THE EFFECTS OF DYNAMIC TOPOGRAPHY AND THERMAL ISOSTASY ON THE TOPOGRAPHY AND GEOID OF VENUS. C. P. Orth and V. S. Solomatov. Department of Earth and Planetary Sciences, Washington University in Saint Louis, St. Louis, MO 63130 USA (corth@epsc.wustl.edu)

Introduction: The Venusian geoid, gravity field, and topography have been used in a variety of applications and are the primary sources of information about the internal structure of the planet. We focus on the relationship between the geoid and topography to determine both the support mechanism for the topography and lithospheric density structure.

Magnitude of Dynamic Topography: The long-wavelength topography on Venus can be supported by various types of isostasy including thermal isostasy due to the thermal thinning of the lithosphere as well as dynamic support due to the convective motions within the mantle. It has been suggested; however, that in the stagnant lid regime of temperature-dependent viscosity convection the dynamic support might be small and the topography and geoid anomalies are largely caused by the lithospheric thickness variation [1, 2, 3]. Here we analyze the relative magnitudes of the dynamic topography and thermal isostasy and show that the dynamic topography is indeed negligible in the well developed stagnant lid convection regime (at large viscosity contrasts).

Thermal Isostasy and Topography: With the dynamic component of topography being negligibly small both the topography and geoid can be calculated in a variety of simple ways. Here we focus on two methods for calculating the topography and geoid and compare the results with previous work.

Calculation of variations in lithospheric thickness. Simple thermal isostasy equations relating the topography and geoid (e.g. [4]) can be used in conjunction with a spherical harmonic representation of the Venusian geoid and topography (namely MGNP180U, [5] and shtjv360.a02, [6]; respectively) to calculate both a global average lithospheric thickness and variations in the lithospheric thickness. This calculation shows that the observed geoid can be explained by a combination of simple thermal isostasy and limited regions of a thickened crust supported by Airy isostasy. These regions of thickened crust include Ishtar Terra, Ovda Regio, Thetis Regio, and portions of the Beta, Atla, and Themis region.

This result is consistent with previous work by *Kucinskas and Turcotte* [4] in a study of five equatorial highlands comparing the actual variation in the geoid and topography to models based on Airy, Pratt, and thermal isostasy. They suggested that simple thermal thinning of the lithosphere is the primary support mechanism for the volcanic rises but cannot completely satisfy the topography and geoid above some of the crustal plateaus (e.g. Thetis and Ovda) where a component of Airy isostasy is necessary. The need for regions of thickened crust is further evident from the small gravity anomalies over these crustal plateaus which is consistent with compensation from Airy isostasy [7]. However, the need for a portion of thickened crust around some of the volcanic highlands (e.g. Beta Regio) is inconsistent with both geologic observations and modeling. The large gravity anomalies and low crater densities suggest young features largely supported by thermal isostasy. This was also shown in a three dimensional model of the topography and gravity of Beta Regio by *Vezolainen et al.* [2] where both the topography and geoid are modeled as a result of a large plume ascending from the core-mantle boundary.

Calculation of geoid anomalies. The second approach for investigating the relationship between the topography and geoid is to calculate the geoid directly from the density variations caused by the thermal thinning of the lithosphere. Here we again assume compensation purely by thermal isostasy and calculate the geoid anomalies based on the lithospheric density structure. We begin with an initial average lithospheric thickness and determine the variations assuming complete isostatic compensation. These calculations are done using a direct three-dimensional integration over the sphere rather than the HOT (Haxby-Ockendon-Turcotte) approximation. The latter predicts a substantially thinner lithosphere. The lithospheric thickness is then used to calculate the lateral variations in the radial temperature profile for either the plate cooling (which is more appropriate for a nearly steady-state thermal lithospheric structure) or half-space cooling models of temperature distribution (which corresponds to a transient cooling and a small contribution from sublithospheric convective instabilities). The deviation in the temperature from a reference temperature profile corresponding to zero topography leads directly to the calculation of the density anomaly. The component of the geoid anomaly associated with the lithospheric density structure is then calculated from a spherical harmonic representation of the density anomaly on each of n radial layers [8]. The component of the geoid anomaly associated with the topography is then calculated from the Bouguer gravity anomaly and added to the geoid anomaly from the lithosphere. The resulting total geoid anomaly is then compared to the observed geoid anomaly and the initial average lithospheric thickness is adjusted to minimize misfit. Following the minimization of the misfit, the average lithospheric thickness and lithospheric variations are compared to the results from the simple thermal isostasy equations (plate cooling and half-space cooling models) as well as work by other authors (e.g. [9, 10, 11]).

Conclusions: The magnitude of the dynamic topography is negligibly small when compared to the magnitude of the topography supported by thermal isostasy. Most of the Venusian topography can be explained by the thermal isostasy associated with the lithospheric thickness variations. The magnitude of these variations is consistent with that expected for the stagnant lid convection regime with the viscosity parameters corresponding to diffusion creep. Only limited, if any, crustal thickness variations are required to explain the observed geoid.

References: [1] Solomatov, V. S. and L. -N. Moresi (1996) *JGR*, *101*, 4737-4753. [2] Vezolainen, A. V. et al. (2004) *JGR*, *109*, doi:10.1029/2004JE002259. [3] Solomatov, V. S. (2008) *EPSC*, *EPSC2008-A-2003*. [4] Kucinskas, A. B. and D. L. Turcotte (1994) *Icarus*, *112*, 104-116. [5] Konopliv, A. S. et al. (1999) *Icarus*, *139*, 3-18. [6] Rappaport, N. J. et al. (1999) *Icarus*, *139*, 19-31. [7] Phillips, R. J. and V. L. Hansen (1998) *Science*, *279*, 1492-1497. [8] Hager, B. H. and R. W. Clayton (1989) in *Mantle Convection: Plate Tectonics and Global Dynamics*, ed. W. R. Peltier, 675-763. [9] Moore, W. B. and G. Schubert (1995) *GRL*, *22*, 429-432. [10] Smrekar, S. E. and R. J. Phillips (1991) *EPSL*, *107*, 582-597. [11] Anderson, F. S. and S. E. Smrekar (2006) *JGR*, *111*, doi:10.1029/2004JE002395.