EGU25-16095, updated on 21 May 2025
https://doi.org/10.5194/egusphere-egu25-16095
EGU General Assembly 2025

Migration of deformation, basin subsidence, magmatism in extensional basins: comparative constraints from numerical models and observations (Pannonian Basin)

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Numerical models are essential tools for investigating a variety of Earth phenomena, providing insights into the role of different surface to deep Earth processes. As with many laboratory approaches the effectiveness of the models can be assessed by comparing their results with natural case studies of the same phenomenon, which helps to constrain the large number of model parameters.

This presentation will take the example of the Pannonian Basin system having been formed within the Alpine–Carpathian–Dinaric orogenic belt, where geological data are abundant, and the temporal resolution of basin evolution including magmatic events are very good and in the range of the numerical modelling results.

We used 3D coupled thermo-mechanical and surface processes numerical models (I3ELVIS-FDSPM code) to simulate continental rifting and to shed light on the temporal evolution of the entire rift system. Namely, the extensional deformation starts than migrates from the (western) basin margins, from inherited lithospheric weakness zones towards the basin centre, but an early jump from the western margin toward the opposite basin part is also present in some experiments. This is followed by a second jump of basin formation toward the basin centre, between the first and second generations of basins. This is in good agreement with the compilation of the ages for the onset of basin subsidence and migration of activity of some major bounding faults including low-angle detachments of metamorphic core complexes. This migration is driven and supported by mantle flow and asthenospheric upwelling, eventually affected by thermal relaxation. Based on detailed geological and geophysical mapping, we point out the role of inherited weakness zone(s) – mostly former suture zones – within the crust and mantle lithosphere. Consequences are

contrasting subsidence and uplift patterns and a variable heat flow evolution in different sub-basins.

The migration of basin formation shows remarkably similar migration of the magmatic activity. This started with granodioritic–dacitic products around 18.6 Ma along the western basin margin, then jumped toward the opposite basin part around 17.3–16.8 Ma and stepped back toward the basin centre around 15.3 Ma with a change toward andesitic volcanism. Geochemical characteristics indicate increasing mantle component in the melts during the continuing extension until ca. 14.4 Ma. The magma generation in the lower crust and mantle (by decompressional melting) is predicted by numerical models.

The evolution of basin formation and magmatism between ~14.9 and ~11.5 Ma is marked by the migration from the basin centre toward the eastern margin and is probably due to subduction roll-back, steepening of the slab and its detachment. This process is combined with self-consistent evolution of mantle processes deriving from the rifting of the overriding lithosphere.

The research was supported by the National Research, Development and Innovation Office project number K134873 granted to László Fodor and no. 145905 granted to Réka Lukács and MTA–HUN-REN CSFK Lendület "Momentum" PannonianVolcano Research Group