rains, moderate-sized mountains, and sharp terrain boundaries. These features are chosen because the goodness of fit is likely to be most affected either by departures from normal incidence angles or by sharp changes in terrain type within a single footprint. Most large features that are elevated with respect to their surroundings will suffer from steep slope effects, and smaller coronae and impact craters will probably suffer due to rapid changes in their appearance within a single footprint (10–20 km).

Since the surface properties of Venus can be derived only through models, it is crucial that surface scattering models be as accurate as possible. The characterization of terrain and the physical quantities that are estimated from surface properties presume an acceptable level of precision in the data, and are misleading if truly incorrect. Once the problem areas are correctly identified, better estimates of surface properties may be obtained through models tailored to particular fitting difficulties. These surface properties, in turn, will provide a means to estimate physical characteristics of the planet's surface, and address the underlying geological processes.

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THE SOLAR WIND INTERACTION WITH VENUS.

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The Pioneer Venus Orbiter (PVO) mission has played a key role in establishing the nature of the solar wind interaction with Venus [1]. Although earlier probes had determined that Venus presented an obstacle much smaller than the size of Earth's magnetosphere to the solar wind, they did not carry out *in situ* measurements pertaining to solar wind interaction studies at low enough altitudes to determine why. They also did not provide datasets of sufficient duration to study the variability of the interaction on both short (one day) and long (solar cycle) timescales [2].

The first 600 of the nearly 5000 orbits of PVO magnetometer data have been used to determine a very low upper limit ($\sim 10^{-5}$ of the terrestrial value) on the intrinsic dipolar magnetic moment of Venus [3]. The consequence of that low magnetic moment is that the solar wind interacts directly with the upper atmosphere and ionosphere. Relative to a dipolar field obstacle, the ionospheric obstacle is rather incompressible. A "bow" shock is observed to stand in front of the nearly Venus-sized ionospheric obstacle at a comparatively steady subsolar altitude of $\sim 1.5\ R_v$ (Venus radii). This shock decelerates the supersonic solar wind plasma so that it can flow around the obstacle. It was found to change its average position in the terminator plane from about $2.4\ R_v$ to $2.1\ R_v$ as the solar cycle progressed from the 1978 orbit insertion near solar maximum through the 1986–87 solar minimum, and back again during the latest solar activity increase [4].

Between the bow shock and the ionosphere proper, the slowed solar wind plasma flow diverges near the subsolar point and makes its way across the terminator where it reaccelerates and continues anti-Sunward. The solar wind magnetic field, which is in effect frozen into the flowing plasma, is distorted in this "magnetosheath" region so that it appears to hang up or drape over the dayside ionosphere before it slips around with the flow. These features of the solar wind interaction are also seen when the obstacle is a dipole magnetic field, but there are two important distinctions.

In the wake of the Venus obstacle one finds an "induced" magnetic tail composed of varying interplanetary fields rather than the constant fields of intrinsic origin [5]. This "magnetotail" is further seen to be populated by heavy (O^+) ions that are evidently escaping from the planet at significant ($\sim 10^{-25}\ s^{-1}$) rates [6]. These heavy ions are also observed in the dayside magnetosheath [7]. The interpretation is that ions are produced by both photoionization and solar wind electron impact ionization of the upper neutral atmosphere that extends into the magnetosheath. The flowing solar wind plasma with its imbedded magnetic field "picks up" the ions and carries them tailward. While many escape, some of the picked up ions impact the dayside atmosphere and sputter neutrals [8]. By these means, the solar wind interaction plays a role in the evolution of the Venus atmosphere, although its importance relative to other loss mechanisms is still undetermined. In any event, because the planetary heavy ion contribution to the plasma in the magnetosheath varies with the solar cycle, it may be the cause of the aforementioned shift in the bow shock position. For all the above reasons, researchers sometimes consider that the Venus-solar wind interaction is in many ways cometlike. These features are all a consequence of the weak intrinsic magnetism, and as such should be relevant to Mars [9] where future measurements are likely to further elucidate the scavenging processes.

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N93-14342

EXTENSIVE LAVA FLOW FIELDS ON VENUS: PRELIMINARY INVESTIGATION OF SOURCE ELEVATION AND REGIONAL SLOPE VARIATIONS.

