EASTERN APHRODITE TERRA,VENUS: EVIDENCE FOR ADDITIONAL DIVERGENT PLATE BOUNDARY CHARACTERISTICS AND CRUSTAL SPREADING FROM DIANA CHASMA TO ATLA REGIO; L.S. Crumpler and J. W. Head, *Department of Geological Sciences, Brown University, Providence, R.I. 02912*

Introduction. The combination of linear discontinuities, regional and local symmetry, offset of symmetry axes, and predictable regional altimetric form in *Western* Aphrodite, have been interpreted recently as analogous to many of the characteristics occurring at terrestrial spreading centers [1, 2]. The continuity between the Western and Eastern Aphrodite raises the question of whether or not the two segments of the equatorial highlands share a similar structure and origin. There are numerous morphologic similarities between Eastern Aphrodite and Western Aphrodite, as well as some fundamental morphologic differences. In the following we examine the known characteristics of *Eastern* Aphrodite using techniques previously applied in Western Aphrodite in order to address this question.

General Characteristics and Analysis. Eastern Aphrodite, naturally divided from Western Aphrodite along CSD 8 at the eastern margin of Thetis Regio, is relatively ridge-like, and rises 1 to 2 km above the surrounding lowlands. Linear chasma, 1 to 3 km deep such as Diana and Dali, previously interpreted as possible extensional rift zones [3,4], strike approximately N70-90°E along the rise crest, and each is typically accompanied by flanking ridges. Distinctive domical mountains 2 to 3 km high that occur distributed about the flanks of the chasma are responsible for much of the local relief throughout Eastern Aphrodite, their isolation and association with the central rift-like chasma suggests that they may be large volcanoes.

Linear discontinuities. Several characteristics of the central rise crest in Eastern Aphrodite are segmented along the strike including (i) central chasma, (ii) rise crest axis, and (iii) margins of the highland, and offsets in each of these features results in an overall segmented appearance. The detailed characteristics of the rise crests flanks, such as the abundance and distribution of the domical mountains and the paired ridges and troughs parallel with chasma, differ in directions at right angles to each chasma segment, accentuating the overall segmented appearance of the highland. These changes in the flanks and central chasma are relatively abrupt, occur across linear zones of regional altimetric rise or fall according to high-resolution Arecibo altimetric profiles [5] crossing their projected lowlands locations, and are oriented at right angles to the strike of the highland. When plotted on the altimetric contour map (Fig. 1), these zones define a series of nearly-parallel, linear discontinuities crossing the overall east-west strike of the highland at approximately right angles to the strike of the central chasma and with orientations similar to the CSD's previously identified in Western Aphrodite.

Bilateral Symmetry. Altimetric profiles across Eastern Aphrodite parallel to the discontinuities are regionally symmetric with one or more deep central troughs along the altimetric crest [5], and with sloping flanks that tend to be convex in the west and more concave toward the east. Alternating ridges and troughs are frequently symmetrically distributed about the central rise crest, which together with the central troughs, are equidistant from the 6052 km altimetric contour marking the morphological margin of the highland. In addition to the offset of chasma and other features, altimetric profiles show that the central axis of symmetry in adjacent profiles parallel to the discontinuities is offset across each of the identified discontinuities in a manner similar to those in Western Aphrodite.

Interpretation of Similarities between Eastern and Western Aphrodite. In Western Aphrodite, linear discontinuities striking across the highland are similar to fracture zones and transform faults in terms of their length, width, altimetric form, nature of their influence on the highlands, and the way in which the regional altimetry steps up or down across them[1,2,6]. Western Aphrodite contains a symmetry similar to that derived from thermal boundary layer-related topography on the seafloor [6], and a bilateral symmetry of small scale features like that formed by the splitting, separating, and drifting apart of individual altimetric features initially formed on a rise crest [7].

The linear discontinuities, regional symmetry characteristic, altitude of the slopes, slope coefficents, and slope lengths in Eastern Aphrodite are similar to that in Western Aphrodite. The altitude varies as the square root of distance from the central rise crest symmetry axis in both highland areas, and because of this, the regional slopes can be accurately predicted in directions at right angles to the symmetry axes. Whereever there is an offset in the symmetry axis, regional altimetric steps and discontinuities such as those that are observed in the highland are a predicted consequence. In addition, the slopes are similar in both broad behavior and overall magnitude to that predicted from simple thermal boundary layer theory in general [8,9], and similar in particular to that predicted for a thermal boundary layer topography on Venus in association with diveregence at rates of 0.5 to 2 cm/yr.

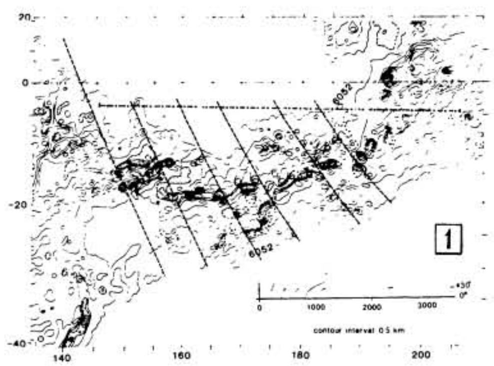
Interpretation of Differences between Eastern and Western Aphrodite. Western and Eastern Aphrodite highland show a range of fundamental morphological and structural similarities, but Western Aphrodite is dominated by central plateaus, whereas Eastern Aphrodite is characterized by a relatively simple ridge-like form similar to "normal" rise crests on Earth (Fig. 2). Plateaus, similar to Western Aphrodite, are known to form along rise crests on Earth in which the characteristic thermal boundary layer topography occurs in the lowlands and the plateau (13). Oceanic rise-crest plateaus are currently restricted in occurrence on Earth where anomalous volcanism has resulted in a greater than average crustal thickness. Rise crest plateaus may have been more common at times in the past, particularly during the Cretaceous

