Numerical simulations of the cooling of an oceanic lithosphere above a convective mantle

Caroline Dumoulin[1], **Marie-Pierre Doin**[2] **et Luce Fleitout**[2]

[1]*Laboratoire de Géophysique Interne et Tectonique, Université Joseph Fourier, 38041 Grenoble Cedex 9, France*

[2] *Laboratoire de Géologie, École normale supérieure, 7, rue Lhomond, 75231 Paris Cedex, France*

Numerical simulations of two-dimensional Rayleigh-Bénard convection are designed to study lithospheric cooling above a convective mantle. A strongly temperature- and pressure-dependent viscosity fluid is heated from below or from within. In a first set of simulations, an imposed velocity at the surface of the box mimicks the plate motion between a ridge and a convergent plate boundary. Dripping instabilities at the base of the lithosphere are not observed close to the ridge. Nevertheless, the material flows along the slope defined by the lower part of the lithosphere and feeds the first descending drip. Afterwards, cold downgoing instabilities develop continuously and randomly at the base of the lithosphere. Surface heat flow, subsidence and lithospheric temperature structure obtained by the convective simulations are compared to the predictions of three 2-D conductive models: the Plate, Chablis, and Modified Chablis models. These models differ by their applied bottom boundary condition which represents the lithosphere/asthenosphere convective coupling, i.e. by the presence or absence of instabilities developing at the base of the lithosphere. The conductive model which best explains the lithospheric cooling obtained by convective simulations is the Modified Chablis model. In this model a variable heat flow (depending upon the viscosity at the base of the lithosphere) is applied along an isotherm located in the lower unstable part of the lithosphere. In the second set of simulations, we model transient lithospheric cooling by imposing a zero temperature at the surface of the mantle with an initially homogeneous temperature. For a while the lithosphere cools approximatively as a conductive half-space and lithospheric isotherms remain flat. As instabilities progressively develop at the base of the lithosphere, lithospheric cooling departs from the half-space model. The Plate model fits better the transient lithospheric cooling in these simulations. We quantify the characteristic timescale of the exponential growth of instabilities as a function of the Rayleigh number and of the viscous temperature scale. This study emphasizes the role of the lithospheric isotherms topography on the development of instabilities.