EPSC Abstracts,
Vol. 4, EPSC2009-198, 2009
European Planetary Science Congress,

Deep vs. shallow origin of gravity anomalies, topography and volcanism on Earth, Venus and Mars

B. Steinberger (1,2), S. C. Werner (3) and T. H. Torsvik (1,4,5)

(1) Center for Geodynamics, Geological Survey of Norway, Trondheim, Norway, (2) Deutsches GeoForschungsZentrum, Potsdam, Germany, (3) Continental Shelf Geophysics Group, Geological Survey of Norway, Trondheim, Norway, (4) Physics of Geological Processes, University of Oslo, Oslo, Norway, (5) School of Geosciences, University of the Witwatersrand, Wits, South Africa (bernhard.steinberger@ngu.no / Fax: +47-7392-1620)

Abstract

The relation between gravity anomalies, topography and volcanism can yield important insights about the internal dynamics of planets. From the power spectra of gravity and topography on Earth, Venus and Mars we infer that gravity anomalies have likely predominantly sources below the lithosphere up to about spherical harmonic degree l=30 for Earth, 40 for Venus and 5 for Mars. To interpret the low-degree part of the gravity spectrum in terms of possible sublithospheric density anomalies we derive radial mantle viscosity profiles consistent with mineral physics. For these viscosity profiles we then compute gravity and topography kernels, which indicate how much gravity anomaly and how much topography is caused by a density anomaly at a given depth. With these kernels, we firstly compute an expected gravity-topography ratio. Good agreement with the observed ratio indicates that for Venus, in contrast to Earth and Mars, long-wavelength topography is largely dynamically supported from the sublithospheric mantle. Secondly, we combine an empirical power spectrum of density anomalies inferred from seismic tomography in Earth's mantle with gravity kernels to model the gravity power spectrum. We find a good match between modeled and observed gravity power spectrum for all three planets, except for 2<=l<=4 on Venus. Density anomalies in the Venusian mantle for these low degrees thus appear to be very small.

We combine gravity kernels and the gravity field to derive radially averaged density anomaly models for the Martian and Venusian mantles. Gravity kernels for l>=5 are very small on Venus below ~ 800 km depth. Thus our inferences on Venusian mantle density are basically restricted to the upper 800 km. On Mars, gravity anomalies for 2<=l <=5 may originate from density anomalies anywhere within its mantle. For Mars as for Earth, inferred density anomalies are dominated by l=2 structure, but we cannot infer whether there are features in the lowermost mantle of Mars that correspond to Earth's Large Low Shear Velocity Provinces (LLSVPs). We find that volcanism on Mars tends to occur primarily in regions above inferred low mantle density, but our model cannot distinguish whether or not there is a Martian analog for the finding that Earth's Large Igneous Provinces (LIPs) mainly originate above the margins of LLSVPs.

EPSC Abstracts,
Vol. 4, EPSC2009-xxxx **(will be included after acceptance)**, 2009
European Planetary Science Congress,

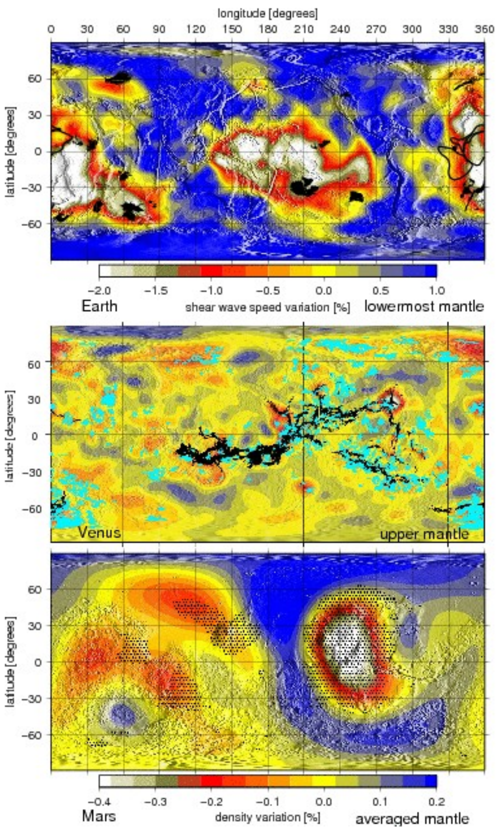

Figure 1: Above: Shear wave speed variations in the Earth's lowermost mantle (*smean* model [1]) overlain by LIPs reconstructed to their eruption locations. Middle and below: density anomaly models of Venus (essentially upper mantle average) and Mars (whole mantle average) inferred from gravity field and geoid kernels. On Venus, distribution of rift zones (in black) and Lobate plains [2] are overlain. On Mars, distribution of volcanics [3,4] is overlain in black and partly transparent. Map projections are centered on 180° meridian; shadings indicate topography.

References

[1] Becker T. W. and Boschi, L. (2002) *Geochem. Geophys. Geosyst.*, 3, 2001GC000168.

[2] Ivanov M. A. (2008) *LPS XXXIX*, Abstract #1017.

[3] Scott, D. H. and Tanaka, K. L. (1986) *USGS Misc. Inv. Ser.* Map I-1802-A.

[4] Greeley, R. and Guest, J. E. (1987) *USGS Misc. Inv. Ser.* Map I-1802-B.