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Large-volume lava flow fields have been identified on Venus [1], the most areally extensive (>50,000 km²) of which are known as "fluctus" and have been subdivided into six morphologic types [2]. Sheetlike flow fields (Type 1) lack the numerous, closely spaced, discrete lava flow lobes that characterize digitate flow fields. Transitional flow fields (Type 2) are similar to sheetlike flow fields but contain one or more broad flow lobes. Digitate flow fields are divided further into divergent (Types 3–5) and subparallel (Type 6) classes on the basis of variations in the amount of downstream flow divergence. Flows that are radially symmetric about a central source (e.g., volcanic shield or corona) are typical of Type 3 flow fields, whereas a similar but slightly asymmetric apron of flows about a central source is characteristic of Type 4 flow fields. A fan-shaped flow field that widens substantially in its distal regions is typical of Type 5 flow fields. Type 6 flow fields (e.g., Mylitta and Kaiwan Fluctus) are not radially symmetric about a central source and do not widen or diverge substantially downstream.

As a result of our previous analysis of the detailed morphology, stratigraphy, and tectonic associations of Mylitta Fluctus [3], we have formulated a number of questions to apply to all large flow fields on Venus. In particular, we would like to address the following: (1) eruption conditions and style of flow emplacement (effusion rate, eruption duration), (2) the nature of magma storage zones (presence of neutral buoyancy zones, deep or shallow crustal magma chambers), (3) the origin of melt and possible link to mantle plumes, and (4) the importance of large flow fields in plains evolution. To answer these questions we have begun to examine variations in flow field dimension and morphology; the distribution of large flow fields in terms of elevation above the mean planetary radius (MPR ~ 6052 km); links to regional tectonic or volcanic structures (e.g., associations with large shield edifices, coronae, or rift zones); stratigraphic relationships between large flow fields, volcanic plains, shields, and coronae; and various models of flow emplacement in order to estimate eruption parameters.

In this particular study, we have examined the proximal elevations and topographic slopes of 16 of the most distinctive flow fields that represent each of the 6 morphologic types. The locations, dimensions, and source characteristics of these flow fields are tabulated elsewhere [2]. The distribution of this subset of large flow fields with respect to altitude of the proximal portion of the flow field (nearest any identified or presumed source region) is shown in Fig. 1. Of the 16 flow fields in this sample, 9 have source regions at elevations between 6051.5 and 6052.25 km. Three are found at elevations below 6051.5 km and five are located above 6052.25 km (only two are situated above 6053.5 km). This distribution is skewed toward slightly higher elevations than that expected if the distribution were uniform with respect to the percentage of surface area at each elevation interval. This may reflect the fact that the majority of flow fields in this sample are associated with fracture belts, volcanic shields, and coronae located within large rift zones that are locally elevated several kilometers above the MPR.

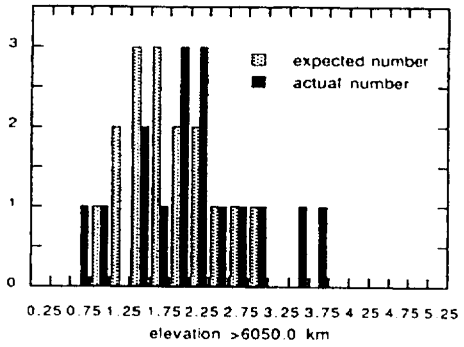

Fig. 1. Histogram of proximal flow field elevation.

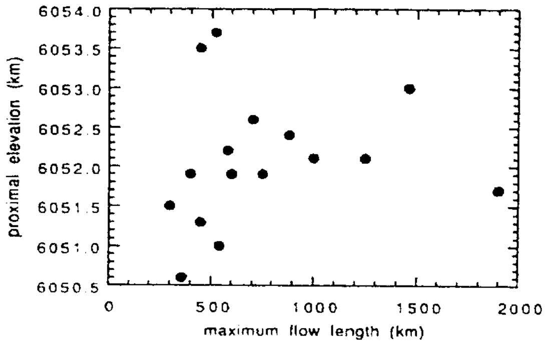

Fig. 2. Proximal elevation vs. flow length.

