Evidence for Divergent Plate-Boundary Characteristics and Crustal Spreading on Venus

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Detailed examination of the topography and morphology of western Aphrodite Terra reveals numerous features that are similar to terrestrial divergent plate-boundary characteristics. Individual domains between fracture-zone–like discontinuities contain a variety of bilaterally symmetrical topographic elements that suggest that topographic features have been created at rise crests, rifted and separated, and moved laterally to their present symmetrical positions. The topographic and morphologic similarities, together with strikingly similar mirror-image map patterns on both sides of the rise axis, suggest that western Aphrodite Terra shares the characteristics of oceanic divergent plate boundaries, and is the site of crustal spreading on Venus. Topographic profiles are consistent with spreading rates of the order of several centimeters per year.

PLANETARY EXPLORATION DURING THE LAST 25 YEARS HAS revealed a variety of tectonic styles on the planets and satellites. The smaller terrestrial planetary bodies (Moon, Mercury, and Mars) are characterized by a single, global unsegmented lithospheric plate that stabilized very early in solar system history. In contrast, segmented, laterally mobile, and continuously recycling lithospheric plates characterize plate tectonics on Earth. Planetary heat loss on the small one-plate planets is dominated by conduction, whereas most of the heat loss from Earth's interior is associated with plate recycling processes (*1*). Venus is similar to Earth in size, density, and position in the solar system, but differs in atmospheric density and composition, surface temperature, lack of oceans, unimodal frequency distribution of topography, and the positive correlation of topography and gravity at long wavelengths. A fundamental question in planetary tectonics for the last decade has been the nature of tectonics on Venus, and the implications for mechanisms of lithospheric heat transfer (*2*). Is Venus, because of its similarities to Earth in major bulk properties, also similar to the present-day Earth in terms of mechanisms of lithospheric heat transfer and the presence of plate recycling? If not, what are the mechanisms, and what are the factors that cause similar planets to have different mechanisms of heat transfer?

Answers to these questions have not been forthcoming because of the difficulty in penetrating through the opaque Venus atmosphere to obtain global high-resolution images that would show the surface and the nature and distribution of tectonic features. The available data include global low-resolution topography and surface property information (*3, 4*), gravity and low-resolution images at low latitudes (*5, 6*), local and regional high-resolution images from Earth-based radar telescopes (*7, 8*) and orbiting spacecraft (*9*), equatorial Earth-based high-resolution altimetry (*10*), and surface observations and measurements from landers (*11*). On the basis of these data, proposals have been made that Earth-like crustal spreading and plate recycling do not occur, or are not significant on Venus (*12–14*), that hot spots are the primary mechanism of heat loss (*15*), and, alternatively, that the primary mechanism has not yet been resolved (*2*).

There is general agreement that one of the most distinctive low-resolution signatures of crustal spreading and plate recycling on Earth is the presence of the global network of oceanic rises and their thermal boundary-layer topographic character and symmetry. Several previous workers examined global Venus topography to search for such rises and concluded that a global network like that on Earth did not exist and that although some areas met several of the criteria for divergent plate boundaries, plate recycling was not a globally significant process (*13*), if it existed at all. Building on these initial studies, and focusing on those areas where broad topographic symmetry of segments of the equatorial highlands have been documented (*6, 13, 16*), we have been impressed with the great linear extent of these highlands, and the global patterns of topography and slope related to the equatorial highlands (*6, 17*). We have explored the nature of the topography and geologic structure of the extensive linear highland regions on Venus (exemplified by Aphrodite Terra) using a variety of data sets (*18–23*), and we have found evidence for linear discontinuities very similar to terrestrial oceanic fracture zones and associated broadly bilaterally symmetrical topography and topographic elements (*18–21, 23*). Many previous studies have emphasized broad geophysical considerations in discussing

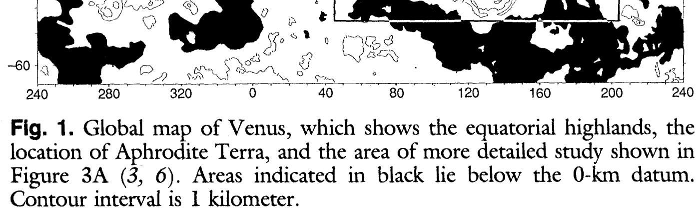

Fig. 1. Global map of Venus, which shows the equatorial highlands, the location of Aphrodite Terra, and the area of more detailed study shown in Figure 3A (*3, 6*). Areas indicated in black lie below the 0-km datum. Contour interval is 1 kilometer.

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