flows emanate and flow northward from east-trending fractures parallel to Diana Chasma. Radar-dark flows flooded the region north of Diana Chasma.

The circular structures comprising Eastern Aphrodite Terra are connected by east-northeast-striking fracture sets that dominantly postdate formation of the circular structures, although locally deformation related to the circular structures cross-cuts the regional fractures. The regional fracture set trends parallel to the radar look direction, and therefore the character of the fractures is difficult to distinguish. However, we interpret the regional fractures as troughlike features on the basis of their sharp boundaries and relatively straight and continuous character (i.e., they are not anastomosing). We further interpret these features as regional extensional fractures similar in nature to fractures of the Guor Linea trough region of Eistla Regio [9].

Formation of these structures is consistent with the model for coronae formation outlined by Squyres et al. [10]; however, we are able to document successive outward stepping of the nested concentric fractures with time. Initial circular uplift of the crust, caused by rising and spreading magma, leads to the formation of radial and concentric fractures. With further uplift the crustal welt grows in diameter and new concentric fracture sets are formed. Once the welt reaches a critical diameter, a moat forms around its perimeter, outward from the oldest concentric fracture set. Lava escapes out of the concentric fractures filling the moat. Within 14S/164 flows emanate from the concentric fracture sets with diameters of ~240, 380, and 510 km. Less viscous radar-dark flows may predate the escape of more viscous radar-bright flows, which can be traced back to individual vents. As the structure continues to expand outward the zone of concentric fractures steps outward and the earlier-formed fracture set and moat are uplifted. A new concentric fracture set and moat form. The newly formed concentric fractures deform earlier-formed volcanic flows, and new flows emanate from these new fractures. This process continues until the structure reaches an average diameter of ~600-800 km. The concentric fracture set may not be equally well developed around the entire 360° arc; in fact, structure 14S/164 is developed around an arc of ~270°. We interpret that the circular structures within Eastern Aphrodite Terra formed in a manner similar to that of 14S/164. This model is similar to a model of corona formation by blistering of the lithosphere as a result of the ascent of a magma diapir to the base of the lithosphere [9,10], although the sequence of deformation and volcanism proposed here is different. Magma diapirs rising passively within a region of crustal extension may be responsible for the circular structures that characterize Eastern Aphrodite Terra [e.g., 11].

Subduction and Spreading: Eastern Aphrodite Terra appears to lack the cross-strike discontinuities proposed from Pioneer Venus data. In addition, it lacks crustal or structural symmetry, which might be predicted for a terrestrial-type rift zone. The area is dominated by circular features as opposed to linear features transected by transform faults. The proposed transform fault [5] that joins Diana and Dali Chasmas is comprised of ridges with no apparent strike-slip or noncoaxial shear component preserved across the belt. In addition, the ridge zone appears to curve into parallelism with east-striking fractures in both Diana and Dali Chasmas; further, the orientation of the ridge belt with respect to the proposed extension troughs (Diana and Dali Chasmata) is kinematically infeasible to be a transform structure.

If Diana and Dali Chasmata are subduction zones as proposed [5], the presence of the radar-bright flows is puzzling as the region north of Diana Chasma should be a subducting lower plate. In addition, a subduction scenario requires a structural distinction between upper and lower plates. However, radial fractures from the center of Latona can be traced through and across its southern boundary (e.g., 21°S, 167.7°E). The continuity of structures across the trough also argues against the interpretation of this trough as a subduction zone [i.e., 5–7]. Furthermore, terrestrial subduction zones are <180°, and generally <120° along their arc, whereas these circular structures are often preserved up to 270°, and locally up to 360°. Subduction along >180° is kinematically difficult; subduction along 270° is even more difficult. In addition, the diameters of the circular features within this region are much smaller than subduction zones on Earth. Artemis, the largest of the circular structures in this region, is equivalent in size to the Sandwich Islands subduction system [5–7], one of the smallest terrestrial subduction zones. Therefore, we believe that Eastern Aphrodite Terra does not represent a zone of major lithospheric spreading, nor does it represent a region of terrestrial-like subduction. Rather, detailed analysis of SAR imagery indicates that Eastern Aphrodite Terra may be the result of rising magma diapirs that blister the surface within a zone of lithospheric tension.