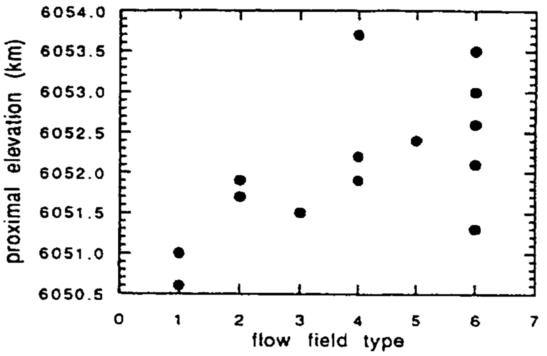

Fig. 3. Proximal elevation vs. flow field type.

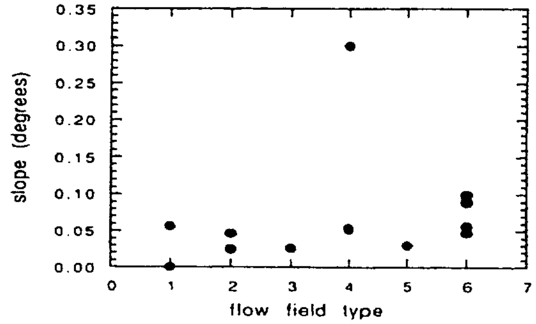

Fig. 4. Slope vs. flow field type.

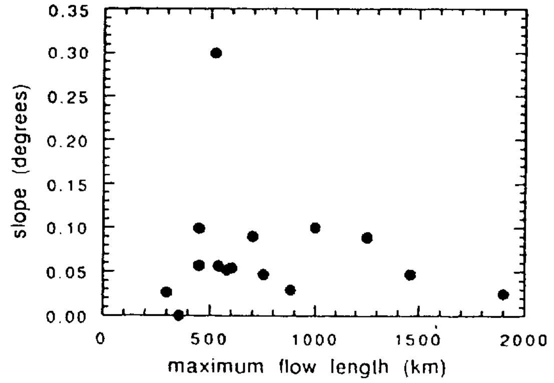

Fig. 5. Slope vs. flow length.

A recent theoretical analysis of magma reservoirs and neutral buoyancy zones on Venus [4] has indicated that large-volume eruptions should be favored at elevations near and below the MPR due to the potential lack of shallow-level magma chambers in regions of low elevation (a result of increased atmospheric pressure). This prediction is broadly consistent with the fact that the majority of flow fields in this study appear to cluster near the MPR. However, there does not appear to be a strong correlation between flow length (taken as an indicator of flow volume) and proximal elevation (Fig. 2). According to the results of the analysis mentioned above, the largest flow volumes (or lengths, as in this study) are predicted to have occurred at the lowest elevations. The trend in Fig. 2 appears to be the reverse of this, with the longer (and presumably more voluminous) flows erupting at higher elevations. However, proximal elevation appears to exert some control on flow field morphology (Fig. 3) to the extent that sheetlike flow fields (Types 1, 2) occur at lower elevations than digitate flow fields (Types 3–6). If digitate flow fields represent multiple individual eruptions of lower volume than sheetlike flow fields, then the fact that sheetlike flow fields appear to have been erupted at lower elevations is consistent with the above predictions. These results are only preliminary, however, and do not represent the entire population of large flow fields or take into consideration the possibility of postemplacement elevation of topography.

In addition, preliminary results indicate that topographic slope has little control on flow length or morphology (Figs. 4 and 5). Given the variation in abundance of discrete flow lobes, flow distribution, and downstream divergence among the flow field types, one might have expected a stronger correlation between flow morphology and slope. It is possible that small-scale variations in local slope beyond the resolution of our data may be associated with variations in flow field morphology.

We are currently extending this analysis to the entire population of large-volume flow fields on Venus and are further investigating implications for their origin and emplacement mechanisms.

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N93-14343

WRINKLE RIDGES ON VENUSIAN PLAINS: INDICATORS OF SHALLOW CRUSTAL STRESS ORIENTATIONS AT LOCAL AND REGIONAL SCALES.

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The plains regions of Venus exhibit a complex array of structural features, including deformation belts of various types, wrinkle ridges, grabens, and enigmatic radar-bright linears [1,2,3]. Probably the most pervasive of these structures are the wrinkle ridges, which appear to be morphologically identical to their counterparts on the Moon and Mars. Almost all workers agree that wrinkle ridges result from horizontal compressive stresses in the crust; they either are explained as flexural fold structures, or alternatively as scarps or folds related to reverse faults [3-8]. Wrinkle ridges generally are narrow, have small amplitudes, and commonly are closely spaced as well, characteristics that imply a shallow crustal origin.

