Integrated records of tectonic and climate interactions in the Northern Alpine Foreland Basin sedimentary architecture

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Peripheral foreland basins form due to flexural subsidence of the downgoing plate driven by topographic- and slab loading. Their architecture records lithospheric- and crustal-scale processes, and the climate history of the adjacent growing orogen. Previous geological and geophysical observational studies revealed that many foreland basins show along-strike heterogeneous sedimentary architecture, implying that mechanisms controlling basin evolution varied laterally. In the Northern Alpine Foreland Basin (NAFB, also known as Molasse Basin) the along-strike heterogeneity in basin architecture is represented by eastward shallowing of depositional environments during Oligocene-Miocene times. This coincided with the suggested two slab break-off and/or tearing events occurring below the Alps. In this project, we test the hypothesis of whether slab break-off and tearing can control along-strike variable foreland basin architecture. We do this by combining tectonostratigraphic analysis of the NAFB fill and numerical models. Tectonostratigraphic analysis includes interpretation of the 2D/3D seismic data located in the transitional zone of the NAFB (German Molasse) connecting the western and eastern parts of the basin. To investigate the effect of the slab-break off and tearing on the foreland basin evolution we combine 3D thermomechanical- and stratigraphic forward models.

The results of the tectonostratigraphic analysis reveal a northward younging trend of syn-flexural normal fault nucleation which agrees with forebulge migration driven by the advance of the Alpine thrust front during the Oligocene-Miocene. Furthermore, the eastward increase in the magnitude of syn-flexural normal fault offsets suggests an increase in the magnitude of flexural bending of the lower plate. This may have been controlled by lateral variations in the architecture of the lower plate and/or spatiotemporal variations in slab breakoff/tearing. The observed along-strike seismic facies integrated with the published data suggests that the north-south trending intrabasinal coastline migrated from west to east at an average rate of ~ 6 cm/yr. Furthermore, 3D thermomechanical models show that slab tearing will initiate either at the location of a subducted continental terrain (if present along the slab) or where collision starts first in the case of oblique convergence. Subsequently, tearing propagates along the strike at velocities ranging from ~35 cm/yr to 120 cm/yr depending on the margin obliquity, slab age and mantle rheology. The surface expression of slab tearing is the orogen parallel migration of uplift, affecting both the orogen and peripheral foreland basin. In the peripheral foreland basins associated with the collision of oblique margins, this uplift leads to a gradual along-strike decrease of accommodations space followed by shallowing of depositional environments. However, during the collision of irregular margins, the size and rheology of irregular terrains exert a key influence on the along-strike distribution of the surface uplift during tearing. Typically, this yields a more stepwise distribution of the accommodation space along the peripheral foreland, i.e. lower above the previously accreted terrain.

Currently, we are focusing on integrating thermomechanical- and forward stratigraphic models to estimate the effect of environmental factors such as sea-level variations, and precipitation rates on the preservation of the slab break-off and tearing signals in the stratigraphic record of peripheral foreland basins.