EPSC Abstracts,
Vol. 4, EPSC2009-446, 2009
European Planetary Science Congress,

Thermal Evolution Models and Their Dependence on Lateral Viscosity Variations

L. Noack and D. Breuer

Dept. of Planetary Physics, Joint Planetary Interior Physics Research Group of the University Münster and IfP DLR Berlin, Germany (lena.noack@dlr.de, http://www.dlr.de/pf)

Abstract

To model thermal evolution models of terrestrial planets and moons, often simplified viscosity laws are used constrained by the limited possibilities of the code or missing computational resources.

One commonly used simplification to model the viscosity in a planetary mantle considers only the radial varying viscosity in the Arrhenius law. This method has been used in particular in spectral codes and is called RV method in our study.

In the present study, we compare the RV method with the so-called LRV method in which we consider also lateral viscosity variations by using the actual temperature at each position.

Model

In the RV method, mean viscosity values per shell are used. Thus, this viscosity law ignores lateral viscosity variations:

$$\eta_{RV}(r,<T(r)>) = \eta_{ref}\left(\frac{E^* + pV^*}{R<T(r)>}\right)$$

with E^* the activation energy, p the pressure, V^* the activation volume, R the gas constant, η_{ref} the reference viscosity, and $<T(r)>$ the mean temperature at depth r. In the LRV method $<T(r)>$ is simply replaced by T.

The simulation runs are done using the 3D spherical code *GAIA* [1]. For the thermal evolution models, the viscosity is depth- and temperature-dependent. We used free-slip boundaries at the surface and the CMB. The amount of heat sources decays with time and the core cools during the evolution of the planets. We further consider the growth of an inner core if the core temperatures decrease below the melting temperature of the core, and in the case of Mars, we will consider the mantle phase transitions.

Comparative Study

In a previous study [2], we already compared the RV and the LRV method, and showed that the use of such a simplification can lead to wrong results, especially when calculating thermal evolution models, as has been shown for Mars-like models.

Without considering lateral viscosity variations, the number and shape of the plumes change, see Fig. 1. This influences the heat flux at the CMB and hence the cooling of the core. Furthermore, the temperature variations and thus the amount of partial melt are damped and the volcanic history of a planet might be underestimated.

We will extend our earlier study and further investigate the thermal evolution of Mars, Mercury, and the Moon. This enhanced study will lead to a more general understanding of how the lateral viscosity influences the simulation runs and the thermal and volcanic history of terrestrial bodies. The results will be compared to recent published simulations, which have been done using the RV method, [3, 4, 5].

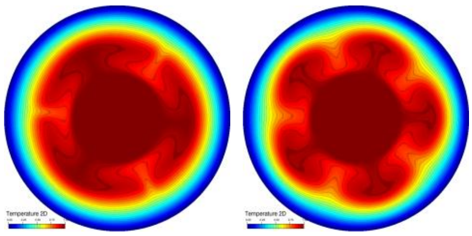

Figure 1: Temperature field for Mars-like calculation using RV method (left) and LRV method (right) in steady-state.

References

[1] Hüttig, C. et al. (2008) *PEPI*.
[2] Noack, L. et al. (2009) *GRA (EGU 2009)*.
[3] Breuer, D. et al. (2007) *Space Science Reviews*.
[4] Ziethe, R. et al (2009) *Planet. Space Sciences*.
[5] Buske, M. (2006) *Dissertation*.