# DYNAMIC ORIGIN AND IMPLICATIONS OF VENUS' GRAVITY SPECTRUM

T. Rolf[1], B. Steinberger[2,1], S.C. Werner[1], [1]Centre for Earth Evolution and Dynamics, University of Oslo, Norway (tobias.rolf@geo.uio.no), [2]Deutsches GeoForschungsZentrum GFZ, Helmholtz-Zentrum Potsdam, Germany

**Introduction:** Earth and Venus have clearly had different evolutions leading to plate tectonics on the former, but not on the latter. Surface tectonics is coupled to internal dynamics such that constraining the internal structure of both bodies may be key to understand their divergent evolutions.

Comparably little observations to constrain Venus' interior are available, but a powerful dataset is the planetary gravity field whose long-wavelength parts are linked to deep density anomalies that excite mantle convection in Venus' mantle [1]. The observed surface response of such anomalies is governed by mantle viscosity structure [2]; thus the observed geoid can be used to constrain this structure, which is of great importance for mantle dynamics and evolution.

However, gravity inversion is non-unique and requires additional constraints. On Venus, some possibilities are given by the lack of an active core dynamo, requiring low core-mantle boundary (*cmb*) heat flow, the number of hotspots related to mantle plumes [3], the young and ~uniform age of the surface [4] and the relation between geoid and topography.

Recent studies have reproduced Venus' observed gravity spectrum reasonably well [e.g. 5,6], but none has yet combined the above constraints systematically with Venus' evolution. This incomplete view of Venus' interior motivates our present work.

We use the mantle convection code *StagYY* [7] to compute the thermal evolution of Venus' mantle. Our models include heat-producing elements decaying with time as well as temperature-, pressure- and stress-dependent viscosity, which allows us to model episodic resurfacing events. During the modeled evolution we compute the self-gravitating geoid [8] and compare it to the observation.

**Results:** Our models with time-independent heat budget and a permanent stagnant-lid mode of convection can produce a relatively good match to the observed geoid spectrum and the observed high correlation of geoid and topography as well as their ratio, in particular if mantle viscosity increases rather gently with depth and without a strong jump across the mantle transition zone, consistent with [6], but unlike on Earth [2]. They also feature a reasonable number of mantle plumes (~10) and low *cmb* heat flux.

However, the longest-wavelength part (spherical harmonic degree 2) of the modeled geoid spectrum is significantly over-predicted and such models also fail to produce relatively recent global resurfacing.

This is overcome in models with finite lithospheric strength (~50-100 MPa) for which episodic resurfacing events can occur. Our favorite model so far features only 1 overturn (ending at ~700 Ma) during which the gravity spectrum is strongly perturbed. However, the perturbation relaxes to the present-day such that the observed spectrum is matched very well (*Fig. 1*). As in the stagnant-lid cases, geoid-topography relations and the number of mantle plumes is reasonably close to the observed [1,3]. *Cmb* heat flow (~8 TW) may also be lower than that conducted down Venus' core adiabat, at least if core conditions are similar to Earth's [9].

**Discussion:** Our evolution models fulfill several constraints on Venus' interior, in particular the gravity spectrum. However, our models are yet purely thermal (not chemical) and do not include magmatic processes. As a consequence, the modeled evolution may deviate from reality and predicted mantle temperatures are too high. Our future models will consider such complexities to buffer mantle temperature, which may impact on the constrained (temperature-dependent) viscosity profile.

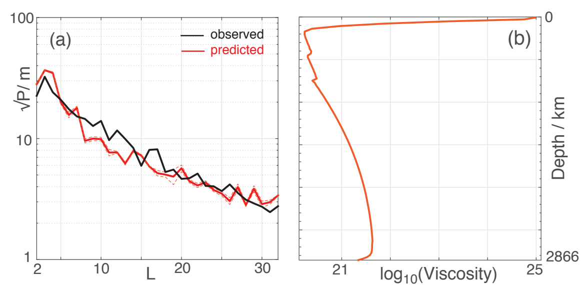


*Fig. 1: (a) Observed and model-predicted Venusian geoid power spectrum P (spherical harmonic degrees L=2-32), (b) Present-day radial viscosity profile leading to the model prediction in (a).*

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