TEPEV MONS AND THE ELASTIC LITHOSPHERE OF VENUS: AN ASSESSMENT OF FLEXURE MODELS. Sean C. Solomon, Dept. of Earth, Atmospheric, and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, MA 02139, and James W. Head, Department of Geological Sciences, Brown University, Providence, RI 02912.

Introduction. An important but unresolved issue for Venus is the magnitude of the heat flux from the interior. The mean heat flux is closely related to the bulk composition and thermal history of the planet [1], while variations in heat flux within and among tectonic provinces - if known - would constrain the formative processes for different tectonic regimes and the mode of interaction of mantle convection with the Venus lithosphere [2]. One indirect measure of heat flux is the thickness T_e of the elastic lithosphere inferred from the flexural response to surface loading, since the lithospheric thickness is limited by the temperature-dependent depth at which ductile behavior dominates brittle behavior at flexural strain rates [3]. Janle et al. [4] first drew attention to an approximately annular depression surrounding the volcano Tepev Mons in Bell Regio. Under the assumption that this depression is of flexural origin, Janle et al. inferred from the radial position and depth of the depression that the elastic lithosphere is 30-100 km thick beneath the volcano.

This range of values for T_e presents a problem. With the assumption that such an elastic lithosphere thickness exceeds the thickness of the crust [5,6], so that the ductile strength of the lower lithosphere is limited by the flow law for dry olivine [3], T_e may be converted to the equivalent depth T_m to the base of the mechanical lithosphere [7] and the average lithospheric thermal gradient [8]. If T_e is 30-100 km and the characteristic flexural strain rate is 10^{-16} s^{-1}, the implied lithospheric thermal gradient is 3-8 K/km [8]. For thermal conductivities of 2.5 and 4 W/m-K for crustal and mantle material, these gradients are equivalent to heat flow in the range 10-27 mW/m^2, values substantially less than the global average of 74 mW/m^2 expected by scaling from Earth [1] and also less than that implied by the thickness of the elastic lithosphere indicated by the flexural reponse to underthrusting of the North Polar Plains of Venus beneath Freyja Montes [8]. There is no reason to expect that the thermal gradient and heat flow in the Tepev Mons region of Bell Regio should be less than in the North Polar Plains to the north of Freyja Montes, a region near the planetary modal elevation [9]. To the contrary, the broadly elevated rise of Bell Regio, the numerous associated volcanic constructs [10,11], and the large apparent depth of isostatic compensation of relief [12,13] suggest that Bell Regio is a site of mantle upwelling and a heat flux that is greater than the global average or that typical for plains units.

In this paper we reevaluate the topographic and geological evidence relevant to lithospheric flexure beneath Tepev Mons. We reexamine the lithospheric thickness and thermal gradient implied by the flexure hypothesis, and we assess the validity of that hypothesis.

Geological Setting. Venera radar imaging and altimetry indicate that Bell Regio is a broad uplift variously faulted by limited extension and partial subsidence [11,12]. The elevated region includes a number of distinct volcanic centers as well as two exposed areas of tesserae older than the plains units that constitute much of the surface (Fig. 1). Venera 15 and 16 altimetric data provide the highest resolution topographic information for the region, but because southern Bell Regio is near the southern limit of coverage, track-to-track spacing is a rather large 140 km. On only a single Venera 16 orbit was the topography of the central Tepev Mons constract sampled (Fig. 2). The depressions outward of Tepev Mons to the NW, NE, SE and S (Fig. 1) re similarly coarsely sampled in the E-W

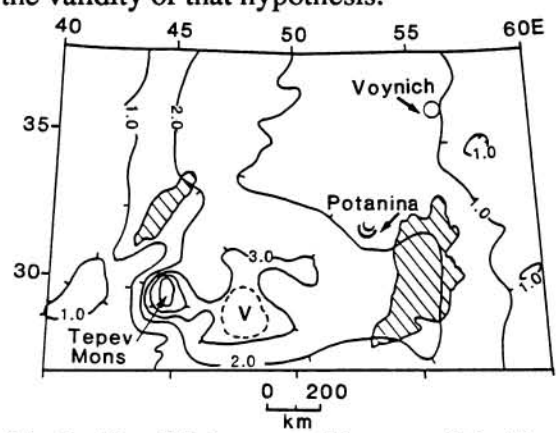

Fig. 1. Simplified topographic map of the Tepev Mons region of southern Bell Regio [12]. Contours are elevation in km with respect of a planetary radius of 6051 km. Shading denotes tesserae. A very broad volcanic construct east of Tepev Mons is indicated by the V. Two impact craters are also noted.

direction, and most of these depressions may simply be relative lows between Tepev Mons and high-standing terrain to the east (a broad volcanic center [14]), north (tessera), and west. Whether these depressions form a quasi-continuous annulus and whether this annular deep is of flexural origin [4] are open to question.

