Sea floor flattening as response to plate deformations in mixed-mode heated self-consistent mantle convection

A. Fahl (afahl@uni-muenster.de), C. Stein and U. Hansen
Institute of Geophysics, University of Münster, Germany

There is a longstanding debate about the cause of the flattening observed in sea floor bathymetry at old ages. The two classic models, the half space cooling model (HSCM) and the plate model (PM), both describe the dependence of topography, heat flow, and geoid on the age of the plate [*1*]. They are based on two-dimensional heat conduction and adequately describe Earth's sea floor younger than 80 Myrs. At older ages the depth of the sea floor is shallower than predicted by HSCM [*2*]. Applying a self-consistent numerical model of mixed-mode heated mantle convection, we find that the flattening of the surface topography is dynamically plausible and that it is controlled by the deformations of the surface plate, which appear with increasing heating rates. Stein et al. [3] argued that mantle convection tends to change from a mobile-lid to a stagnant-lid type of convection with increasing internal heating rate.We observe a typical surface topography in each of the end-member cases and in between the topography shows characteristics of both regimes. In the transitional interval we find that the topography follows a sqrt-age-dependence at young ages and starts to oscillate around an equilibrated level when it becomes older. This behaviour is likewise observed for the boundary of the plate. While HSCM adequately explains topography at young ages, it underestimates the values at the older ages, which positively deviate. The PM perfectly follows the time averaged topography for all ages, while the oscillations can be understand as a time-dependent deviation.

References

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[3] **C. Stein, J. Schmalzl and U. Hansen** (2004): The effect of rheological parameters on plate behaviour in a self-consistent model of mantle convection, *Physics of the Earth and Planetary Interior*, 142, pp. 225–255