Alps through deep seismic profiling. Results of the TRANSALP deep reflection seismic profile together with data from other Earth Science disciplines and an already existing extensive database on the stratigraphic and P-T-t evolution of the Eastern Alps will be used to set up a three-dimensional (3D) numerical model for the collision zone and the adjacent foredeep. Key questions relate to the influence of rheology on the geometry of the orogen, the topography and strain distribution in time. Dynamic modelling will be used to explore the interplay of lower crustal flow and concomitant brittle upper plate deformation during orogen-parallel extension and lateral escape tectonics and to study the mechanics of lower crustal wedging. Numerical modelling will be complemented by lithospheric-scale analogue modelling. Emphasis will be put on lateral variations of lithospheric strength and its influence on the evolving geometry and topography of the orogen. Indentation experiments with rheologically stratified indenters will be performed to evaluate conditions for indenter deformation, and its influence on lateral escape tectonics. Thick-skinned analogue experiments will include subduction of the European continental lithosphere underneath that of the Adriatic plate. Computed tomography (CT) recording allows for continuous non-destructive analysis of experiments and the transfer of data to powerful work stations for detailed analysis of the kinematic, structural and topographic evolution of the collision zone. The proposed project represents a new research line that enables the exchange of data between numerical and analogue modelling. Of particular importance will be the feedback relation between numerical and analogue modelling that complements each other. Comparison, validation and improvement are key aspects of the integrated approach that will lead to a higher precision in quantitative analysis of collision tectonics. On the other hand, process oriented modelling will shed light on the 3D dynamics of collision zones that ultimately control the build-up and destruction of mountain ranges.

Dynamic processes controlling foreland development – the role of mechanical (DE)coupling of orogenic wedges and forelands

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Depending on their position with respect to polarity of the subduction system controlling the evolution of an orogenic wedge, we distinguish between pro-wedge (fore-arc, foreland) and retro-wedge (retro-arc, hinterland) forelands. Flexural foreland basins can develop in retro-wedge domains of Andean-type and in pro- and retro-wedge domains of Himalaya-type orogens.

Whereas the subsidence of retro-wedge foreland basins is largely controlled by the topographic load exerted by the orogenic wedge on the foreland lithosphere, the subsidence of pro-wedge foreland basins is governed by the loads of the orogenic wedge and of the subducted foreland lithospheric slab. Forebulges of purely flexural orogen develop only if the orogenic wedge and the foreland lithosphere are mechanically decoupled. Under conditions of mechanical coupling between an orogenic wedge and its foreland, compressional stresses are transmitted into the latter, inducing reactivation of pre-existing crustal discontinuities and broad crustal and lithospheric scale buckling at distances of up to 1700 km from the collision front. Such stresses can overprint potential pre-existing flexural forebulges or impede or amplify their development. Moreover, depending on the rheological structure of the crust and the thickness of its sedimentary cover, thick- and/or thin-skinned thrusts can propagate far into forelands, either destroying pre-existing flexural foreland basins or impeding their development. Collision-related compressional stresses can be transmitted into pro-wedge forelands during 1) initiation of subduction zones, 2) periods of subduction impendence caused by the arrival of more buoyant crust at a subduction zone, 3) initial collision of an orogenic wedge with a passive margin, and 4) post-collisional over-thickening and uplift of an orogenic wedge and the development of a mantle-back-stop. Development of intraplate compressional/transpressional structures in forelands is indicative for the build-up of collision related stresses, and thus for their strong mechanical coupling.
with the associated orogenic wedge, either at crustal and/or mantle-lithospheric levels. The absence of syn-orogenic intraplate compressional structures suggests that the respective orogenic wedge and its foreland(s) were mechanically decoupled. The level of mechanical coupling between an orogenic wedge and its foreland can vary temporally and spatially.

Coupling and uncoupling of orogenic wedges and their forelands probably depends on the geometry and frictional shear strength of their common boundary zone. Subduction resistance of the foreland, as well as the build-up of high fluid pressures in subducted sediments presumably play an important role. Pro-wedge continental crust and mantle-lithosphere, containing eclogitized crustal material, can be subducted to depths of 100–150 km at which it can no longer support the weight of the attached oceanic slab and fails. Slab-detachment results in uplift of the orogen, mantle back-stop development and the transmission of major collision-related stresses into the forelands.

The tectono-stratigraphic record of forelands monitors the evolution of collision-related stress fields and thus the level of their mechanical coupling with the associated orogen. As such, it contributes to dating orogenic activity affecting the respective plate margin.

In this paper we discuss these concepts on the basis of the evolution of selected forelands of Palaeozoic and younger orogens of Europe and North America.