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ESTIMATES OF LITHOSPHERIC THICKNESS ON VENUS: C. L. Johnson and D. T. Sandwell, Scripps Institution of Oceanography, La Jolla, CA 92093 - 0215

Summary

Magellan altimetry data have revealed many examples of topographic flexure on Venus. Modeling of flexural features is of interest as it provides information on spatial (and for the earth, temporal) variations in lithospheric thickness. Lithospheric thickness may be determined solely from modeling topographic flexure or by combining gravity and topography data. On Venus even the highest resolution gravity is insufficient for modeling all but the very longest wavelength flexural features, so we rely heavily on altimetry data for information about lithospheric thickness. Sandwell and Schubert [1] modeled flexure around four coronae and found lithospheric thicknesses h, in the range 35 - 70 km. Studies of several more flexural features [2] suggests that these are typical of Aphrodite Terra and other chasmata regions on Venus [2]. However lithospheric thicknesses associated with other regions are in the range 15 - 30 km [2]. McKenzie et al.[3] noted that part of Aphrodite Terra appeared similar in planform and morphology to the subduction zones of the East Indies on Earth. Other flexure studies using Magellan data have looked at smaller coronae [4] (h = 5-30 km), and rifts [5] (h = 8-20 km). It can be seen that the range of thicknessses suggested by studies to date is extremely large and it is difficult to establish whether their mean is in agreement with that predicted by heat flow scaling arguments (h ~ 18km) [6]. Here we present results from a global study of flexure on Venus, with particular emphasis on the variation in our results with different tectonic settings.

Analysis and Results

Initially 12 flexural features were modeled assuming a 2-D loading geometry applied to a thin elastic plate [1]. This approximation is valid for any features with a sufficiently large ratio of radius of curvature to flexural wavelength. The model predicts lithospheric thickness, surface stresses (which can be compared with deformation patterns seen in the SAR images) and a bending moment associated with the flexure. The mechanical thickness of the lithosphere can be estimated once a yield strength envelope for the lithosphere is assumed. Preliminary results for the 12 features are shown in figure 1. The distinction between the much larger thicknesses associated with Aphrodite Terra and the smaller values obtained for other areas can be clearly seen.

Modeling of terrestrial gravity - topography admittance has shown that approximating a 3-dimensional feature by a 2-dimensional feature can lead to an overestimate of elastic thickness [7]. On Venus most flexural signatures are associated with either linear loads (e.g. chasmata) or axisymmetric loads (coronae). If we consider flexure due to a ring load, width Δa, (e.g. coronae), then the important parameter is the ratio of the (planform) radius of curvature (a) to the flexural

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parameter (α). As a/α exceeds a critical value the load can be approximated by a 2-D load of width Δa. We have investigated the validity of a 2-D approximation to an axisymmetric geometry in the following way. Synthetic flexure profiles were generated for ring loads with increasing a/α for a given $\Delta a/\alpha$ (0.1). Our 2-D flexure code was then used to retrieve the best fitting flexural parameter. When a/α exceeds about 2 the 2-D model provides a good fit to the synthetic profile and it also yields a correct estimate of the true flexural parameter (Figure 2). However, for a/α less than about 2, the 2-D model overestimates the true flexural parameter by up to 10%. While this overestimate may appear acceptable, the fits of the 2-D model to the synthetic profile is quite poor, especially on the outer rise. This type of approach allows a quantitative discrimination between features requiring an axisymmetric model and those for which a 2-D approximation is valid. For example, the radius of Latona is 340 km and the estimated flexural parameter is 70 km so it is appropriate to use a 2-D model in this case. Smaller features require axisymmetric modeling. Estimates of lithospheric thickness for such features will be presented.

It has been suggested that viscous models for lithospheric bending on Venus are more appropriate than purely elastic models. We have investigated bending of a viscous lithosphere at Latona Corona using the approach of DeBremaecker [8]. This allows the quantity $h^3\eta U$ to be established where h is the sheet thickness, η is the viscosity of the sheet and U is the bending rate. To estimate the elastic thickness we need to make some assumption about the viscosity and the horizontal velocity. Preliminary results for Latona indicate that a viscous model requires a thick lithosphere unless the horizontal strain rate is very high. Stresses predicted by the viscous model are much lower than those predicted by thin elastic plate theory as expected.

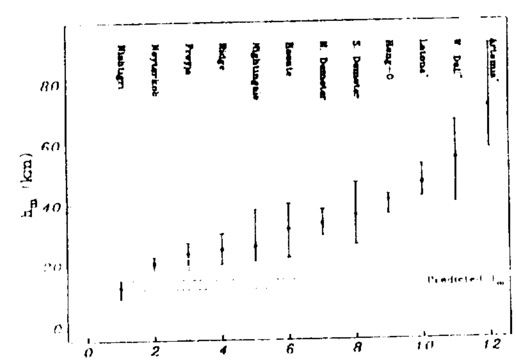

Figure 1: Mechanical thicknesses for 12 features on Venus. Features within Aphrodite are denoted by an asterisk. Dashed lines give predicted range [6].

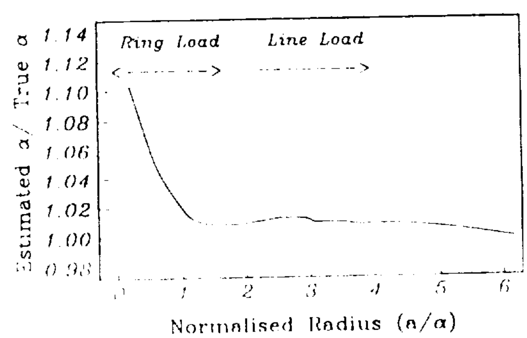

Figure 2: Ratio of estimated flexural parameter (2-D model) to true flexural parameter (3-D axisymmetric geometry) for increasing a/α.

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