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3D numerical modeling of nappe stacking applied to the Helvetic nappe system

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The Helvetic nappe system of the Western Swiss Alps formed during the Alpine orogeny by the deformation of half-grabens in the European passive margin. This system exhibits both thin- and thick-skinned tectonics. Several studies on the mechanics of fold and thrust belts agree that the rheology of the basement-cover sequence and the lithospheric layering has a major impact on the deformation style of thin- and thick-skinned systems. Previous results from two-dimensional numerical models have shown that the viscosity ratio between the basement and the sedimentary cover, together with the depth of the brittle-ductile transition zone strongly control the deformation behavior. Furthermore, field observations for the Helvetic nappe system indicate that the bulk deformation of many nappes was dominated by ductile creep. Nevertheless, two-dimensional numerical models and cross-sections are not sufficient to describe and investigate the complete deformational behavior during nappe formation because they ignore the effect of lateral stratigraphic variations in three-dimensional (3D) space. Therefore, we employ 3D thermo-mechanical numerical modeling with a viscoplastic rheology to constrain the impact of (I) lateral variation of half-graben depth and (II) temperature gradient on nappe formation during continental collision. The formation of a 3D accretionary wedge is modeled by the application of velocity boundary conditions with a velocity discontinuity, which provides a bulk deformation similar to typical sandbox models of accretionary and orogenic wedge formation. In order to quantify the deformation we compute the 3D finite strain tensor in every point of the model domain. From the 3D finite strain tensor we calculate the strain magnitude and the principal strain orientations (dip direction and angle) which can be compared to geological field data to gain further insight into the deformational behavior.