VENUS TECTONICS: ON THE RELATIONSHIP OF ISOSTATIC TOPOGRAPHY TO THE WAVELENGTHS OF SURFACE DEFORMATIONAL FEATURES;

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The spatial distribution and structural characteristics of tectonic surface features on Venus provide a basis for understanding the thermal, mechanical, and compositional structure of the lithosphere. Tectonic features in many areas of the surface consist of sub-parallel lineations [1-4] which exhibit well-defined wavelengths [5-7]. Continuum deformation models suggest that these features formed in response to unstable horizontal extension or compression of the lithosphere, and that the wavelengths are controlled mainly by the depth distribution of lithospheric strength [5,6]. Surface features that exhibit two wavelengths indicate that the lithosphere contains two strong layers, which may correspond to the upper crust and upper mantle, separated by a weak layer which may correspond to the lower crust. Features that exhibit a single, short wavelength (10-20 km) spacing may be explained by a lithosphere which contains a thick crust overlying a weak mantle.

The lithospheric strength stratification is sensitive to crustal thickness and vertical thermal gradient. Surface topography, which is also related to the crustal thickness and temperature, may provide an important observational constraint on the lithospheric structure. A high thermal gradient and/or a thick crust, both of which correspond to a high isostatic surface elevation [8], will reduce the strength and thickness of the strong upper mantle layer. A low thermal gradient and/or thin crust, which correspond to a low surface elevation, will reduce the thickness of the weak lower crustal layer.

To investigate the relationships between crustal thickness, thermal gradient, and topographic elevation on Venus, we consider two simple lithospheric thermal structures. The first is a transient cooling halfspace in which the surface thermal gradient is defined on the basis of the characteristic depth of the temperature distribution. The second is a conducting steady state thermal boundary layer which contains a crust with radiogenic heat-producing elements. In the latter case the lithosphere is underlain by a convecting asthenosphere that supplies a constant heat flux to the base of the lithosphere. Figure 1 shows the isostatic elevation d as a function of crustal thickness c for a range of surface thermal gradients for the cooling halfspace model. Note that surface topography is more sensitive to crustal thickness than to thermal gradient, and that observable differences in isostatic topography may indicate significant crustal thickness variations.

The dominant wavelengths of tectonic features, which are controlled by the lithospheric strength stratification, should also vary with crustal thickness. Figure 2 illustrates this relationship for an unstably extending Venus lithosphere. For small crustal thicknesses, either two or three dominant wavelengths are expected, depending on whether the upper mantle layer is viscous (deforming mainly by creep) or plastic (deforming mainly by faulting). For larger crustal thicknesses a single wavelength of four times the upper crustal layer thickness is predicted for both models. Figure 2 was constructed without regard to the amplitude of the growth rate associated with a given dominant wavelength. However, if multiple dominant wavelengths develop, the dominant growth rates should be of comparable magnitudes. This additional constraint may result in limits on the range of lithosphere rheologies which can produce multiple wavelengths of deformation.

Dominant wavelengths and surface topography are measurable quantities on Venus. Figures 1 and 2 illustrate that these quantities should be correlated, and that the relationship between them would provide constraints on Venus' crustal thickness and lithospheric structure.

References: [1]Campbell, D.B., et al. (1983) *Science, 221*, 664-667. [2]Campbell, D.P., et al. (1984) *Science, 226*, 167-170. [3]Barsukov, V.L., et al. (1986) *J. Geophys. Res., 91*, D378-D398. [4]Basilevsky, A.T., et al. (1986) *J. Geophys. Res., 91*, D399-D411. [5]Zuber, M.T. (198[illegible]) *J. Geophys. Res.*, in press. [6]Zuber, M.T. (1986) *Lunar Planet. Sci. Conf. XVII*, 979-980. [7]Banerdt, W.B. and M.P. Golombek (1986) *Lunar Planet. Sci. Conf. XVII*, 22-23. [8]Morgan, P., and R. Phillips (1983) *J. Geophys. Res., 88*, 8305-8317.

Figure 1. Isostatic elevation *d* vs. crustal thickness *c* for the cooling halfspace model for surface thermal gradients of 12 and 22 K km^{-1}. The calculations assume $T_{surface}$=700 K, T_{mantle}=1350 K, ρ_{crust}=3000 kg m^{-3}, and ρ_{mantle}=3300 kg m^{-3}. For a mantle heat flux q_m=74E-3 W m^{-2} and crustal heat production *H*=1.E-7 W m^{-3}, the steady state conduction results are similar to those of the cooling halfspace model for dT/dz_o 20 K km^{-1}.

Figure 2. Dominant wavelengths (L_d/h_l) and wavenumbers ($k_d' = 2\pi h_l / L_d$) vs. crustal thickness (*c*) for viscous and plastic upper mantle layers for the Venus lithosphere in extension. Assumes plastic ($n_l = 10^4$) upper crust, and viscous ($n_2 = n_4 = 3$) lower crust and mantle substrate, h_l=5 km, and $h_l + h_2 + h_3$=25 km where h_l, h_2, and h_3 correspond to the upper crustal, lower crustal, and upper mantle layer thicknesses.

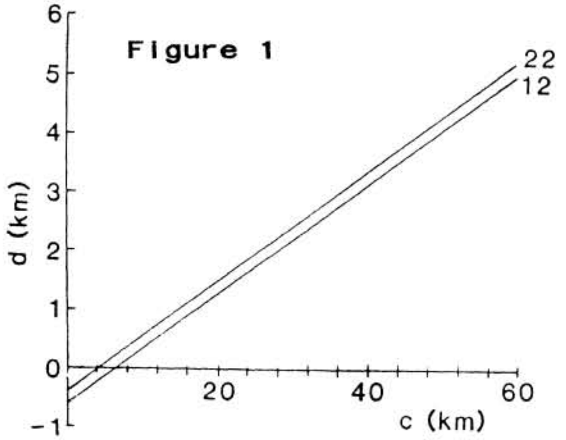
Figure 1

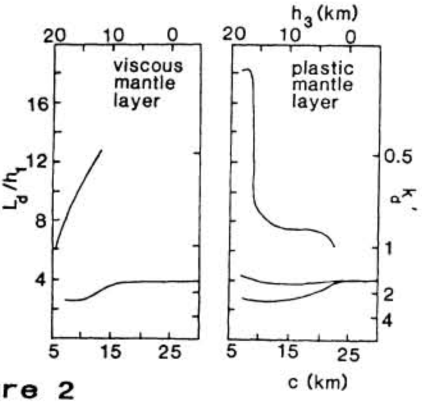

Figure 2