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DIVERGENT PLATE BOUNDARIES AND CRUSTAL SPREADING ON VENUS: EVIDENCE FROM APHRODITE TERRA.

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Introduction. The modes of lithospheric heat transfer and the tectonic styles may differ between Earth and Venus, depending on how the high surface temperature (700K = 430°C), dense and opaque atmosphere (~10 MPa = 100 bars), lack of water oceans, and the other known ways in which Venus differs from Earth, influence basic lithospheric processes, thermal gradient, upper mantle temperature, thermal and chemical evolution, and convection. A fundamental question is whether the lithosphere of Venus is horizontally stable, like the other terrestrial planets, or is mobile like that on Earth. Previous studies have suggested on the basis of the presence of rift-like topography [1, 2] that Aphrodite Terra may be a zone of relatively recent lithospheric extension and potential volcanism. Large positive correlations between gravity and topography [3] similarly suggest that the current topography is supported dynamically by mantle convection perhaps with associated volcanism [4,5,6]. Tectonic deformation in these models is mainly vertical and the crustal extension is limited, representing either traction from mantle convection beneath [7] or rifting resulting from stresses associated with gravitational spreading of high-standing regional topography [8, 9]. Recently, the detailed characteristics of Aphrodite Terra and the equatorial highlands have been analyzed and interpreted to be analogous to divergent plate boundaries on Earth [9, 10, 11, 12], a model which is distinguished primarily by the requirement of large horizontal motions of the surface and lithosphere similar to that associated wih plate tectonics on Earth. This interpretation is based on (a) the presence of linear discontinuities crossing the approximately east-west strike of Aphrodite Terra with many of the characteristics of oceanic fracture zones, (b) bilateral symmetry in directions parallel to these linear discontinuities similar to that associated with (i) evolving thermal boundary layers and (ii) splitting and separating of features along rise crests by crustal spreading at divergent boundaries, and (c) a variety of map [11] and geophysical [13] relationships consistent with the presence of features linked to both crustal spreading and the thermal evolution of lithosphere migrating over great distances laterally away from a zone of extension and crustal creation.

Crustal Spreading and Plate Boundary Characteristics. Zones of crustal spreading and divergent plate boundary characteristics display organized relationships, many of which may be predicted on the basis of the existence of rise crest offsets at transform faults and fracture zones in the presence of horizontal divergent motions of a thermal boundary layer. If Western Aphrodite Terra represented processes similar to a spreading center and divergent plate boundary, we would expect to see (i) a broad symmetric altimetry associated with a thermal boundary layer in which regional symmetry and overall altimetry may be approximated as a surface which descends as the square root of distance and at a rate consistent with the form of a thermal boundary layer , (ii) offset of this symmetry at nearly right angles along linear transform faults, (iii) continuation of the transform zone beyond the offset ends of the rise crest as fracture zones, (iv) regional step up or down in altimetry of the surface across the CSD's depending on the sense of the rise crest offset, and (v) differences between the detailed features of the surfaces in adjacent rise crest segments which are (vi) individually symmetric about the rise crest and the result of splitting and drifting apart of topography associated with anomolous crustal production.

Observed Characteristics of Aphrodite Terra. These predicted characteristics of the organized relationship between divergent plate boundaries processes may be compared with observed altimetric and radar image characteristics in Western Aphrodite Terra which include (i) broad symmetry which is quantitatively similar to that predicted for thermal boundary layer topography [14, 15, 16] diverging at rates of a few centimeters per year in the environment of Venus [17, 18]. Least squares analysis of altimetric profiles show that the plateau-like highlands of Western Aphrodite are similar also in slope to adjacent lowlands and differ mainly in absolute altitude (Fig. 2). This symmetry occurs along linear axes and is also frequently (ii) offset at right angles along through-going and linear and parallel discontinuities (CSD's) which (iii) can be traced for several thousand kilometers across the highlands and into the surrounding lowlands. Altimetric profiles in the lowlands across the CSD's show that there is frequently a (iv) regional altimetric step up or down across the CSD's depending on whether the horizontal sense of offset across the CSD moves the rise crest closer or farther away respectively. Removal of the broad symmetry of a thermal boundary layer from the altimetric profiles across Aphrodite Terra results in a (v) residual short wavelength topography which is shown to be symmetric about the same symmetry axis (Fig. 3), and (vi) which differs in character from one domain to the next.

