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A Comparison of the Regional Slope Characteristics of Venus and Earth: Implications for Geologic Processes on Venus

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The range of 3° by 3° regional slopes of the earth and Venus is similar (approximately 0.0°–2.4°); however, the surface distribution of these values differs significantly. On earth, cratonic and abyssal plains form extensive regions of 0.0° slope. Within these regions a variety of features (mid-ocean ridges, volcanic island chains, subduction zones, and folded mountains) have regional slope characteristics influenced by seafloor spreading and plate recycling, as well as an active weathering regime. Continental margins form laterally continuous zones of relatively high slope (passive margins up to 1.9°; active margins up to 2.4°). The plains provinces of Venus are much more rugged than earth's plains and are marked by numerous closely spaced circular and linear features (0.1°–0.2° regional slope) concentrated into broad linear zones of global extent. Although Venus highlands are bounded by narrow zones of relatively steep slope, the margins of Aphrodite Terra and Beta Regio are not as steep as earth's continental margins and appear to be best developed parallel to the trends of major chasmata within these regions. Linear trends formed by some highland margin segments extend into the plains provinces as rugged belts densely populated with circular and linear features. Ishtar Terra's margins are significantly steeper and more continuous than other highland margins and are comparable to passive margins on earth. The Venus highlands do not contain appreciable smooth, flat interior regions, implying that highland topography is not significantly modified by erosion or deposition. Systematic variations in the density of plains features, elongate planitia, highland margin trends, and aligned highland topography form several major great-circle-like patterns oriented at generally less than 45° to the equator and differing in character from both the mosaiclike patterns of terrestrial lithospheric plates, and the subdued tectonic fracture grids of the smaller terrestrial one-plate planets (the moon and Mercury).

INTRODUCTION

Current efforts to understand the geology of Venus have relied strongly upon the documentation and analysis of this planet's topographic characteristics [*Pettengill et al.*, 1980; *Masursky et al.*, 1980; *Arvidson and Davies*, 1981; *Kaula and Phillips*, 1981; *Solomon and Head*, 1982; *McGill et al.*, 1983; *Phillips and Malin*, 1983; *Sharpton and Head*, 1985]. Global coverage of Venus is limited to that derived from the Pioneer Venus (PV) radar experiment which provided altimetry as well as radar reflectivity and small-scale roughness measurements, each at approximately 100 km resolution [*Pettengill et al.*, 1980; *McGill et al.*, 1983; *Head et al.*, 1985]. In addition, higher-resolution images of the surface, from the Soviet Venera 15–16 spacecraft (approximately 1–2 km resolution [*Barsukov et al.*, 1986; *Basilevsky et al.*, 1986]) and Arecibo radar measurements (1–3 km resolution [*Campbell et al.*, 1983, 1984]) are beginning to provide insight into the nature of geological processes operating at the regional scale. These images, however, cover only about a third of the surface of Venus. Thus the PV data sets currently provide an unique and important synoptic perspective from which to evaluate the global significance of features and processes revealed in the high-resolution data.

On the basis of elevation characteristics derived from PV topography, *Masursky et al.* [1980] have divided the surface of Venus into three major provinces: (1) lowlands which are regions below the Venus datum (0.0 km equals a planetary radius of 6051.0 km) and comprise about 27% of the surface, (2) upland rolling plains which are extensive regions with elevations from 0.0 km to 2.0 km (this province includes approximately 65% of the surface of Venus), and (3) highlands which include those surfaces above 2.0 km and make up approximately 8% of the total mapped surface of Venus.

Like elevation, regional slope is a scale-dependent topographic relationship which is fundamental to the description of a geologic surface [e.g., *Selby*, 1982; *Scheiddeger*, 1970]. Regional slope describes the planar surface gradient measured over a given area [*Sharpton and Head*, 1985]. As it is the first scalar derivative of topography, it emphasizes high-frequency variations in the data. Spatial variations in regional slope values thus characterize the texture or topographic roughness of a surface. To understand better the nature of the information contained in the large-scale Venus and earth topography, we have assessed and compared the 3° by 3° regional slope characteristics of these two planets. Elsewhere [*Sharpton and Head*, 1985] we analyze the global statistics resulting from this study and treat the effects of removing the load of the earth's oceans on regional slope measurements. Here we analyze the surface distribution of regional slope values, examine the large-scale textural variations of Venus and earth topography, and discuss their implications regarding the nature of the geological processes which have shaped the surface of Venus.

The global topography data for Venus [*Pettengill et al.*, 1980] and earth [*Gates and Nelson*, 1975*a*, *b*] are comparable in resolution: 1° by 1° spatial resolution, 100 m vertical accuracy [*Sharpton and Head*, 1985]. The slope of the least squares planar fit to the nine gridded elevation data points within each 3° by 3° region of the topography was calculated, and maps were assembled using a spatial filtering technique (e.g., *Moik*, 1980]. The regional slope maps of earth and Venus are presented in Plate 1.

Regional slopes range from 0.0° to approximately 2.4° for both planetary surfaces, although the spatial distribution

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