The nature of the venusian surface has been revealed by Pioneer-Venus (PV) observations to be diverse at scales from tens to hundreds of kilometers. In this study [1], we investigate the spatial correlation of elevation, surface roughness, and radar reflectivity as a means of assessing the degree of homogeneity of surface radar properties within topographic provinces and develop a map of possible geologic boundaries. Correlations were performed in a supervised fashion whereby unit boundaries were selected on the basis of statistical and empirical studies of the individual data sets [2,3,4]. Interpretations of these units in terms of geologic characteristics are based on the determination of physical units which are model dependent.

Topographic divisions follow those of previous studies [4,5]: 1) lowlands, <6051.0 km radius; 2) rolling plains, 6051.0 to 6053.0 km; 3) highlands, 6053.0 to 6055.5 km; and 4) mountainous regions, >6055.5 km. The planetary mean radius, 6051.5 km, is within the rolling plains, which covers ~75% of the planet. These divisions define topographic provinces that are spatially distinct and serve to outline specific geographic regions. The topographic divisions may be geologically significant in that chemical and physical weathering processes are likely to be pressure-temperature and thus elevation dependent [6]. Divisions for radar roughness and reflectivity were chosen on the basis of statistical distribution and physical interpretation [7,8]. RMS surface slope is indicative of small-scale (0.1 to 10 m) roughness averaged over the radar field of view [3]. Three divisions in RMS slope were made: 1) 0° to 2.5°, smooth; 2) 2.5° to 5.0°, transitional from smooth to rough; and 3) >5.0°, relatively rough. Boundaries were chosen such that a sharp distinction could be made between smooth and rough surfaces. The transitional range, which comprises ~45% of the observed surface area of the planet, is probably inhomogeneous and contains a mixture of both smooth and rough elements. Three divisions in reflectivity were chosen: 1) < 0.1, low bulk density (< 2.0 g/m^3) and absence of materials with high dielectrics; 2) 0.1 to 0.2, moderate bulk density (2.0 - 3.2 g/m^3) and minor amounts of high-dielectric material (<1%); and, 3) >0.2, either high bulk density (>3.2 g/m^3) and/or the presence of high-dielectric materials. The three divisions were chosen to discriminate between regions that could be described as containing predominantly porous and unconsolidated fine material (soil), predominantly rock, or significant percentage of high-dielectric material. The moderate range, which contains ~67% of the observed venusian surface, is unlikely to be representative of surfaces with a significant unconsolidated regolith typical of the Moon and much of Mars.

Spatial correlations of roughness and elevation show a pattern of increasing roughness with elevation. Most lowlands are smooth or transitional from smooth to rough. Within these regions the low- and moderate-roughness units are spatially well-defined, while high-roughness units are isolated (i.e., single cell-sized equivalent to 10^4 km^2). Small topographic depressions (<10^6 km^2) tend to have moderate roughness values, while broader lowlands are both smooth and transitional. Rolling plains display broad regions of both smooth and transitional roughness. Rough units occur as either small regional clusters or isolated features. Many of the small elevated plateaus (e.g., Alpha Regio) contained within this topographic unit have transitional to high roughness values. Chasmata contained within Aphrodite Terra appear to be...
relatively rough. Highlands appear mostly transitional in roughness. Smooth regions can be seen in Lakshmi Planum, near mountains in Ishtar Terra, and in isolated sections of Aphrodite. Rough regions occur adjacent to mountainous terrain within highlands, as seen, for example, in western and central highlands of Aphrodite and eastern Ishtar Terra. Mountainous regions are mostly transitional to rough, with only isolated occurrences of smooth surfaces.

Correlations of radar reflectivity and elevation show a less distinctive relationship than those for elevation and roughness. For a given elevation interval a full range of reflectivity can be observed. Spatially, reflectivity units appear to be better defined than roughness units (i.e. more contiguous). Lowlands are mostly moderate in reflectivity, suggesting a predominantly rock surface, with small patches and a few isolated occurrences of lower and higher reflectivity areas. Rolling plains are also mostly moderate in reflectivity, implying a predominance of surface material with an average bulk density of rock. Low-reflectivity units tend to be adjacent to highland regions, such as Beta and Aphrodite Terra, but are not evenly distributed around the entire highlands. Chasmata appear to contain some material with low reflectivity. High-reflectivity units occur mostly as isolated small areas with the notable exception of the region west of Atalanta Planitia. Highland regions show a pattern of highest reflectivity adjacent to mountainous terrain, with decreasing reflectivity away from these peaks. This pattern is well illustrated in the western and central highlands of Aphrodite. In Ishtar Terra, the pattern of reflectivity units follows a more regional pattern than the circumscribed pattern around Beta and Aphrodite Terra. Mountainous regions contain the highest reflectivity values observed on Venus [9]. These high-reflectivity values are in excess of what would be expected based on bulk density, and as such are inferred to contain considerable percentage of high-dielectric material. Not all mountainous terrains, however, are characterized by high-reflectivity values; for example, most of Akna and Freyja Montes and Rhea Mons have surface materials with moderate to low reflectivities.

Roughness-reflectivity spatial correlations result in a map of spatially distinct units. Of the 9 defined roughness-reflectivity units, 90% of the observed surface is clustered into 4 units; two low-reflectivity units, which are smooth and transitional in roughness and account for ~25% of the observed venusian surface; and two moderate-reflectivity units, which are also smooth and transitional, and make up ~65% of the observed surface. The low-reflectivity units must likely contain >50% soil and generally surround highland regions. This suggests that lateral sediment transport could be an important geologic process on Venus. The widespread distribution of moderate-reflectivity units suggests extensive exposures of relatively smooth rock. The distribution of high-reflectivity units indicates that high-dielectric materials occur in a wide range of localized environments and that altitude-dependent chemical reactions may not be the only factor responsible for the occurrence of these materials.