Propagation of tectonic waves

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Mountain building depends on the disequilibrium between boundary stresses, either at the base of the deforming lithosphere or its lateral boundaries, and buoyancy stresses arising form lateral density variations within the lithosphere itself. On the basis of the thin viscous sheet approximation, we propose a model which accounts for both crustal and lithospheric thicknesses variations. The deformation is controlled by the sum of the moments of density anomalies (i.e. density anomalies times depth) of compositional and thermal origins. The transport of the compositional moment is obtained from the continuity equation while the transport of the thermal moment is obtained from the heat equation. The resulting set of equations controls the coupled behavior of the crust and lithosphere. It shows that various type of solutions can exist. When the crust dominates the system, the composite lithosphere tends to get back to a stable situation, when the lithosphere mantle dominates, it is unstable and the system ultimately reaches a convective mode. A third situation may occurs, where none of the two components dominate but the heterogeneities propagate laterally, i.e., the deformation of the lithosphere migrate in an undulatory mode. When propagation occurs, the crustal and the lithospheric thickness variations are out of phase. The tectonic waves propagate with velocities around 5 mm yr^{-1} that increase with the crustal thickness and decrease with the lithospheric viscosity. We found that continents may in large part be in a domain of propagating tectonic waves. We show that the propagating mode can explain the progradation of deformation in high plateaus. Crustal thickening in the Central Andes or Tibet may have initiated in the convergence zone, then gradually migrated away form it, independently from the original source of stresses at subduction zones.

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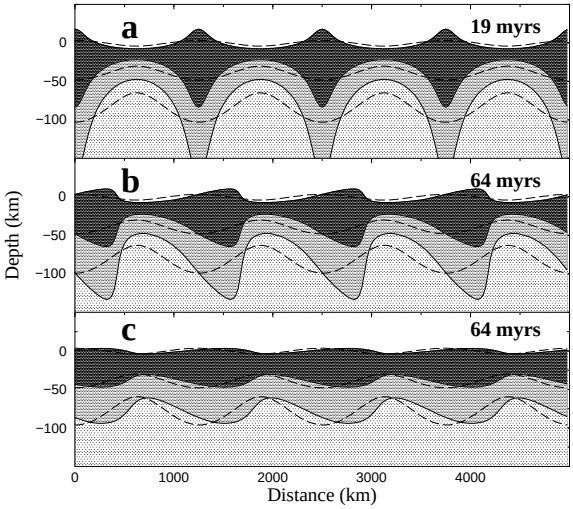

Figure 1. Evolution of the crust and lithosphere with time. The initial sinusoidal interfaces are depicted with dashed lines, the final interfaces with solid lines. The crust, mantle lithosphere and asthenosphere are shaded (darker, intermediate and lighter shades). The initial wavelength is in the domain of unstable (a), propagating (b), and stable (c) regime. For clarity the surface topography has been multiplied by a factor 5. The final solutions have been computed after 19 myrs, (a), and 64 myrs, (b) and (c).