In conclusion, Eastern Aphrodite Terra is dominated by circular structures within which deformation and volcanism are intimately related. These structures are marked by radial and concentric fractures, and volcanic flows that emanate from a central vent, as well as from concentric fracture sets. Cross-cutting relations between flows and concentric fracture sets indicate that outer concentric fractures sets are younger than inner fractures sets. The circular structures are joined by regional northeast- to east-trending fractures that dominantly postdate formation of the circular structures. We propose that the circular structures "grow" outward with time. Although these structures probably represent addition of crust to the lithosphere, they do not represent significant lithospheric spreading or convergence, and the region does not mark the boundary between two distinct tectonic plates. This region is not easily explained by analogy with either terrestrial midocean rifts or subduction zones. It is perhaps best explained by upwelling of magma diapirs that blister the surface, but do not cause significant lithospheric spreading [1]. Further study of the structural and volcanic evolution of this region using Magellan altimetry and SAR data should lead to better understanding of the tectonic evolution of this region.

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N93-14322

WESTERN APHRODITE TERRA, TECTONICS, GEOLOGY, AND LINE-OF-SIGHT GRAVITY. John E. Hays and Paul Morgan, Department of Geology, Box 6030, Northern Arizona University, Flagstaff AZ 86011–6030, USA.

Aphrodite Terra is the largest area of high-standing topography on Venus, and isostatic considerations strongly suggest that this high topography is supported at least in part by thickened crust [1]. Previous studies of line-of-sight gravity data from the Pioneer Venus orbiter indicate rapidly changing apparent depths of compen-

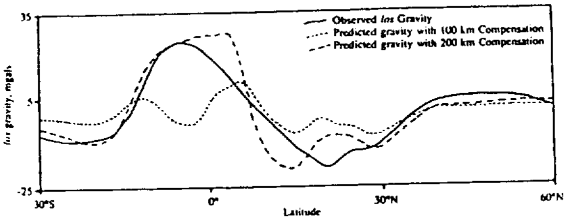

Fig. 1. Observed and predicted line-of-sight (los) gravity as a function of latitude for orbit 440 of the Pioneer Venus orbiter [from 4]. Line extends from approximately 30°S, 77°E to 60°N, 122°E, and the location of the southern portion of the line with respect to the region mapped from Magellan data is shown on Fig. 2. Predicted gravity values were computed using ORBSIM, an orbital simulation program [5], assuming perfect isostatic compensation of topography with compensation masses at 100 and 200 km, as indicated.

sation across Aphrodite Terra as shown in Fig. 1 [2–4]. Magellan imaging data provide the first detailed images of this region, and we are mapping the region along Pioneer Venus orbit 440 to investigate whether the changing apparent depths of compensation correlate with changes in surficial tectonics.

We have commenced our mapping effort at the southern end of Pioneer Venus orbit 440, where the gravity modeling indicates good agreement among the observed los gravity and los gravity predicted with a 200-km apparent depth of compensation, but less agreement with los gravity predicted for a shallower depth of compensation. We have mapped three C1 radar images (C1-MIDRP.15S095;1, C1-MIDRP.15S077;1, and C1-MIDRP.30S081;1) at a scale of approximately 4,000,000:1, and these maps are summarized in Fig. 2. Along the portion of Pioneer Venus orbit 440 covered by these images, surface features include a major corona in relatively smooth lowland plains to the south of Aphrodite Terra at an elevation of about –1 km relative to mean planetary radius (mpr), and the steep rise to the axis of Aphrodite Terra in tessera and tectonized terrain at elevations up to 4 km above mpr. In this region, the terrains and the topography appear to be relatively well correlated, but the large apparent depth of compensation (200 km, Fig. 1) suggests that this correlation may be fortuitous. The gravity data suggest that the primary compensation of western Aphrodite Terra is in the mantle, and may not be directly linked to crustal thickness variations associated with surficial tectonics.

Immediately to the north of the area covered by the map in Fig. 2 there is very poor correlation among the observed and predicted los gravity data for apparent compensation depths of either 100 or

