TABLE 1. Statistics for Topographic Provinces

Topographic Province	Elevation Range (km > 6051) z	Percent Surface Area	Average Reflectivity $\bar{\rho}$	Standard Deviation Reflectivity	Correlation of Reflectivity* With Elevation	
					R^2	Slope m
Provinces Defined by Masursky et al. [1980]						
Lowlands	−2 to 0	27	0.12	0.003	0.29	0.044
Upland rolling plains	0 to +2	65	0.12	0.006	0.88	−0.012
Highlands	2 to 12	8	0.13	0.03	0.02	0.005
Topographic Zones Defined on the Basis of the Correlation of $\bar{\rho}$ With z						
Zones I and II	−2.0 to −0.7	0.9	0.13	0.009	0.44	−0.085
Zone III	−0.7 to 0.9	60	0.13	0.002	0.65	0.006
Zone IV†	0.9 to 2.0	27	0.12	0.005	0.88	−0.016
Zone V	2.0 to 3.5	8	0.11	0.006	0.58	0.013
Zone VI†	3.5 to 5.0	3.5	0.16	0.02	0.93	0.045
Zone VII	5.0 to 5.9	0.4	0.18	0.02	0.04	0.106
Zone VIII	5.9 to 12	0.2	0.22	0.07	0.08	−0.022

*Correlation evaluated using linear regression of mean reflectivity $\bar{\rho}$ versus elevation z in the form $\bar{\rho} = mz + b$, where m is the slope of the correlation line and R^2 is the correlation coefficient ($R^2 = 1.0$ is the perfect linear correlation). The slope m is in reflectivity per kilometer units ($\Delta\rho$/km).

†Zones of statistically significant correlation ($R^2 > 0.88$).

kov and Troitsky, 1963; *Evans and Hagfors*, 1968; *Tyler and Howard*, 1973; *Olhoeft and Strangway*, 1975] have demonstrated the strong correlation between radar reflectivity measurements and surface material properties such as porosity and density. Radar studies of Mars [*Tyler et al.*, 1976; *Simpson et al.*, 1984] have also shown that soil-covered surfaces have reflectivities commensurate with the dielectric properties of highly porous materials. Thus the radar ρ properties of the surface of Venus may provide the only means of assessing the porosity structure of the upper surface layer as well as the regional and global distribution of materials enriched in Ti and Fe minerals. In this way, the radar ρ data complement the other radar data sets currently available and permit one to apply material property information to the interpretation of high-resolution radar images of Venus from Arecibo [*Campbell et al.*, 1984*a*, *b*] and the Venera 15 and 16 orbiters.

The aim of this study is to provide a geologic analysis of the global radar reflectivity data for Venus. We first analyze the statistical and map pattern distribution of ρ in the context of the porosity structure of the surface. We then correlate ρ with elevation in order to examine the degree of topographic control on material properties which could depend on PT sensitive chemical weathering phenomena. Comparison of the rms slope α and ρ correlations with elevation demonstrates that there are distinct topographic zones defined on the basis of the ρ and α trends. Finally, we employ hierarchical clustering analysis to the global ρ, α, and 100-km baseline regional slope [*Sharpton and Head*, 1984] data sets in order to define radar property related subregions. The Pioneer Venus (PV) data used in this analysis include data collected and processed as of December 1982.

DATA DESCRIPTION AND INTERPRETATION

The 17-cm wavelength radar altimeter on board the Pioneer Venus orbiter has been previously described [*Masursky et al.*, 1977; *Pettengill*, 1977; *Pettengill et al.*, 1980*a*, *b*]. On the basis of the absolute time delay, the time dispersion, and the intensity of the radar echo, information about the altimetry and surface properties (ρ, α) can be derived. For small angles θ of departure from normal incidence to the mean resolved surface, a scattering law devised by *Hagfors* [1964, 1967, 1970] provides a reasonable approximation to the observed radar echo strength. For the range to which altimeter observations are limited, $0° \leq \theta \leq 10°$, the Hagfors law for the quasi-specular component of the total scattering behavior of the surface can be written

$$\sigma_0(\theta) = (\alpha^{-2}\rho/2)\{\cos^4\theta + \alpha^{-2}\sin^2\theta\}^{-3/2} \tag{1}$$

where $\sigma_0(\theta)$ is the dimensionless specific radar cross section (radar cross section divided by surface area), ρ is the power reflectivity at normal incidence to a smooth surface, and α is the rms slope (in radians) of coherently reflecting surface facets with dimensions larger than the observing wavelength (i.e., α is sensitive to features from 0.1 m to tens of meters) [*Pettengill et al.*, 1982]. From each altimeter measurement, a value for ρ and α can be computed (cf. *Pettengill et al.* [1982] for details). Owing to the restriction on θ (the observation angle), values of α larger than 10° are poorly determined, so that the diffuse part of the total surface scattering behavior is not known. Because of this, the values of ρ may be underestimated by 10–15%, particularly for surfaces with large degrees of roughness (e.g., $\alpha \gg 10°$ or high subwavelength scale roughness). Knowledge of the diffuse scattering behavior of such surfaces from data acquired by the PV radar in side-looking mode can provide a correction for ρ values likely to be underestimated (P. Ford, personal communication, 1984). We treat the uncorrected data here with the caveat that geologic interpretation of possible soil-dominated surfaces with high roughnesses is tenuous at best. However, low values of ρ for radar smooth surfaces ($\alpha < 3°$ rms) are unlikely to need correction. Systematically low ρ values in regions of high roughness ($\alpha > 7°$ rms) could require correction upward of the order of the formal errors of 10–30% (0.01–0.03 in ρ) [*Pettengill et al.*, 1982].

The altimeter data set from which ρ is derived consists of over 200,000 surface radar measurements. Each measurement footprint depends on the spacecraft altitude which is a function of the periapsis latitude (15°–17°N). Footprints vary in size from 23 × 7 km at the periapsis latitude to over 100 km on a side at the 3000-km-height limit of the radar instrument [*Pettengill et al.*, 1980*a*, *b*]. We have analyzed the data in an unprojected format as well as in a 1° × 1° per resolution element Mercator projection. In this study we present statistics in terms of percent surface area to aid in geologic interpretation. Because of the dominance of the rolling plains on Venus (65% of the surface area lies within 6051.0 and 6053.0 km), the