u> typical of the entire region. There is a general increase in the amount of smoother terrain south of Phoebe -- large clusters with roughness < 2.5^0 can be found. Terrain with roughnesses between 2^0 and 3^0 is most common to the east and southeast of Phoebe: Veneras 11, 13, and 14 all landed in areas such as this. V12 landed in a small, high-roughness region amidst much smoother terrain.

A different pattern emerges for reflectivity (or density). Most of the plains surrounding Beta have $\rho \leq 0.1$ (density < 2g/cm^3), but as one proceeds SE, small regions of isolated higher ρ occur (ρ > 0.13 or density > 2.3 g/cm^3). The ρ units appear to be more gradational than the roughness ones, and larger continuous regions are most common. Isolated regions of high or low ρ are uncommon except to the SW of Beta and far to the SE of Phoebe. V9 landed on the edge of a vast region of low ρ (ρ < 0.1) and V12 landed in a small, semicontinuous region of very low ρ, but with high roughness. V11, 13, and 14 sampled a wide region with average ρ (0.13-0.16) typical of the plains east of Phoebe. V10 landed at the edge of a unit with ρ like V11, V13 and V14;

this unit is adjacent to the continuous, low ρ (< 0.1) region surrounding Beta, and extending to the NE. The exact interpretation of geologic nature of these units must await VRM and future Venera landers.

In summary, the Beta-Phoebe region, and in particular the elevated plains in this area, appear to be atypical of the more common lower plains (0-1 km) on Venus. They are low to average in ρ, variable in roughness, but rougher than average, and more elevated than average. Most of the Venera landers sampled typical plains for this area. The exceptions are V9 (blocky, low ρ, more elevated) and V12 (lowest ρ, highest roughness), both of which sampled "locally" anomalous areas in the region, perhaps related to small volcanic or impact structures. Evidence for volcanism and meteor impact {12} can be found in the Beta-Phoebe region. VRM and further high-resolution Arecibo coverage of the region will greatly clarify these findings.

Table I: Radar properties from PV data (V9-V14 are Venera lander regions, 200 x 200 km).

	Beta-Phoebe	Venus	V9	V10	V11	V12	V13	V14
Avg. elev. (km>5051)	0.83±0.79	0.92±0.55	2.1±0.4	1.5±0.6	1.2±0.2	1.3±0.5	1.4±0.3	1.0±0.3
Avg. RMS slope	2.79±0.97	2.65±0.75	4.0±1.3	3.1±0.8	2.9±0.8	5.1±1.8	3.0±0.3	2.9±0.7
Avg. Reflectivity	0.126±0.04	0.13±0.03	0.10±0.02	0.10±0.03	0.15±0.04	0.08±0.04	0.15±0.08	.14±.04
Avg. "Density" † (g/cm^3)	2.20 (1.67-2.75)	2.26 (1.84-2.7)	<1.9	1.9	2.5	1.6	2.6	2.4

† From Krotikov {4}model where density = $4\sqrt{\rho}/(1-\sqrt{\rho})$ g/cm^3 for a given reflectivity ρ.

References: 1) Moore, H.J. et al. (1975) USGS Interagency Report: Astrogeology 75, 88 pp. 2) Moore, H.G. et al. (1976) USGS Interagency Report: Astrogeology 80, 101 pp. 3) Pettengill, G. et al. (1982) Science 217, 640. 4) Krotikov, V.D. (1962) Izv. Vysshikh Uch. Zav. Radiofiz. 5, 1057. 5) Campbell, D.B. et al. (1984) submitted to Science (Beta Regio). 6) Florensky, C.P. et al. (1977) GSA Bull. 88, 1537. 7) Basilevsky, A.T. et al. (1982) Moon and Planets 28, 63. 8) Garvin, J.B. et al. (1984) LPSC XV, this volume (Venera landers). 9) Garvin, J.B. et al. (1983) JGR, in press (Venera lander sites). 10) Peterfreund, A.R. et al. (1984) LPSC XV, this volume (Unit definition). 11) Peterfreund, A.R. et al. (1984) submitted to JGR (Unit definition). 12) Campbell, D.B. and Burns, B. (1980) JGR 85, 8271.