Flexural Interpretation of Topography. If we disregard other potential sources of topography exterior to Tepev Mons, then we may test the hypothesis [4] that the depressions arranged approximately circumferential to the construct are signatures of lithospheric flexure. The only reliable topographic profile with which to assess the hypothesis is that obtained along the single orbit that sampled the volcano itself. Even that profile (Fig. 2) indicates that the topography outward of the construct is asymmetric, with a depression indicated on the northern limb but no clear depression to the south.

We have fit the northern limb of the profile in Fig. 2 to a flexural loading model for Tepev Mons. For a circularly symmetric approximation to the volcano profile, we represented the volcano as a stack of coaxial cylinders of density 3.0 g/cm^3. For a range of assumed values for T_e, we calculated the deflection profile [15] outward of the volcano, after scaling the total load to account for subsidence beneath the construct itself [16]. A comparison of these profiles with the observed topographic profile north of Tepev Mons (Fig. 3) indicates that a value for T_e of about 30 $\pm$ 10 km provides the best fit. This value is at the lower limit of the range suggested by Janle et al. [4]; in particular, much of their range (e.g., T_e = 50-100 km) can be excluded by Fig. 3. As noted above, T_e = 30 km would imply dT/dz = 8 K/km and a heat flux q = 24-27 mW/m^2 for a crustal thickness in the range 10-20 km [5,6].

Assessment of the Flexural Interpretation. While the topographic profile in Fig. 3 can - as demonstrated - be interpreted in flexural terms, the absence of symmetry in the depression (Fig. 2) and the high-standing tessera to the immediate north of the volcano (Fig. 1,3) cast the flexural hypothesis into doubt. As noted above, other depressions flanking Tepev Mons can also be interpreted as relative lows between the volcanoes and neighboring high terrain arising from construction or thickened crust and Airy isostasy. We conclude that Tepev Mons is not sufficiently isolated spatially from other nearby highs to derive a meaningful estimate of elastic lithosphere thickness from the topography alone.

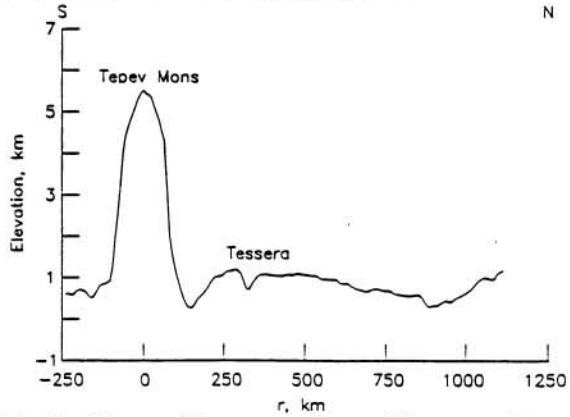

Fig. 2. Venera 16 topographic profile across Tepev Mons (orbit 29). The orbit track passes through the volcano at an azimuth of about N03°W.

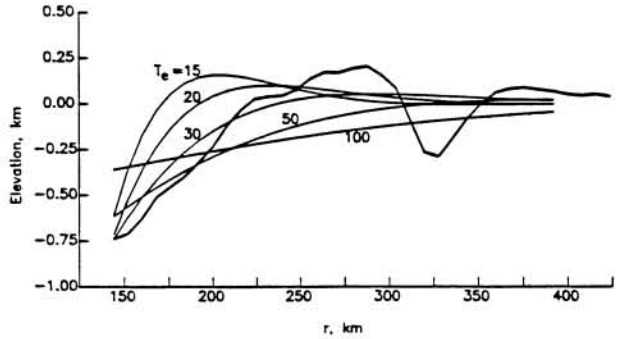

Fig. 3. Fit of the topographic profile from Fig. 2 northward of Tepev Mons to models of lithospheric flexure for a range of values of T_e. The datum for the topography far from the volcano has been set to zero.

References. [1] S.C. Solomon and J.W. Head, *JGR, 87*, 9236, 1982; [2] P. Morgan and R.J. Phillips, *JGR, 88*, 8305, 1983; [3] C. Goetze and B. Evans, *GJRAS, 59*, 463, 1979; [4] P. Janle et al., *Earth Moon Planets, 41*, 127, 1988; [5] M.T. Zuber, *JGR, 92*, E541, 1987; [6] R.E. Grimm and S.C. Solomon, *JGR, 93*, 11911, 1988; [7] M.K. McNutt, *JGR, 89*, 11180, 1984; [8] S.C. Solomon and J.W. Head, *LPS, 20*, 1032, 1989; [9] R.O. Kuz'min et al., *Sol. Syst. Res., 21*, 8, 1987; [10] M.S. Markov et al., *Sol. Syst. Res., 21*, 8, 1987; [11] A.T. Basilevsky and P. Janle, *Sol. Syst. Res., 21*, 672, 1987; [12] P. Janle et al., *Earth Moon Planets, 39*, 251, 1987; [13] S. Smrekar and R. J. Phillips, *LPS, 20*, 1028, 1989; [14] B.A. Campbell and R.C. Kozak, *LPS, 19*, 158, 1988; [15] S.C. Solomon and J.W. Head, *JGR, 84*, 1667, 1979; [16] R.P. Comer et al., *Rev. Geophys., 23*, 61, 1985.