elevation and/or slopes and which may be reflected in terms of variations in surface roughenss or proportions of soil/rock/high-dielectric material.

METHOD

The three PV data sets used to produce the maps for this study include data collected and processed as of December 1982. Analyses were done utilizing the PV data mapped into a Mercator projection with a spatial resolution of 1° × 1° (equivalent to 105 km × 105 km at the equator and 53 km × 105 km at ±60°). The maps were produced using a 5° × 5° boxcar filter with uniformly weighted coefficients in order to fill in those 1° × 1° cells for which valid PV data were unavailable. Approximately 10% of the cells required filling. Surface areas were estimated from these Mercator maps by using a correction factor for latitude. Banding observed in these maps is due primarily to absent or invalid data associated with a specific PV spacecraft revolution (e.g., orbital ground tracks) and, to a lesser extent, with orbit-to-orbit variations. Geographic place names for Venus used for reference in the following discussion can be found on the U.S. Geological Survey (USGS) 1:50,000,000 maps [*USGS*, 1981, 1984] and in the works by *Strobell and Masursky* [1983] and *Masursky et al.* [1984] and are shown in Plate 1.

Global subdivision of topography into provinces has been previously proposed by *Masursky et al.* [1980] as follows: (1) lowlands were defined as regions with altitude <6051.0 km radius (i.e., <0 km elevation), (2) rolling plains as regions between 6051.0 and 6053.0 km (0.0–2.0 km), (3) highlands (>6053.0 km). We further subdivide the highlands of *Masursky et al.* [1980] into highlands (regions between 6053.0 and 6055.5 km; 2.0–4.5 km), and mountainous regions (>6055.5 km; >4.5 km) (Plate 2). The mean planetary radius of 6051.2 km [*Pettengill et al.*, 1980*b*] (updated to 6051.9 km for the December 1982 data set by *Garvin et al.* [1984*a*]) is within the rolling plains unit, which covers ~75% of the planet. The subdivisions of *Masursky et al.* [1980], amended by us, define topographic provinces on Venus that are spatially distinct and serve to outline specific geographic regions.

Subdivisions for radar roughness and reflectivity were chosen on the basis of standard interpretations of radar roughness and reflectivity measurements (reviewed by *Pettengill et al.* [1980*b*, 1982] and *Garvin et al.* [1983*a*, *b*, 1984*a*] and summarized here). The rms surface slope is a measure of the small-scale (0.5–100 m) roughness averaged over the radar resolution element. The rms slope is derived from a model based on the Hagfors scattering law for the quasi-specular radar return from a planetary surface as follows [*Hagfors*, 1970]:

$$\sigma_0(\theta) = (\rho_0\, C/2)\,(\cos^4\theta + C\sin^2\theta)^{-3/2} \qquad (1)$$

where σ_0 is the radar cross section per unit surface area at angles of incidence θ, ρ_0 is the Fresnel reflection coefficient at normal incidence angle, and C is the Hagfors parameter. In Hagfors' original model calculations [*Hagfors*, 1964], the rms slope of the reflecting (specular) surface facets (≫wavelength) was found to be equal to $180/\pi C^{1/2}$ for low to moderate roughness ($C \gg 100$). As the calculations are based on a model, however, the resulting values for rms slope are only an indication of the angular distribution of scattering objects on the surface. The larger the rms slope, the greater the amount of surface undulation or surface block cover. The mean rms slope for Venus is 2.65° ± 0.75° [*Pettengill et al.*, 1980*a*; *Garvin et al.*, 1984*a*] where the scale length for the roughness measurement is approximately 0.5 m to tens of meters [*Pettengill et al.*, 1980*b*]. In comparison with similar radar measurements for the moon and Mars (see reviews by *Pettengill* [1978] and *Ostro* [1983]), Venus appears to be relatively smooth. Three subdivisions in rms slope were chosen: (1) smooth, 1°–2.5°, typical of the smoothest regions of Mars, (2) transitional from smooth to rough, 2.5°–5.0°, typical of the lunar maria, and (3) relatively rough, >5.0°, typical of lunar highlands and the roughest surfaces on Mars [*Simpson et al.*, 1984] (Plate 3). The transitional range comprises ~46% of the observed surface area of the planet. It could either be inhomogeneous, possibly containing a mixture of both smooth and rough elements, or could represent a distinct surface morphology.

Reflectivity values are derived from the scattering model by fitting the Fresnel reflection coefficient ρ_0 to the data [*Pettengill et al.*, 1982]. The reflectivity is a function of the complex dielectric constant ε, where

$$\rho_0 = \left|\frac{1-\sqrt{\varepsilon}}{1+\sqrt{\varepsilon}}\right|^2 \qquad (2)$$

The entire Hagfors theory [*Hagfors*, 1964], including this equation, concerns only the quasi-specular surface component and none of the diffuse (random scattering) component. It is possible, therefore, that if a surface is covered by a large fraction of random-scattering elements, the reflectivity calculated from the remaining quasi-specular echo will be less than the Fresnel reflectivity of the surface materials. The complex dielectric constant is a characteristic of the surface material and includes a dependence on the volume conductivity and the bulk density (porosity) as well as rock chemistry. *Krotikov* [1962] and *Krotikov and Troitsky* [1963] have measured dielectric properties of a variety of dry terrestrial rocks ranging in density from pumice, $\rho = 1000$–1800 kg m^{-3}, to dunites, $\rho = 3300$ kg m^{-3} (including basalts, glasses, and granites). They found an approximate relationship between density and dielectric constant. For dry, nonconducting terrestrial materials, the bulk density d (in kilograms per cubic meter) can be approximated by

$$d = \left|\frac{\sqrt{\varepsilon}-1}{0.5}\right| \times 10^3 \qquad (3)$$

where the constant 0.5 was empirically derived for measurements at PV radar wavelengths [*Krotikov and Troitsky*, 1963]. *Campbell and Ulrichs* [1969] also measured the dielectric constant and loss tangent for a variety of geologic materials, including both solid rocks and powdered samples of identical rocks. At least for the solid rock samples it is observed that (3) remains a good approximation of bulk density [*Garvin et al.*, 1985]. Hence for terrestrial materials the observed dielectric constant ε for solid rock exhibits a lower limit of about 4 (reflectivity of 0.11). Observed values of reflectivity lower than this are likely to be due to a significant fraction of porous materials (e.g, soils), with the expected fraction of such material increasing as the observed reflectivity decreases. For example, the lunar surface is dominated by a porous regolith with a mean reflectivity of 0.07 [*Tyler and Howard*, 1973].

For Venus the observed mean reflectivity is 0.13, which suggests that either the fraction of porous material is much lower on the Venusian surface than on the moon or that the dominant materials have a remarkably higher bulk dielectric constant [*Pettengill et al.*, 1982]. In light of the observed range in reflectivity over the planet's surface, we have subdivided the