A STATISTICAL TREATMENT OF THE REGIONAL SLOPE CHARACTERISTICS OF VENUS AND EARTH. V. L. Sharpton and J. W. Head (Department of Geological Sciences, Brown University, Providence, Rhode Island 02912)

Introduction. Regional slope is a scale-dependent parameter that describes the planar gradient over some (relatively broad) area of topography. As such, it has a fundamental relevance to the geological evolution of a planetary surface: it is controlled by the interaction of those processes which tend to increase or reduce surface relief (e.g. tectonism, volcanism, impact cratering, weathering, viscous relaxation) and in turn, exerts control on the erosion, transportation and deposition of surface materials. We have calculated the regional slope values, measured over 3° by 3° regions, for Venus and Earth. In a companion paper[1], we have presented the regional slope characteristics for the major topographic features discernable at *PV* resolution[2], and compare these with slope features associated with terrestrial landforms. Here we analyze the regional slope frequency distribution information for Venus and Earth and examine the effects on terrestrial regional slope resulting from the removal of the ocean load from sea floor topography. To aid in understanding the nature of the Venus surface, we calculate the *mean* regional slope value of each elevation interval of the *PV* topography.

Method. The method used to calculate the regional slope values for Venus and Earth and the data limitations are summarized in Sharpton and Head[1]. Topography of the *unloaded* Earth was derived in a manner outlined in Head *et al.*[3], using relationships presented in Parsons and Sclater[4] to describe ocean floor elevation as a function of age and distance from the spreading ridge. This topography was then processed in the same manner as the previous topographic data sets. These regional slope data were then used to generate the statistical relationships that follow.

Slope-frequency relationships. Fig. 1 gives the relationship between regional slope and percent surface area for Earth, unloaded Earth, and Venus. The general shape of these curves can be described by a function relating regional slope and percent area of the form $A = k\,S^{\alpha}$, where A is percent area (expressed as a fraction), S is regional slope in degrees, and k and α are constants. Table 1 gives the values of these constants, as well as the correlation coefficient, mean, median and range for each curve.

The modal regional slope value for the Earth curve is 0.0°, where ~26% of the surface area occurs. For Venus, the mode occurs between 0.07° to 0.1° and includes ~23% of the surface, whereas only ~20% fall in the 0.0° to 0.07° range. The non-zero mode and the lower proportion of 0.0° surfaces in the Venus curve are indicative of a global deficiency in regionally flat surfaces compared to Earth. Surfaces of 0.07° to 0.24° are substantially more abundant on Venus than on Earth. About 66% of the surface of Venus and ~48% of the terrestrial surface have regional slopes falling in this range. The region beyond ~0.24° contains ~14% of all Venus surfaces and ~26% of all Earth surfaces.

The characteristics of the unloaded Earth curve are even less like those of Venus. About 33% of unloaded Earth's surface has 0.0° slope, exceeding the Venus value by ~13%. In the range of 0.07° to 0.24°, there is little variation between the two terrestrial curves; Venus has a significantly larger percentage (~66%) of its total surface within this interval than does the unloaded Earth (~47%). It is only for slopes greater than ~0.3° that the differences between the Venus and Earth distributions are lessened slightly from ~8% (loaded) to ~6% (unloaded).

Mean regional slope vs. elevation. The plot of the Venus mean regional slope (calculated from all regional slope values at a given elevation) as a function of elevation is shown in Fig. 2. Within the lowermost elevations are a few small regions of high mean slope associated with the *chasmata*, and a narrow zone between -1.8 km and -1.0 km where mean slope values increase sharply from ~0.0° to 1.0°. This zone is followed by an elevation range characterized by constant regional slope (~0.1°) extending to elevations of ~0.3 km. From 0.3 km to 3.5 km the regional slope increases consistently with increasing elevation. Above 3.5 km mean regional slope varies widely with elevation but a slight depression in slope is apparent between 3.5 km to 5.0 km corresponding to high plateau regions associated with western Aphrodite, Lakshmi Planum and eastern Ishtar. In the

