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Unraveling the crustal structure of hyper-extended rifted margins: the example of the Bernina domain in the Alpine Tethys (SE Switzerland)

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A long-standing problem in Earth Sciences is to understand how continents break apart to form new oceanic basins. The discovery of exhumed continental mantle and hyper-extended crust devoid of significant normal faulting directly overlain by shallow marine sediments, as observed in many rifted margins, is proving fundamental in defining the controls and processes that thin the continental lithosphere. This leads to the questions of what structures/processes can explain major crustal thinning and when and where they were active? A more direct access to the sedimentary record of deep rifted margins and the underlying crust/mantle lithosphere is exposed in the Alps in Western Europe. Remnants of the ancient Alpine Tethys rifted margins are well exposed and the palaeo-geographic position of these units can be reconstructed satisfactorily. We initiated a research project in the Bernina domain in SE Switzerland, where remnants of the transition between the proximal and the distal/deep Adriatic margin, comparable with the necking zone in present-day magma-poor rifted margins are exposed.

The Bernina domain preserves a pre-rift crustal section formed by (1) lower and middle crust comprising Permian gabbros and granulites, (2) upper crust formed by a poly-metamorphic basement intruded by post Variscan granitoids, and (3) remnants of a sedimentary cover, which comprises a Permo-Triassic pre-rift sequence and Lower to Middle Jurassic syn-rift sequence that are overlain by Upper Jurassic to Lower Cretaceous deep water post-rift sediments. The thinning of the continental crust is characterized by a system of conjugate crustal scale detachment systems along which the middle crust (e.g. Campo/Grosina units) is omitted (necking zone). As a result, upper crustal rocks are juxtaposed against lower crustal and mantle rocks (e.g. Margna shear zone). Locally, these faults reach the surface (e.g. Val dal Fain) and form top-basement detachment faults, which are overlain by extensional allochthons or syn-rift sediments that were onlapped by post-rift.

How detachment systems are organized and evolve on a crustal scale in space and time and how they can thin and finally omit the middle crust within the necking zone remains, however, a major question. Field mapping of the relations between mid-crustal rocks and detachment/décollement structures, coupled with new data on the thermo-chronological evolution of the Campo and Grosina units will enable the unraveling of the deformation history of the mid-crustal level during the extreme crustal thinning. The results of this study will lead to better constraints of the thinning processes of the crust and give access to the deformation of the middle crust during the rifting. These results have major implications for the thermal evolution and consequently for the rheology and isostasy of the extending lithosphere.