

THE STATE OF STRESS IN VENUS' LITHOSPHERE FROM LONG WAVELENGTH GRAVITY AND TOPOGRAPHY. W. Bruce Banerdt and R. Stephen Saunders, Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA 91109.

One of the great surprises of the Pioneer Venus mission was the high degree of correlation between topography and gravity found at all wavelengths (1). This implies a close relationship between topography and lateral density anomalies, such as passive or dynamic compensation (2), and indicates that sources at great depth do not contribute significantly to the gravity field (3).

If all density anomalies are assigned to the lithosphere and lateral movements (such as plate tectonics) are excluded, global stress trajectories can be computed for various modes of topographic support. These stress trajectories can then be compared with observed tectonic features in order to constrain models of the planet's interior (4).

Assuming a Sleep-Phillips (5) type compensation model with a variable crustal thickness and a variable mantle density, we have used thick shell (4) and thin shell (6,7) theory to investigate three "end-member" cases: 1) loading by topographic construction, resulting in a downward deflection of the surface (no mantle support); 2) pure isostatic support of a constructional load (no surface deflection); 3) topography due entirely to upward deflection of the surface supported by a low-density upper mantle (no surface load). All models were required to simultaneously satisfy the observed Venusian topography (8) and gravity (9) through harmonic degree and order 7.

The stress patterns generated for these three cases are markedly different, and should provide some clear diagnostic information on types of support when coupled with tectonic observations. Unfortunately, global resolution at present is not sufficient to clearly delineate fault systems. Higher resolution images are available for certain small regions, but without a broader sample, it is difficult to judge the magnitude of local effects. What observations are available tentatively suggest that Venus falls somewhere between case 2 and case 3, implying some degree of dynamic or thermal support (10,11). Our models imply extremely thick crust and dense lithosphere for Ishtar Terra and Ovda Regio (western Aphrodite), slightly thinner crust and bouyant lithosphere for Tethus Regio and regions near Sappho and Apha Regio, and slightly thickened crust with a bouyant lithosphere for Beta Regio and Alta Regio (eastern Aphrodite). This latter finding is consistent with the interpretation of lightning bursts (12) being associated with active volcanism. The most likely regions of active volcanism include those where lightning discharges were observed, that is, Beta and central and eastern Aphrodite. Western Aphrodite, although elevated, appears to have a thicker crust and higher density (colder) mantle. Ishtar Terra is apparently a region of thicker crust and higher density mantle that would not be a likely site of recent volcanism under our interpretation of these models.

Venus topography appears to be supported by a combination of isostatic and dynamic mechanisms. Since these lead to different regional stress systems, we can use observations from Earth-based, Venera 15/16 and Venus Radar Mapper to constrain the models for different regions. Simple isostatic support (case 2) of Aphrodite would imply stresses that favor a system of east-west trending graben across the entire region. Uplift (case 3) would provide a nearly orthogonal regional stress system.

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