Convective destabilization of a thickened continental lithosphere

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One consequence of orogenic building (by thrusting or homogeneous thickening) is to lead to a thickened lithosphere. Many studies have focused on consequences of convective removal of thickened lithospheric roots in terms of stress, strain, and metamorphism (Houseman et al., 1981; England and Houseman, 1989; Molnar et al., 1998). But first of all it seems important to understand how a thickened lithosphere reaches back equilibrium.

Two mains mechanisms may take place: 1) a large part, or the whole mantle lithosphere peels suddenly from the upper lithosphere by the propagation of a strongly localised shear zone, and sinks into the mantle (Bird (1979), Houseman (1996), Schott and Schmeling (1998)), or 2) a small scale convection progressively thins the lithosphere thanks to the development of instabilities due to lateral density contrast at the edge of the root and/or because of a density gradient at the base of the root (Doin et al., 1997).

We have used a 2D convective code to study the convective destabilization of a thickened continental lithospheric layer. The numerical simulations of convection include a Newtonian and a non Newtonian rheology with a viscosity depending exponentially on temperature and pressure, or following the Arrhenius law. The way the lithosphere reaches back equilibrium in 2D convective simulations can be fitted by using a 1D conductive CHABLIS modified model. This comparison shows that the thinning is triggered by a heat transfer due to small scale convection at the base of the lithosphere. The parameters controlling this heat transfer have been established by Dumoulin et al (1999). We show that after a thickening of the lithosphere, it slowly tends towards its equilibrium state (in about 100 Ma) compared to quickly destabilization (in about 10 Ma) obtained by Houseman et al. (1981) (in simulations involving an isoviscous fluid, 10^{21} Pa.s) and Marotta et al. (1999) (in simulations with a weak temperature dependence of the rheology). We have also studied the influence of the thickening factor and the thickened zone width, using the 2D convective code; we evaluate a limit width for which the main mechanism of erosion is no longer sublithospheric but is controlled by small scale convection on the edges of the root.