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Asymmetric tectonics at rift zones: geodynamics and numerical modeling

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Tectonic evolution at rift zones is commonly considered symmetric along mid-ocean ridges, when modeling with relative plate motions and steady-state processes. However, the bathymetry of rift zones is generally asymmetric, being the eastern flank in average slightly shallower (100-300 m) than the western one. Also, based on surface wave tomographic models, shear wave velocities in the upper mantle indicate a difference between the western and eastern flanks of an oceanic basin. A better way to understand dynamics of the lithosphere at rift zones, and lithosphere/mantle interactions corresponds to absolute plate kinematic analyses, i.e., with respect to the mantle, modeling time-dependent tectonic processes. We performed numerical simulations of plate-driven mantle flow beneath mid-ocean ridges and we considered a time-dipendent flow induced by absolute motion of overlying rigid plates in an incompressible viscous mantle. In absolute frameworks, a net "westward" rotation of the lithosphere relative to the mantle can be observed, and we used velocities obtained in the hotspot reference frame, as boundary conditions. This implies that plates along a ridge, and the ridge itself, move toward the west but with different velocities, relative to the fixed mantle, and the separation between plates triggers mantle upwelling. Numerical solutions for viscosity flow beneath plates that thicken with increasing age are presented. The mantle can be modeled as a viscous fluid, and its dynamics can be described using the Stokes equations. At a first approximation the fluid is considered Newtonian. A further step in the description of the phenomena would require the inclusion of thermal effects: in this case the fluid viscosity and density have to be considered as a function of the temperature. For solving both the Stokes equations and the thermal effects, a finite element approach has been adopted. Results show an asymmetric thickening of plates along the ridge, as suggested by geological and geophysical observations, and provide useful relationships between mantle temperature and thickness of the oceanic lithosphere.