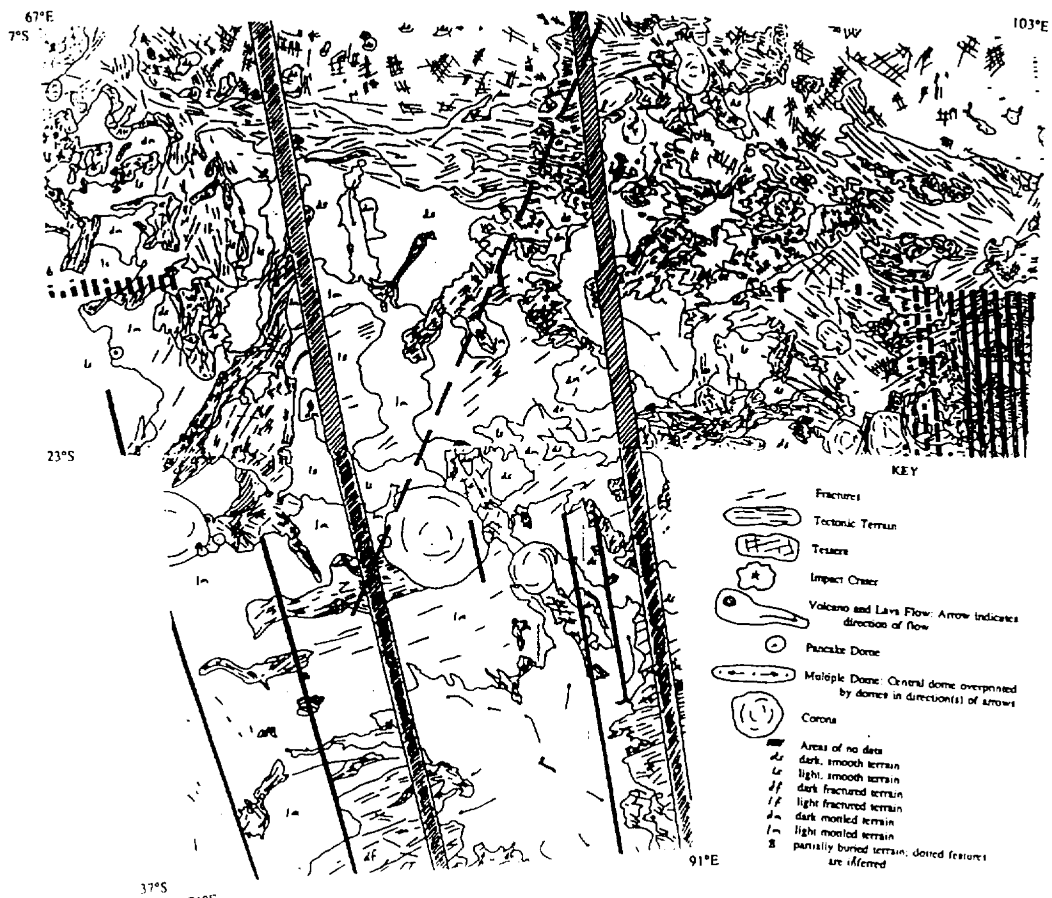

Fig. 2. Sketch map of the geological features of a region of southern, western Aphrodite Terra covered by Magellan images C1-MIDRP.15S095;1, C1-MIDRP.15S077;1, and C1-MIDRP.30S081;1. Mapped area is approximately 3600 km in longitude and 3100 km in latitude. Dashed line shows the approximate location of the southern end of useful los gravity data available from orbit 440 of the Pioneer Venus orbiter.

200 km. The apparent depth of compensation appears to shallow from about 200 km at 7°S to close to 100 km at about 10°N. Preliminary mapping of this region (image C1-MIDRP.00N095;1) indicates complex terrain, dominated by tessera, and represents the northern slope of Aphrodite Terra where elevations drop to around mpr or lower. We interpret this region to be a zone of rapidly changing crustal thickness, resulting in a relatively shallow apparent depth of compensation. Five impact craters have been mapped in this region, perhaps suggesting that this may be a region of relatively old crust.

At approximately 20°N, the observed and predicted los gravity anomalies are roughly anticorrelated, a low in the observed gravity corresponding to highs in the predicted gravity for compensation depths of both 100 and 200 km. Much of this region is below an elevation of –1 km relative to mpr, and the relatively dense subsurface predicted by the isostatic models is clearly in error. Subsurface densities appear to be less dense than expected in this region, suggesting flexural or more likely dynamic control of this low topography. Coronae and fractured volcanic features dominate this region.

From approximately 30°N to 60°N the observed and predicted los gravity anomalies are in reasonable agreement, and there is clearly little resolution of the apparent depths of compensation in this region as there is little difference among the anomalies predicted for 100- and 200-km compensation depths. This region is mostly lowland plains at an elevation of -0.5 ± 0.5 km relative to mpr. Major terrain differences between this region and the region immediately to the south, where observed and predicted gravity are very poorly correlated, are not readily apparent in the Magellan images.

