STRESS DISTRIBUTION AND TOPOGRAPHY OF TELLUS REGIO,

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The Tellus Regio area of Venus represents a subset of a narrow latitude band where Pioneer Venus Orbiter (PVO) altimetry data (1), line-of-sight (LOS) gravity data (2), and Venera 15/16 radar images (3,4) have all been obtained with good resolution. Tellus Regio also has a wide variety of surface morphologic features, elevations ranging up to 2.5 km, and a relatively low LOS gravity anomaly. This area has therefore been chosen in order to examine the theoretical stress distributions resulting from various models of compensation of the observed topography. These surface stress distributions are then compared with the surface morphology revealed in the Venera 15/16 radar images. Conclusions drawn from these comparisons will enable constraints to be put on various tectonic parameters relevant to Tellus Regio.

The stress distribution is calculated as a function of the topography, the equipotential anomaly, and the assumed model parameters. The topography data is obtained from the PVO altimetry. The equipotential anomaly is estimated from the PVO LOS gravity data. The PVO LOS gravity represents the spacecraft accelerations due to mass anomalies within the planet. These accelerations are measured at various altitudes and angles to the local vertical and therefore do not lend themselves to a straightforward conversion. A minimum variance estimator of the LOS gravity data is calculated, taking into account the various spacecraft altitudes and LOS angles and using the measured PVO topography as an a priori constraint. This results in an estimated equivalent surface mass distribution, from which the equipotential anomaly is determined.

Banerdt (6) has solved equations for a global thin elastic shell, representing the elastic portion of the lithosphere. The assumptions inherent in these solutions are that the shell thickness is less than about 1/10 the planetary radius, that the shell is isotropic, single-layered, and continuous, and that the toroidal terms, representing rotational forcing, can be neglected compared to the poloidal terms, which account for pure loading. Solving these equations requires one further assumption, which will vary depending on the particular model chosen. These models currently include: 1) topographic support due entirely to a combination of density anomalies in the mantle, lithospheric flexure, and the resulting deflection of the crust-mantle boundary, 2) support due to crustal thickness variations combined with lithospheric flexure and deflection of the crust-mantle boundary, and 3) a support model where both mantle density anomalies and crustal thickness variations are considered, and the shell flexure is proportional to the topography. The equations are solved for subsurface mass distribution and lithospheric flexure using the topography and surface equipotential anomaly as data. We also assume a lithospheric, crustal, and upper mantle thickness for a given model. The flexure and mass results are used to solve for a surface stress distribution, which is represented as magnitudes and directions of principal tensile and compressive stresses.

Banerdt's original formulation (6) solves for the surface spherical harmonic coefficients on a spherical shell. We have recast the solutions to be applicable to Fourier coefficients in order to solve for regional scale in addition to global scale stresses. The dependence of the solutions on spherical shell geometry has been retained. The solutions themselves give the short and intermediate wavelength stresses generated by topography and flexure in the immediate vicinity of the Tellus Regio area. These regionally induced stresses are combined with the long-wavelength global stress field, calculated using the spherical harmonic formulation. The stress distribution is then compared to the surface features shown in the high resolution Venera radar images of the Tellus Regio area.

The Tellus Regio area exhibits a wide range of geological features (figure 1). These include complex systems of long sub-parallel ridges and grooves (trending in various directions) and associated wide valleys and flat depressions. A large proportion of the central part of this region is characterized by a chaotic parquet terrain. The northern and southern margins of the elevated region are covered with plains-forming material. A preliminary sketch map is being

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prepared for comparison with the stress distribution results. Preliminary calculations of regional stress distribution show close correlation between principal stress directions and various surface features. For the case of density anomalies in the mantle loading the lithosphere from below, or supporting a lithosphere loaded at the surface, unreasonably high stresses on the order of 1 to 3 kbars result. If crustal thickness variations are included in the solution, and the lithospheric flexure is assumed to be proportional to the topography, more reasonable values for the regional surface stresses result, on the order of 0.1 to 0.5 kbar. Assuming a thinner lithosphere decreases the magnitude of these stresses only slightly. Calculations for an end-member lithosphere with a thickness of only 1 km show stresses ranging up to ~ 0.3 kbar. Variations in assumed crustal thickness have almost negligible effect on the magnitude of the stresses. The principal tensional and compressive directions are perpendicular to the dominant linear surface features for values of flexure consistent with a lithosphere loaded from above. Solutions for regional stresses for a lithosphere loaded from below do not show a good qualitative match between stress direction and surface morphology.

References

(1) Pettingill et al., J. Geophys. Res., 85, 8261-8271, 1980, (2) Sjogren et al., J. Geophys. Res., 85, 8295-8302, 1980, (3) Barsukov et al., J. Geophys. Res., 91, D378-D398, 1986, (4) Basilevsky et al., J. Geophys. Res., 91, D399-D411, 1986, (5) Kaula, Theory of Satellite Geodesy, 1966, (6) Banerdt, J. Geophys. Res., 91, 403-419, 1986, (7) Phillips et al., J. Geophys. Res., 83, 5455-5464, 1978.
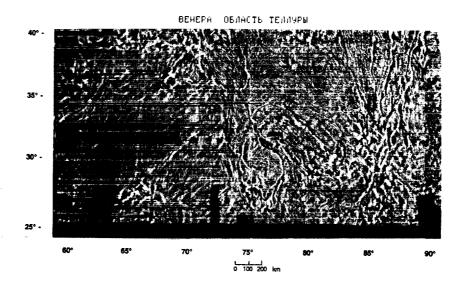

FIGURE 1
Venera 15/16 radar image of Tellus Regio