Thermal evolution of the oceanic lithosphere revisited with the help of an upper-mantle velocity model

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There are presently several candidate models for the thermal structure and evolution of the oceanic lithosphere, which essentially differ by the imposed basal condition. The latter condition represents the additional heat brought at the base of lithosphere (should it exist), and it can take the form of a fixed basal temperature or a fixed basal heat flow. I investigate this problem with the help of a shear velocity model of the upper mantle. Velocities of the lithospheric mantle are converted to temperatures using up-to-date constraints related to the velocity-temperature relationship (namely, constraints on thermoelastic parameters, mantle composition and attenuation factor), and an averaging by age interval is then applied. A particular care is dedicated to the estimation of final uncertainties on temperature, to allow for a quantitative interpretation. This work reconfirms that heat is brought by some mean at the base of the lithosphere, as a half-space cooling thermal evolution falls well below the seismically derived temperatures and their uncertainties. However, I do not observe within the age range (0–160 My) an asymptotic thickness for the lithosphere, which is at odds with the widely used plate model, whereby the additional heat supply is represented by a fixed temperature at some depth. Adding bathymetry and surface heat flow as joint constraints, I find that a model which prescribes a constant heat flow at some isotherm (the so-called Chablis model) provides a better fit to the data than the plate model. Only a strongly reduced thermal expansivity (reduction by at least 30 per cent with respect to the experimental value) allows the latter model achieving a joint-fitting comparable to the former model, and then with a fit to temperature that remains poor. The good fit of the plate model thus relies on a thermal expansivity reduced down to the lowest limit and on ocean depth, whose behaviour at old ages is considerably obscured by anomalous crust. The Chablis model therefore appears as a better representation of the thermal evolution of the oceanic lithosphere. Its best-fitting mantle temperature, 1270°C, is in good agreement with petrological estimates. The basal heat supply at a rate of 30–35 mW m^{-2} whatever age and the continued growth of the lithosphere, which are implied by the model, should give new perspectives on various mantle processes such as small-scale convection or the initiation of subduction.