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range 0.3 km to 2.4 km (Fig. 2) the systematic increase of regional slope with elevation can be separated into two zones: a lower zone from ~0.3 km to 1.4 km and an upper zone from 1.4 km to 2.4 km. The incorporation of relatively steep highland margin slopes[1] appears to explain the increase in mean slope in the upper zone. The systematic trend across the lower zone, however, reflects the addition of more 0.1° to 0.2° slopes as elevation increases. These slopes are typical of the lowlands and upland rolling plains provinces, and are arranged in systematic patterns separating small zones of 0.0° slope; they appear to be most similar in shape, size and magnitude to the regional slope characteristics of some older folded mountain belts on Earth.[1]

Conclusions. There are significant distinctions between the regional slope frequency distributions of Venus and Earth. Although these differences could be influenced by the presence of a hydrosphere on Earth, they do not appear to be related to the depression of the terrestrial seafloor due to ocean loading. When a correction for ocean loading is applied to the terrestrial data, the variations in the low slope range become more pronounced. The shortage of flat regional surfaces on Venus relative to Earth, suggests that degradation and aggradation processes (e.g. erosion, deposition, volcanic infilling) are relatively ineffective. In addition, the abundance of regional slopes on Venus between 0.07° and 0.24° implies either that surface processes are not effective at reducing slopes beyond this range or that some geological process operates to preferentially generate regional slopes in this range. We are presently comparing Venus regional slopes to those of cratered terrain and volcanic plains on the moon, Mars, and Mercury.

Table 1. Regional Slope-Frequency Distribution Statistics

	k	a	R^2	Mode	Mean	Median	Range
Earth	$10^{-3.11}$	-2.87	0.88	0.00°	0.21°	0.12°	0.0 - 2.4°
Unloaded Earth	$10^{-3.37}$	-3.01	0.89	0.00°	0.16°	0.08°	0.0 - 2.4°
Venus	$10^{-3.81}$	-3.32	0.90	0.09°	0.14°	0.12°	0.0 - 2.4°

Figure 1

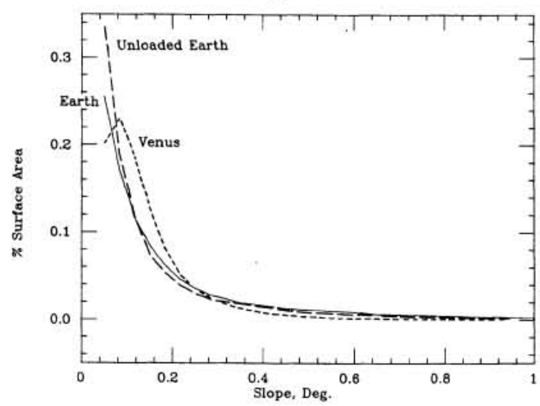

Figure 2. Venus Mean Slope

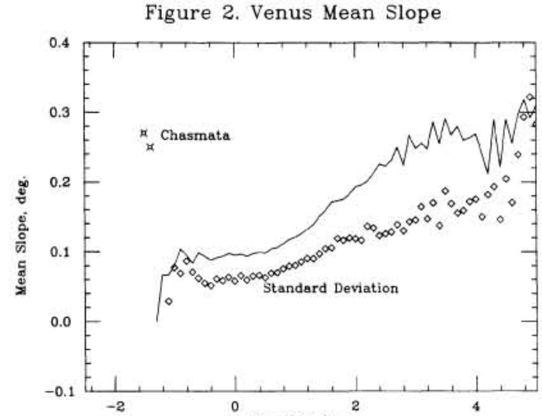

Fig. 1. Slope-frequency curves for Venus, Earth, and Unloaded Earth join discrete groups of data. The first group extends from 0.0° to 0.07° (where curves begin), all other groups are 0.03° wide. *Fig. 2.* Mean slope vs. elevation curve for Venus is represented by solid line. Diamonds give magnitude of standard deviation associated with each mean slope calculation.

References. [1] Sharpton and Head (1984) *this volume.* [2] Pettengill *et al.* (1980) J.G.R. *85,* 8261-8270. [3] Head *et al.* (1981) Am. Scientist, *69,* 614-623. [4] Parsons and Sclater (1977) J.G.R., *82,* 803-827.