Conclusions. The variety of characteristics, their detailed integrated relationships, and their predictable behavior throughout Western Aphrodite Terra are similar to those features known to occur in association with the terrestrial seafloor at spreading centers and divergent plate boundaries. We conclude that Western Aphrodite Terra represents the site of crustal spreading and displays many of the characteristics of divergent plate boundaries [11]. The extent of similar characteristics and processes elsewhere on Venus outside of the 13,000 km long Western and Eastern Aphrodite Terra rise is unknown at the present, but their presence in other areas of the equatorial highlands, suggested from recent analysis[12], may be tested with forthcoming Magellan data.

DIVERGENCE/CRUSTAL SPREADING: Crumpler, L.S., and Head, J.W.

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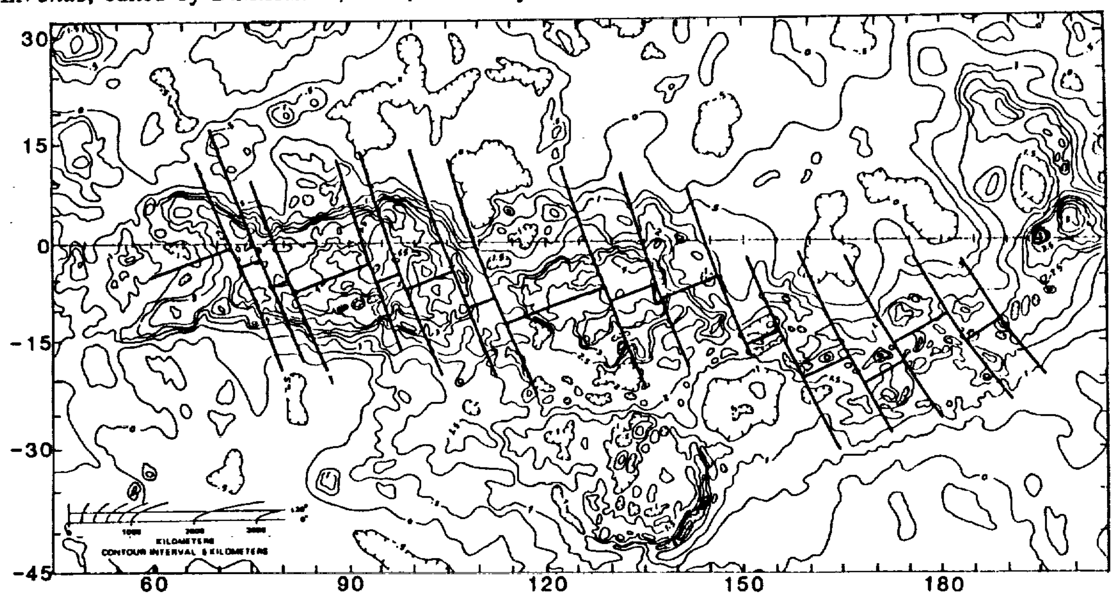

Figure 1. Altimetric map of Aphrodite Terra showing location of identified CSD's and axes of bilateral symmetry.

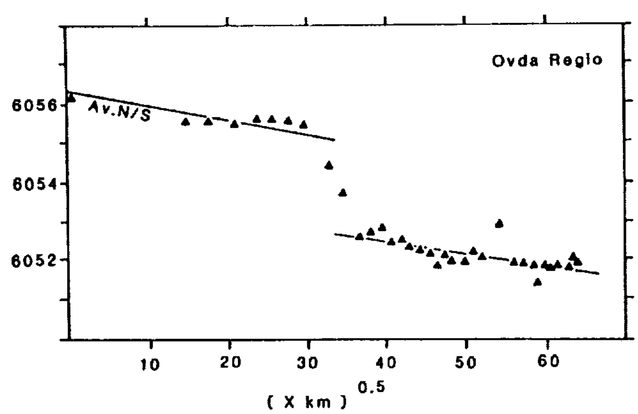

Figure 2. Example of altimetry in direction parallel to CSD's plotted as a function of the square root of distance. Lines are best fitting linear trend through the data for the highlands and lowlands evaluated separately.

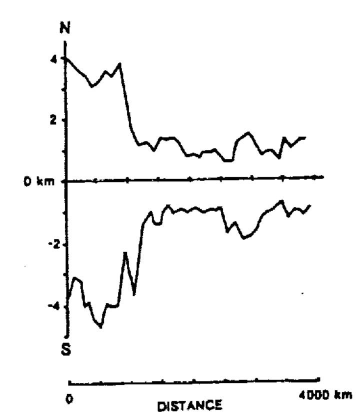

Figure 3. Example of residual altimetry after removal of the thermal boundary layer-like component, $f(X^{0.5})$. The data from the north and south flanks are plotted together, one inverted beneath the other.