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Joint application of thermo-mechanical and stratigraphic numerical modeling: the tectono-sedimentary evolution of back-arc basins

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The formation and evolution of extensional back-arc basins are controlled by the overall crustal and lithospheric thinning linked to their rheological layering, amount and rates of extension, as well as surface processes, such as erosion and sedimentation coupled with climatic variations. Understanding the inherent connections between large-scale tectonic and local basin-scale surface processes requires the joint application of thermo-mechanical and stratigraphic modeling techniques (Balázs et al., 2017).
In this study we applied a coupled thermo-mechanical lithospheric-scale 2D numerical code and the high-resolution 3D deterministic stratigraphic software DionisosFlow (Granjeon, 2014). We conducted a series of experiments to analyze the extension, subsidence and thermal evolution of an initially thick, hot lithosphere with a pre-existing suture zone resulting from an earlier orogenic phase. In such settings, the syn-rift subsidence rates are initially low to moderate and are associated with uplift pulses, creating asymmetric sub-basins where extensional deformation migrates in space and time. The subsequent post-rift times are characterized by kilometer-scale differential vertical movements caused by further mantle dynamics enhanced by sediment re-distribution and lower crustal flow effects.
The modeled tectonic subsidence and uplift rates and half-graben geometries are imported into the 3D stratigraphic modelling code. Our modeling of a 120 km $\times$ 150 km area shows that such scenarios are associated with continental alluvial to shallow-water sedimentation and footwall erosion during the early stages of the syn-rift, followed by rapid deepening during the subsequent syn-rift evolution. Finally, during the following post-rift times the basins are filled by a large-scale prograding shelf-margin slope system. This modeling quantifies forcing factors, such as tectonics, sea-level and climatic variations associated with water and sediment influx. The evolution of the overall sedimentary architecture is analyzed by the modeled paleo-water depth, erosion and sedimentation rates and lithology distribution inside the half-grabens and neighboring areas. Our modeling highlights the differences between the low-order tectonic and higher order sea-level and climatic driven transgressive-regressive cycles and we analyze the auto-cyclic nature of the depositional systems. Our results are compared with geological and geophysical constraints from the Pannonian Basin of Central Europe.

Balázs A., Granjeon D., Matenco L., Sztanó O., Cloetingh S., 2017: Tectonic and climatic controls on half-graben sedimentation: inferences from numerical modeling. Tectonics, 2017TC004647.
Granjeon D., 2014: 3D forward modeling of the impact of sediment transport and base level cycles on continental margins and incised valleys. Int. Assoc. Sedimentol. Spec. Publ., 46, 453–472.