Pannonian Basin syn- and post-rift evolution; dynamic modelling of the transition from passive to active rifting

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Balancing extension in the Pannonian Basin with E-ward translation and shortening in the E-Carpathians shows that no significant E-ward escape (< 25 km), took place in the eastern Alps. We show that passive extension followed by active upwelling of the mantle lithosphere is a more viable mechanism for during the Panonian Basin formation.

We model the dynamic interplay between far-field driven passive extension and active thinning of the mantle lithosphere by convective upwelling beneath the rift zone. We predict that time-scales of- and stresses generated by-both processes are comparable.

We employ a two-dimensional thermo-mechanical finite element model with a non-linear visco-elasto-plastic rheology. The power law viscous rheology is temperature and strain-rate dependent. Brittle behaviour is modelled using Mohr-Coulomb plasticity.

Thermal buoyancy, related to the syn-rift asthenospheric doming, drives active upwelling in a lithospheric scale convection cell. In this way horizontal stresses are generated which begin to compete with the far-field intraplate stress. In the late syn-rift or early post-rift stage, domal forces may dominate and even drive the system, causing a change from passive to active rifting mode. If this transition occurs, the numerical model predicts: 1) drastic increase of sub-crustal thinning beneath the rift zone, 2) lower crustal flow towards the rift flanks, 3) the coeval occurrence of tensional stresses within and compressive stresses around the upwelling region, 4) possible surface uplift. Late post-rift cooling removes the thermal buoyancy forces. At this stage, the far-field forces dominate the stress-state again and the lithosphere becomes more sensitive to small changes in the intra-plate stress field.

The model predictions may explain several poorly understood observations that characterise the Pannonian Basin. Among others features there are observed strong differential thinning, e.g. intermediate crustal extension, [1.6–1.8] and strong thinning of the mantle lithosphere [8–10], the late (end of syn-rift — early post-rift) shallow mantle related calc alkaline volcanics, a second phase of extension in the post-rift of the basin, the post-rift surface domal uplift, the coeval occurrence of extension in the internal basin part and compression in the external parts of the system, and late stage acceleration of subsidence caused by compressive intraplate stresses. The model predictions also suggest that the thickened crustal roots of the Apuseni Mts and the Transdanubian Range and related surface uplift may be interpreted in terms of rift flank uplift associated, with extension of a weak lithosphere (shallow level of necking case) and lower crustal flow outwards of the rift zone.