Preliminary mapping of geological features on Magellan images along the path of Pioneer Venus orbit 440 do not indicate a first-order correlation among surface features and changes in the apparent depth of compensation of los gravity data. The apparent depth of compensation appears to be most variable in regions dominated by tessera, but not all areas of tessera have distinct gravity signatures. There is a weak correlation among areas in which impact craters are relatively common and areas in which the observed and predicted gravity anomalies are poorly correlated.

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N93-14323

VENUS VOLCANISM: A GLOBAL OVERVIEW FROM MAGELLAN DATA. J. W. Head[1], L. S. Crumpler[1], J. C. Aubele[1], and the Magellan Team, [1]Department of Geological Sciences, Brown University, Providence RI 02912, USA.

A preliminary analysis of a global survey of Magellan data covering over 90% of the surface and designed to document the characteristics, location, and dimensions of all major volcanic features on Venus has revealed over 1660 landforms and deposits [1]. These include over 550 shield fields (concentrations of small volcanos <20 km in diameter), 274 intermediate volcanos between 20 and 100 km diameter with a variety of morphologies, 156 large volcanos in excess of 100 km diameter, 86 calderalike structures independent of those associated with shield volcanos and typically 60–80 km in diameter, 175 coronae (annulus of concentric ridges or fractures), 259 arachnoids (inner concentric and outer radial network pattern of fractures and ridges), 50 novae (focused radial fractures forming stellate patterns), and 53 lava flood-type flow fields and 50 sinuous lava channels (all of which are in excess of 10^2–10^3 km in length).

The near-global coverage of Magellan data analyzed in this study confirms and extends the results of earlier observations [2] that showed that volcanism is a widespread and significant process on the surface of Venus for the period of time in the presently observed record (less than about the last one billion years [3,4]). Volcanic units comprise in excess of 80% of the surface of the planet, and indeed the remainder of the planet largely consists of tessera, which itself may be deformed lava flows. The minimal influence of erosion on the surface results in the stunning preservation of the wide array of volcanic features and edifices documented in this study. The high-resolution and global coverage of the Magellan image data has provided the opportunity for the global inventory [1]. On the basis of the characteristics of the landforms and deposits, the vast majority of the units appear to be of basaltic composition, consistent with the results of the earlier Venera landers [5]. However, important morphologic variations suggest a wider range of lava compositions on the surface, consistent with a range of petrogenetic environments [6]. For example, the morphology of the steep-sided domes and festoons [7,8] suggests that they may represent more viscous magmas with more evolved compositions. Long sinuous rilles and channels may indicate the location of sites of extrusion of ultramafic or other very fluid magmas [9]. The large lava floods indicate that effusions comparable to terrestrial flood basalts were a relatively common occurrence on Venus. In addition, the array of features that have associated volcanism strongly suggest that volcanism is related to a wide variety of scales of mantle upwelling, from hot-spot-like plumes of about 200 km diameter [10] to much larger several thousand-kilometer-diameter broad rises such as Beta and Atla Regiones [11]. Similarly, the variations in surface morphology and amount of associated volcanism of many of these features strongly suggest that there is a wide range of intrusive and extrusive processes operating, including the largely intrusive aspects of arachnoids, the radial dikelike patterns associated with novae [10,12], and the predominantly extrusive large volcanos. Indeed, there is some evidence that there may be an evolutionary sequence of features beginning with novae, extending through large volcanos, and ending in coronae. Evidence also exists for large calderas, coronae, and other features that indicate that many magma reservoirs may be relatively large on Venus compared to Earth. One of the major outstanding questions in Venus volcanology is the nature of the melting process, the evolution of the melts, and the intrusion to extrusion ratios typical of different environments.

The distribution of volcanic features on Venus (Fig. 1) is not concentrated along linear zones, such as the divergent and convergent plate boundaries concentrations seen on Earth. This, and the distribution of impact craters [3,4], is further evidence for the lack of large-scale crustal spreading in the last hundreds of millions of years. However, the distribution is not random, and there is evidence for a major Tharsis-like concentration in the Beta/Atla/Themis region that covers about 20% of the planet and is probably related to major mantle anomalies [1,13]. There is also a deficiency of many features in the lowlands and this is attributed to a combination of altitude-dependent eruption conditions [14] and partial burial of features in lowland regions. Ongoing detailed analysis of these