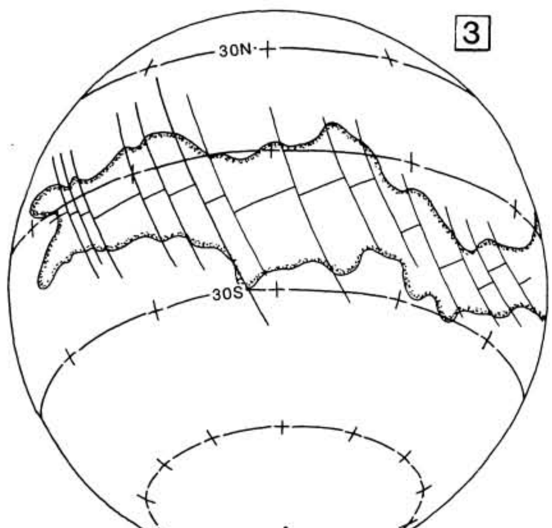
[10], as the abundance of oceanic plateaus in the Western Pacific suggests.

The origin of the difference between normal rise crests (normal crustal thickness) and rise crest plateaus (larger than average crustal thicknesss) can be related to any of the processes that result in anomalous mantle melting, including chemical, thermal, and convective inhomogeneities in the mantle characteristics, or the interaction of a "plume" with a normal divergent boundary as proposed for Iceland [11]. Recently, Reid and Jackson [12] have disscussed how relatively small differences in mantle temperature on Earth will result in excess melting, volcanism, and crustal thickness along a divergent boundary in which the resulting crustal thicknesses will be characteristic of oceanic plateaus. If Aphrodite Terra represents a divergent plate boundary, the plateau-like form of Western Apohrodite can result from an increase in the crustal thickness [1] associated with modest local increases in mantle temperature [13].

Conclusions. Eastern and Western Aphrodite Terra are similar in a variety of characteristics, including linear discontinuities, axial symmetry, and predictable surface altitude characteristics with respect to distance from the symmetry axes. These characteristics in association with the length, width, parallelism, offset of symmetry axes, and influence on the highlands of discontinuities, as well as the evidence for extensional rifting, large volcanoes, and axial plateaus are comparable to the known charcteristics of spreading centers on Earth. The differences between Western Aphrodite (central symmetric plateaus) and Eastern Aphrodite (symmetric ridge) can occur along spreading centers where the underlyinng mantle supplying melts to the rise crest is characterized by variable temperatures. For regions of higher temperature, ano volcanism and crustal thicknesses result, and a broad plateau replaces a normal rise crest. The total length of Eastern and Western Aphrodite is 14,000 km, or more than one-third of the global circumference, implying that spreading center characteristics may exert an influence on the tectonic style of a significant proportion of the surface of Venus (Fig.3).

References. [1] Head. J.W., and L.S.Crumpler, 1987, *Science* **238**, 1380-1385. [2] Crumpler, L.S., and J.W. Head, 1988, *Jour. Geophys. Res.* **93**, 301-312. [3] McGill, G.E., and others, 1982,*Venus, (U.ofA.Press)*, 69-130. [4] Schaber, G.G., 1982, *Geophys. Res. Letts.* **9**, 499-502. [5] Crumpler, L.S., and J.W. Head, 1989, Eastern Aphropdite, in prep. [6] Crumpler,L.S., and J.W.Head, 1989, Western Aphrodite, in prep. [7] Crumpler, L.S., and J.W.Head, 1988, *LPSC XIX*, 235-236, and in prep. [8] Davis, E.E., and C. R.B. Lister, 1974, *Earth Planet. Sci. Letts.* **21**, 405-413. [9] Parsons, B. and J.G.Sclater, 1977, Jour. Geophys. Res. **82**, 803-827. [10] Ben-Avraham, Z., and others, 1981, *Science* **213**, 47-54. [11] Vink, G.E., 1984, *Jour. Geophys. Res.* **89**, 9949-9959. [12] Reid, I., and H.R. Jackson, 1981, *Marine Geophys. Res.* **5**, 165-172. [13] Sotin, C., and others, 1989, submitted to *Earth Planet. Sci. Letts.*





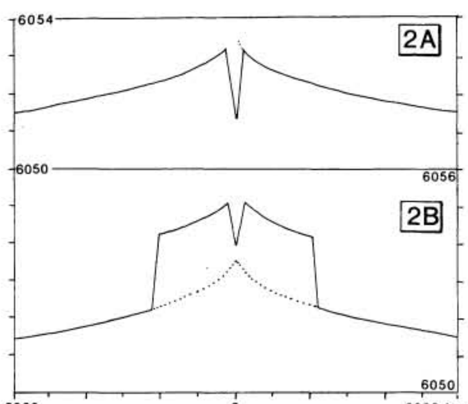


Figure 1. Location and distribution of linear discontinuities within the highland part of Eastern Apohrodite.

Figure 2. Difference between "normal" rise crest like that in Eastern Aphrodite(A), and rise crest with anomalous crustal thickness similar to that in Western Aphrodite (B).

Figure 3. Global perspective on the distribution of known linear discontinuities and symmety axes in Aphrodite Terra