Numerical Models of Continental Rifting with Melt Generation

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Active or passive continental rifting is always associated with thinning of the lithosphere and the ascent of the asthenosphere. Depending on the vigour of asthenospheric upwelling decompressional melting may occur. This melt may percolate within the partially molten source region, accumulate and be extracted via dykes. It is not very well known, at which depth levels and to which extent solidification takes place: near the solidus temperature at the top of the asthenosphere, at the base of the crust or at the surface after extrusion.

Two-dimensional numerical models of extension of the continental lithosphere-asthenosphere system are carried out using an Eulerian visco-plastic formulation. The equations of conservation of mass, momentum and energy are solved for a multi-component (crust – mantle) and two-phase (solid – melt) system. Temperature, pressure and stress dependent rheologies based on laboratory data for granite, pyroxenite and olivine are used for the upper, lower crust and mantle, respectively. A typical extension experiment is characterized first by the formation of a weak boudinage structures followed by rapid strain localization and necking of the whole lithosphere (see Fig. 1). This necking phase is associated with a pronounced negative topography ("rift valley"), being the result of dynamic stresses and density and thickness variations within the rift zone. If melt is generated (Fig. 2) and extracted, basaltic layers of a few km thickness can be formed with a maximum thickness near the rift flanks. Not all melt may be extracted, solidification at depth leads to basaltic enrichment in parts of the thinned lithospheric mantle. Comparing models with and without melting but with equal extension rates show, that the occurrence of melting accelerates thinning and stretching at the rift axis. Consequently, models with melting seem to show a slightly stronger subsidence in the rift axis. Once extension stops, partial melt might be present in the mantle beneath the rift for several tens of Mio years. Due to the absence of dynamic stresses the "rift valley" seems to become deeper, followed by further deepening due to cooling. These models demonstrate the importance of melting processes for the topography of extensional regions.

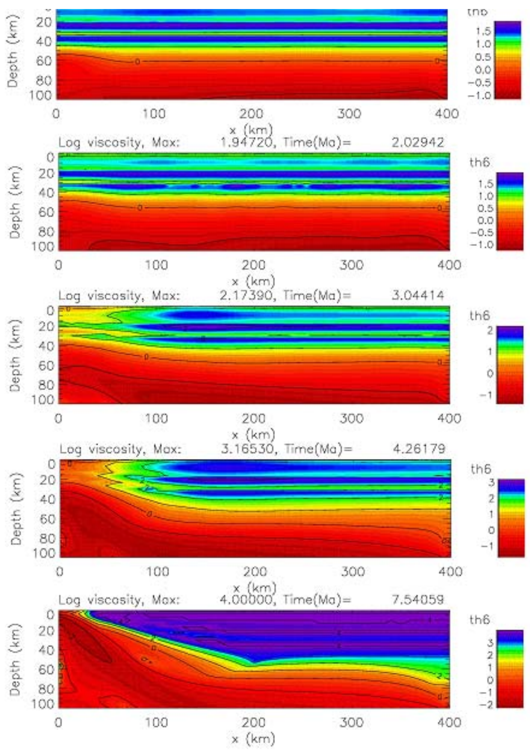

Fig. 1. Viscosity of the rift model

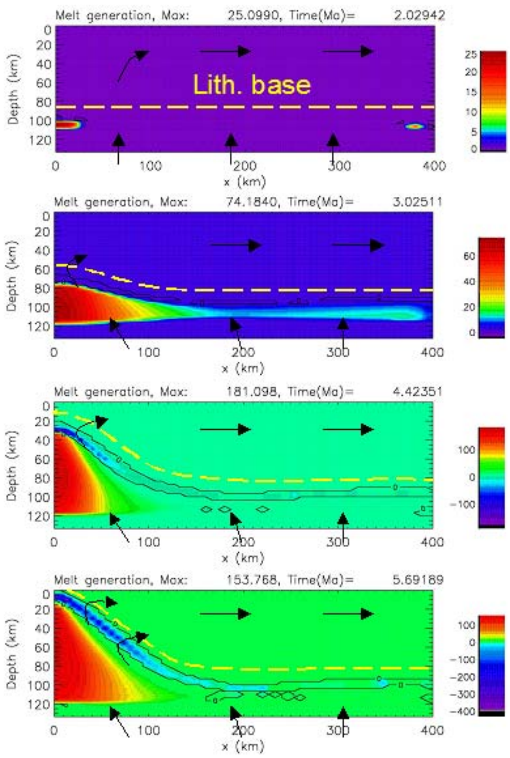

Fig. 2. Melt generation rate