# Small-scale convection produces sedimentary sequences

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It is generally acknowledged that heat transfer in the sub-lithospheric mantle is dominated by convection that maintains an adiabatic temperature gradient close to 0.6 K/km. Transfer of the advected heat to the conductive lithosphere takes place at the base of the lithosphere, which is maintained at a relatively constant temperature in the vicinity of 1300 °C. However, the thermo-mechanical details of this highly dynamic boundary condition at the base of the lithosphere are frequently approximated by a fixed temperature at the assumed long-term equilibrium depth of the base of the lithosphere (the plate model). The present contribution investigates this approximation. We apply a two-dimensional, numerical, thermo-mechanical model of the lithosphere and upper mantle [Petersen, 2010] to asses the effects resulting from a more correct representation of the sub-lithospheric small-scale convection, which is responsible for heat transfer in the sub-lithospheric mantle. Given a particular mantle rheology, our model shows small-scale convection, and converges over time towards a self-consistent, quasi-steady-state with a stable lithosphere, the thickness of which depends on the chosen creep parameters (within experimental constraints) and hence on the vigour of small scale convection and the heat transfer. At the base of the long term stable litho-sphere, a thermal boundary layer is formed in which the heat exchange between the convecting sub-litho-spheric mantle and the lithosphere takes place. Small ascending diapers of warmer material slow down and spread out laterally at the base of the lithosphere, pealing off colder material that descends back into the upper mantle. The buoyancy effects of this partly chaotic mass movements cause low-amplitude and relatively rapid vertical movements of the surface of the lithosphere, which show only limited horizontal correlation. The faster vertical movements occur with periods from 2—20 Myr and have amplitudes up to 20—40 m. Long term surface movements have higher amplitudes and are caused by quasi-static organisa-tion of the convective pattern in the sub-lithospheric mantle, which last long enough to influence the ther-mal state of the lithosphere. Because of the visco-elastic nature of the lithosphere, the more rapid buoy-ancy changes are filtered by a stiffer lithosphere than long term buoyancy changes. The shorter periods therefore correlate for slightly larger distances.

much like the well-known plate model. However, in contrast to the plate model, the elevated astheno-sphere is not instantaneously decoupled from the convecting upper mantle below, and cooling is thus not entirely conductive above the former base of the lithosphere. This causes significantly protracted cooling and slower and more linear post-rift subsi-dence. This model exhibits improved consistency with subsidence data from several rifted margins and intra-continental basins. Because of the small scale convection the long-term subsidence pattern in the presence of small-scale convection is superimposed by the aforementioned low-amplitude vertical move-ments due to convection dynamics at the base of the lithosphere. These movements are a recurrent and a potential cause for the development of strati-graphic sequences at similar time scale. Such se-quences are commonly assumed to be caused by eustatic variations. The results therefore have im-portant implications for inferences on global eustat-ic variations inferred form sedimentary sequences by e.g. back stripping analyses and assumptions about the thermal subsidence history based on the plate model of lithospheric cooling. Our results are furthermore important for the assessment of hydro-carbon potential of sedimentary basins in terms of stratigraphic correlation and thermal maturation. Extension of the convecting equilibrium model causes fault-controlled continental rifting and sub-sidence, followed by protracted thermal subsidence,

## References

*Petersen K.* Continental rifting in the presence of small-scale convection — subsidence, strati-graphy and upper mantle strength: PhD-thesis, Aarhus University, 2010.