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Lithospheric structure of the equatorial region of Venus

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Abstract

In this work we analyse the lithospheric structure of the equatorial region of Venus from gravity and topography, revaluating the regional variations of the crustal and elastic thickness present on it, in order to improve our knowledge of the long-term rheology and mechanical behaviour of the Venusian lithosphere.

1. Introduction & Aims

Venus and Earth share a similar size, a nearly equivalent density and bulk composition, and comparable distances from the Sun. Despite these similarities, Venus' surface tectonics and dynamic evolution are very different from Earth. The Venusian lithosphere is stagnant and shows no evidence for global plate tectonics at present [e.g., 1]. Recent data provided from the ESA's Venus Express Mission show evidence of geologically young volcanism on the Venusian surface [2]. However, the thermal history of Venus remains an enigma and there are many fundamental and unanswered questions on the structure and evolution of its lithosphere; key issues to understanding Venus in the context of terrestrial planets.

The joint spectral analysis of the gravity and topography data provides useful constraints to solve many fundamental questions on the geodynamics of terrestrial planets, probing the structure and the behaviour of their lithospheres [e.g., 3-4]. In particular, a useful parameter that describes this behaviour is the effective elastic thickness (T_e) of the lithosphere, which, in turn, can be used in order to constrain the thermal structure and evolution of a planetary body [e.g., 5-7]. Previous studies have been carried out both regionally and globally with the aim of investigate the internal structure of Venus, providing important constraints on the crustal, elastic and lithospheric thicknesses and/or on its rheology, as well as on its mantle dynamics. Our work is motivated by similar efforts that have been carried out for the Earth, where recent advances in the joint analysis of the gravity and topography and improvements in lithospheric modelling have lead to mapping of T_e on the Earth at unprecedented resolution [4].

Within this framework, it is of special interest to revaluate the regional variations of T_e present on Venus following recent models and methods developed for the Earth, to characterize the structure and the rheological behaviour of the Venusian lithosphere.

2. Lithospheric Modelling

To estimate T_e we calculate the coherence function relating the topography and Bouguer anomaly (i.e., the Bouguer coherence), using the wavelet method [8], following the coherence deconvolution method of Forsyth [9]. Gravity and topography data acquired by the NASA's Magellan Mission between 1990 and 1994 remain the most complete set for constraining the structure of the Venusian lithosphere. We use the spherical harmonic models SHTJV360u (topography) and SHGJ180u (gravity), whose coefficients were truncated beyond degree (and order) 70 in our analysis to mitigate the large errors of the data.

In the coherence deconvolution method of Forsyth [9], T_e is estimated by comparing the observed coherence curve with coherence functions predicted for a range of T_e values. For each given T_e, we calculate via deconvolution the initial surface and subsurface loads and compensating deflections that generate a predicted topography and gravity that best fit the observed topography and gravity anomaly, and a predicted coherence that best fits the observed coherence.

The deconvolution requires detailed information on the internal structure of the lithosphere. To define the lateral variation of the Moho relief, we use the global crustal thickness model obtained in this study, which is based upon the premise of an average crustal thickness of 25 km, and crust and mantle densities of 2900 and 3300 kg m^{-3}, respectively. To model the crustal thickness, we use the relationship between global topography and gravity data following the potential theory approach of Wieczorek & Phillips [10]. We assume that the observed gravitational anomalies arise only from a combination of surface topography and variations at the crust-mantle interface. In this fashion, we first calculate the Bouguer gravity anomaly from the surface topography, and then compute the relief along the crust-mantle interface that is needed to explain the observed Bouguer gravity anomaly. By subtracting the relief on the Moho from surface topography, we estimate the crustal thickness [for a review see 3, 10]. Finally, the T_e value that minimizes the differences between the predicted and observed quantities is the optimal one for the analyzed area.

3. Results, regional correlations & implications

We will present a high-resolution global map of crustal thickness from the relationship between topography and gravity data. We will also present high-resolution maps of spatial variations of T_e, as well as of their associated surface and subsurface loading mechanisms, for the equatorial region of Venus from the analysis of the Bouguer coherence using the wavelet method. Finally, we will examine in detail the relationships between the surface deformation, lithospheric structure and mantle dynamics in order to improve our knowledge of the long-term rheology and mechanical behaviour of the Venusian lithosphere.

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References

[1] Solomon S.C. et al.: Venus tectonics: An overview of Magellan observations, JGR 97, 13,199-13,255. 1992.

[2] Smrekar, S.E. et al.: Recent hotspot volcanism on Venus from VIRTIS emissivity data, Science 328, 605-608, 2010.

[3] Wieczorek, M.A.: Gravity and topography of the terrestrial planets, Treatise on Geophysics, Vol. 10, 165-206, 2007.

[4] Audet, P.: Toward mapping the effective elastic thickness of planetary lithospheres from a spherical wavelet analysis of gravity and topography, Physics of the Earth and Planetary Interiors 226, 48-82, 2014.

[5] Zuber, M.T. et al.: Internal structure and early thermal evolution of Mars from Mars Global Surveyor, Science 287, 1788-1793, 2000.

[6] McGovern, P.J. et al.: Correction to Localized gravity/topography admittance and correlation spectra on Mars: implications for regional and global evolution, JGR 109, E07007, 2004.

[7] Ruiz, J. et al.: The thermal evolution of Mars as constrained by paleo-heat flows, Icarus 215, 508-517, 2011.

[8] Kirby, J.F. and Swain, C.J.: Improving the spatial resolution of effective elastic thickness estimation with the fan wavelet transform, Comput. Geosci. 37, 1345-1354, 2011.

[9] Forsyth, D.W.: Subsurface loading and estimates of the flexural rigidity of continental lithosphere, J. Geophys. Res. 90, 12623-12632, 1985.

[10] Wieczorek, M.A. and Phillips, R.J.: Potential anomalies on a sphere: applications to the thickness of the lunar crust, J. Geophys. Res. 103, 1715-1724, 1998.