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The role of inherited structures and basin geometry during the 3D inversion of a passive continental margin: the case of the Doldenhorn-Aar Massif system (Central Swiss Alps)

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Inversion of passive margins and their transportation into fold-and-thrust belts is a critical stage of mountain building processes and their structural interpretation is fundamental for understanding collisional orogens. Due to the multitude of parameters that influence their formation (e.g. the interaction between sedimentary cover and basement, the mechanical stratigraphy or the rheology of different rock types) as well as along-strike internal variations, a single cross-sectional view is insufficient in exploring the 3D evolution of a fold-and-thrust belt. Hence, a 3D geological characterization is required to better comprehend such complex systems. Based on a detailed digital map, a 3D structural model of the current tectonic situation and sequential retrodeformation, we elaborate the 3D evolution of a part of the former European passive continental margin. In this setting, we focus on the Doldenhorn Nappe (DN) and the underlying western Aar massif (external Central Alps, Switzerland). The DN is part of the Helvetic nappe system and consists of a large-scale recumbent fold with a thin inverted limb of intensively deformed sediments (Herwegh and Pfiffner 2005). The sedimentary rocks of the DN were deposited in Mesozoic-Cenozoic times in a small-sized basin, which has been inverted during the compression of the Alpine orogeny (Burkhard 1988). Along NNW-SSE striking geological cross-sections, restoration techniques reveal the original asymmetric triangular shape of the DN basin and how the basin has been exhumed from ~ -12 km (Berger et al. 2020) to its present position at 4km elevation above sea level throughout several Alpine deformation stages. Moreover, the model allows to visualize the current structural position of the DN and the massif as well as the geometric and overprinting relationships of the articulated deformation sequence that shaped the investigated area throughout the Alpine evolution. Here we document that: (i) the DN is a strongly non-cylindrical recumbent fold that progressively pinches out toward the NE; (ii) significant along-strike (W-E) stratigraphy thickness variations are reflected in structural variations from a single basal thrust deformation (W) to an in-sequence thrust deformation (E); and (iii) the progressive exhumation of the basement units towards the E and thrusting towards the N. In this context, special emphasis is given to illustrate how three-dimensional geometry of inherited pre-orogenic structures (e.g., Variscan-Permian and rifting related basement cover structures) play a key role in the structural style of fold-and-thrust belts. In summary, today's structural position of the DN is

the result of the inversion of a small basin in an early stage of thrusting, which was followed by sub-vertical buoyancy driven exhumation of the Aar massif and subsequent thrust related shortening. All three stages are deeply coupled with an original non-cylindrical shape of the former European passive continental margin.