If wrinkle ridges are due to horizontally directed compressive stresses in the shallow crust, as generally has been inferred, then the trends of these features provide a means to map both local and regional orientations of principal stresses in the uppermost part of the venusian crust: maximum compressive stress is normal to the ridges, minimum compressive stress is normal to the topographic surface, and thus the wrinkle ridge trends trace the orientation of the intermediate principal stress. Because there are few plains areas on Venus totally devoid of wrinkle ridges, it should be possible to establish a number of interesting relationships on a near-global scale by mapping the trends of wrinkle ridges wherever they occur. The present study is addressing three questions: (1) Do the trends of wrinkle ridges define domains that are large relative to the sizes of individual plains regions? If so, can these domains be related to large-scale topographic or geologic features? (2) Are regional trends of wrinkle ridges affected by local features such as coronae? If so, is it possible to determine the relative ages of the far-field and local stresses from detailed study of trend inheritance or superposition relationships? (3) What is the relationship between wrinkle ridges and the larger ridges that make up ridge belts?

Mapping completed as of May 1992 includes parts of Lavinia, Guinevere, Sedna, Tinatin, and Aino Planitiae. Detailed maps of wrinkle ridge trends have been prepared by systematically displaying all of the 56 tiles making up each C1-MIDR on CDROM on a high-resolution monitor connected to a SUN SPARCstation 2. The observed trends are then plotted on the corresponding hard copies of the full MIDRs. The detailed maps are used to generate more generalized plots of wrinkle ridge trends that are digitized and combined for presentation as a global display.

The patterns defined by wrinkle ridge trends vary widely. The simplest cases occur where the ridges all have about the same trend over a very large area, as is the case for much of that portion of Lavinia Planitia imaged on C1-MIDR45s350 [3]. At many localities, however, there are two or even three definable sets of wrinkle ridges with clearly distinct trends. In places, ridges of one set curve into a merging relationship with another set; in other places, one set seems to truncate another; in still other places, sets cross each other, commonly without clear clues concerning relative age. At a few localities, the pattern made by wrinkle ridges can be described as "cellular"; in such places, it is difficult to distinquish any dominant sets defined by trend. Cellular patterns may well indicate localities where the horizontal compressive stresses in the shallow crust are very nearly isotropic. Preliminary results suggest at least partial answers to the three questions posed above.

Trends of wrinkle ridges do define domains that occupy a large fraction of the area of a single C1-MIDR or large fractions of two or more adjacent C1-MIDRs. The boundaries between these domains commonly are regions occupied by complex ridged terrain or elevated young volcanic terrains, but some boundaries do not relate to any obvious geologic or topographic feature. These more enigmatic boundaries are interesting because they may define more subtle regional crustal features. Clearly, wrinkle ridges must be mapped over a substantial fraction of the planet before the large-scale domainal characteristics can be fully understood.

The regional trends of wrinkle ridges that define the large-scale domains clearly are affected by at least some local features, especially coronae. Part of the concentric structure that characterizes coronae consists of closely spaced ridges that are morphologically indistinguishable from wrinkle ridges. The relationships commonly are complex, but in a number of cases it appears as if the regional set of wrinkle ridges both cuts across a corona and is warped into parallelism with the concentric corona structure. A good example occurs where a strong regional set of wrinkle ridges trending slightly north of east interacts with concentric structures related to Heng-O. Some wrinkle ridges parallel to the regional set cross the eastern margin of Heng-O and extend into the center of the structure. Along the northeastern margin of Heng-O the regional wrinkle ridges bend to merge into the corona concentric structure, but also appear to be in part overprinted by these concentric structures. Along the northern and southern margins of Heng-O the regional set of wrinkle ridges appears to be simply enhanced. These relationships suggest that the stresses associated with the formation of Heng-O interacted with far-field stresses; Heng-O formed in part at the same time that the far-field stresses were active, in part later than the far-field stresses. At least some smaller coronae show similar geometric and kinematic relationships with regional wrinkle-ridge sets, but much more work needs to be done before a definitive conclusion can be reached concerning relative ages.

Detailed work in Lavinia Planitia has focused attention on an apparent paradox. Using stratigraphic relationships that are clearer