Geophysical Research Abstracts,
Vol. 11, EGU2009-2758, 2009
EGU General Assembly 2009

The role of melting in continental breakup and ocean formation

H. Schmeling and H. Wallner

Goethe University Frankfurt, Institute of Meteorology and Geophysics, Frankfurt/M, Germany
(schmeling@geophysik.uni-frankfurt.de)

Active or passive continental rifting is associated with thinning of the lithosphere, ascent of the asthenosphere, and decompressional melting. This melt may percolate within the partially molten source region, accumulate and be extracted. 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 and lower crust, and mantle, respectively. Rifting is modelled by externally prescribing a constant rate of widening. A typical extension experiment is characterized by 3 phases: 1) distributed extension, with superimposed pinch and swell instability, 2) lithospheric necking, 3) continental break up, followed by oceanization. The timing of the transition from stage 1) to 2) depends on the presence and magnitude of a localized perturbation, and occurs typically after 100 - 150 km of total extension for the lithospheric system studied here. This necking phase is associated with a pronounced negative topography ("rift valley") and a few 100 m of rift flanks. The dynamic part of this topography amounts to 1 – 2 km positive topography. This means, if rifting stops (e.g. due to a drop of external forces), immediate additional subsidence by this amount is predicted. Melt solidification of ascended melt beneath rift flanks leads to basaltic enrichment and underplating beneath the flanks, often observed at volcanic margins. After continental breakup, a second time-dependent upwelling event off the rift axis beneath the continental margins is found, producing further volcanic volumes. Melting has almost no or only a small accelerating effect on the local extension value (beta-value) for a constant external extension rate. Melting has an extremely strong effect on the upwelling velocity within asthenospheric wedge beneath the new rift. The melt induced sublithospheric convection cell is characterized by downwelling flow beneath rift flanks. Melting increases the topography of the flanks by 100 – 200m due to depletion buoyancy. Another effect of melting is a significant amplification of the central subsidence due to an increase in localized extension/subsidence. Modelled magma amounts are smaller than observed for East African Rift System (EARS). Increasing the mantle temperature, as would be the case active rifting due to a large scale plume head, better fits the observed magma volumes. Interestingly, if the localized perturbation at the central axis is removed, and only a long-wavelength elevated plume head-like temperature anomaly is assumed, a double rift develops. This seems to be a consequence of off-plume axis stress concentrations associated with non-Newtonian rheology.
New models including lithospheric weakening due to melt extraction from the asthenosphere and emplacement within the stiff mantle lithosphere will be shown