Signals of slab breakoff- and tearing in the stratigraphic architecture of a foreland basin

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A significant change in the architecture of peripheral pro-foreland basins observed in all natural examples is the flysch to molasse transition (i.e., shift from underfilled- to overfilled conditions). Forcing mechanisms for pro-foreland basin architecture include changes in sediment supply from the adjacent growing orogen and flexural subsidence in the basin. As these forcing mechanisms themselves are driven by orogenic processes in the adjacent mountain range, the flysch to molasse transition can be regarded as the sedimentary fingerprint of hinterland tectonics.

Slab breakoff of the foreland plate leading to isostatic rebound of both the pro-foreland basin and adjacent orogen (leading to increased sediment supply) has been suggested to be a driver of the flysch to molasse transition[1,2,3]. However, this cause-and-effect relationship between slab breakoff and the flysch to molasse transition is based on qualitative assessments. This raises the question whether other external forcings may have masked the contribution of slab breakoff to the flysch to molasse transition.

In this study we investigate the stratigraphic signal of slab breakoff in a pro-foreland basin. To quantitatively assess the relationship between slab breakoff and the flysch to molasse transition, we coupled 2D geodynamic models (GMs) of slab breakoff using LaMEM[4] with 2D forward stratigraphic modelling (FSM) using the GPM software (SLB). To better understand the influence of slab breakoff on pro-foreland basin architecture, we tested slab breakoff scenarios in our GMs for varying 1) slab bending angles and 2) slab necking durations (depending on slab rheology). To test whether the stratigraphic signal of slab breakoff may be masked by other external forcings, we introduced eustatic sea level changes (50 m amplitude with a 1 My period). From our FSMs we generated sediment thickness maps used to reconstruct sediment supply rates, grain size distribution- and facies maps and synthetic seismic data to compare with observed seismic data.

Our preliminary results indicate that vertical uplift due to isostatic rebound in the pro-foreland basin (1.5 – 7 cm/yr, where fast necking of steep slabs yields higher values) decreases the accommodation space, leading to a stratigraphically upward shallowing. Furthermore, isostatic rebound of the adjacent mountain range (2-5 cm/yr, same relationship with slab dynamics as pro-foreland basin) results in up to 2.5x increased rates of sediment supply with very little lag time, adding to the stratigraphically upward shallowing. The eustatic sea level changes do not mask the stratigraphic signal of slab breakoff. Lastly, the facies of the flysch to molasse transition in our synthetic seismics looks similar to that observed on seismics of the Austrian Molasse which occurred coeval with slab breakoff under the Eastern Alps[5].

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