ANALYSIS OF GLOBAL AND REGIONAL SLOPE DISTRIBUTIONS FOR VENUS. James W. Head, Emily M. Stewart and Stephen Pratt, Department of Geological Sciences, Brown University, Providence, RI, 02912 (James_Head@brown.edu).

Introduction: Global and regional topography and slope data can provide important information on the nature of geologic and geodynamic processes operating on planets (e.g., impact basins versus plate tectonics), the current style and distribution of heat loss (e.g., broad thermal rises versus plate boundary topography), the signatures of different tectonic processes (e.g., rifting, distributed deformation, convergent plate boundaries), the role of planation processes in surface evolution (e.g., continental and abyssal plains), and the relict signatures of processes that have operated in the past (e.g., continental margins on Earth, highland crust on the Moon). We use global Magellan altimetry data [1] to derive slope information for Venus, and we assess this information in terms of the: 1) range of slopes observed, 2) global slope frequency distribution, 2) variation of average slope with altitude, 3) geographic distributions of regional slopes, 4) the relation of regional slopes to classes of geologic features revealed by Magellan imaging data, and 5) relationship of regional slopes to geologic units and geological history.

Methods: In a previous study, analysis of relatively low resolution Pioneer-Venus altimetric data [2] gridded to $1^\circ \times 1^\circ$ was undertaken to produce and analyze regional and global slope data for Venus and to compare to Earth [3,4]. Regional slope values were calculated for each $3 \times 3$ pixel region of topography, giving a baseline of 300 km, and the effects due to oceanic loading on Earth were treated by removing the load. In this study we use the same techniques and approaches to derive detailed slopes using the global Magellan altimetry data (GTDR)[1]. Since each GTDR pixel measures 4.5 km, the baseline length is ~14 km, increasing the resolution of the resulting slope map by a factor of 20 over that derived from the PV data [3,4].

Results: 1) Range of slopes: The slopes calculated from the Magellan data range from 0° to 24°. This is higher than previously observed (0°-2.4° for the longer baseline PV data; [3]) because of the increased ability of the higher resolution Magellan data to resolve shorter-wavelength topography and slopes such as those observed along the western margin of Maxwell Montes and in the chasmata [2].

2) Global slope frequency distribution (Fig. 1): Previous work [3,4] showed the slope-frequency distributions of Venus and Earth to be quite different, an observation reinforced in the present study. The mean Venus slope derived from Magellan data is 0.6°, higher than the 0.14° observed for 300 km baselines [3,4], because of the much shorter baseline and resultant greater sensitivity to short, steep slopes. The modal value is 0.10°, comparable to that for the PV data (0.09°).

3) Variation of mean slope with elevation (Fig. 2): The PV data showed the mean slope to increase systematically with elevation; this is true as well for the Magellan data except that very high slopes are here observed for the lowest elevations, corresponding to chasmata walls. In contrast, the Earth exhibits a complex relationship marked by four modes which were interpreted to be related to the presence of an active, hydrosphere-driven weathering regime, a distinctive crustal dichotomy related to composition and thickness, and the presence of plate tectonics on Earth [3].

4) Geographic distributions of regional slopes: We produced global slope maps for each individual 0.1° interval of slope and studied the geographic distribution. The high resolution data shows that the surface of the lowlands has a tremendous and broadly distributed diversity of slopes in the range of $0^\circ$-$0.5^\circ$. No single area is regionally dominated by slopes in a particular 0.1-degree range, although trends can be seen, with northwestern Guinevere Planitia and parts of Aino Planitia showing some of the largest abundances of low slopes.

5) Relation of regional slopes to classes of geologic features revealed by Magellan imaging data: There is a very high correlation of steep slopes and the occurrence of tessera terrain [5]. Tesserae are outlined by distinctive changes in slope; these high resolution maps resolve individual linear components of tessera fabric and show numerous low-slope areas within tesserae seen to be post-tessera patches of volcanic plains. Chasmata [6] also show significant concentrations of very steep slopes (>5 degrees). There is evidence for slope variations with age: Beta and Atla rifts have the highest concentration of steep slopes. Channel and sinuous rille distribution [7] show a strong correlation with some regions characterized by the lowest slopes on Venus, as do several occurrences of extensive lobate lava flows [8], although some of these occur on the slopes of tesserae and ridge belts. Broad rises (Beta, Atla, Western Eistla [9]) are difficult to distinguish in the global slope maps except for minor changes in regional slope and the concentration of other features such as chasmata. The high resolution slope map provides an important tool for detection of coronae [10] in the plains; their shape and multiple ring structures are readily visible. Coronae are clearly responsible for some of the regional roughness of the venusian plains relative to terrestrial abyssal plains. Wrinkle ridges, seen as very small variations in slope, also contribute to the roughness of the regional plains.

6) Relationship of regional slopes to geologic units and geological history: We compared maps of regional slope distribution to geological maps of large regions of Venus, including a global latitudinal swath
mapped at 30°N [11], and a geologic map of the northern high latitudes (above ~35°N; [12]). We found that the highest slopes tended to be associated with tessera terrain, and the lowest slopes tended to be associated with the pervasive regional plains units (Pwr), but that there was a wide diversity of low-slope values in Pwr, apparently representing the presence of wrinkle ridges of various scales. Densely fractured plains (Pdf) and plains with shields (Psh), which are located along the margins of tessera, and embayed by Pwr, tended to characterized by slopes intermediate between the tessera and Pwr, suggesting that they were emplaced after the tessera, and deformed prior to the emplacement of Pwr.

Conclusions: These new slope data underline the major trends found in the PV data [3,4] and reveal the high correlation of regions of different slopes with various geologic features and units mapped from Magellan image data (e.g., channels, large flows). Among the most striking results of the high-resolution data are the details of the tectonic fabrics revealed in the tessera, and the abundance of coronae and coronae-like features seen in the plains and adjacent regions. Equally important is the indication of continuing (but decreasingly significant) deformation during the emplacement of these units, suggesting a positive correlation between slope and age. The fundamental difference in the slope distribution revealed by the comparison of PV Venus and Earth data (with Venus deficient in areas with 0° slope but enriched in areas with slope from 0.07° to 0.24° relative to Earth) is interpreted to be the result of corona topography and the distributed deformation associated with the wrinkle ridges on the globally pervasive ridged plains on Venus, as well as the effects of planation and deposition by the hydrological cycle on Earth.