Geophysical Research Abstracts
Vol. 19, EGU2017-9031, 2017
EGU General Assembly 2017

3D Numerical Modelling and Finite Strain Analysis of the Lateral Transition between Overthrusting and Folding with Application to the Helvetic Nappe system

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The Helvetic nappe system in Switzerland is generally described as fold and thrust belt. While the overall geology has been studied in detail, the tectonic development and mechanical interconnection between overthrusting and folding is still not fully understood. One important clue comes from the mechanical stratigraphy and the corresponding lateral transition from overthrusting to folding, which is characteristic for the Helvetic nappe system. We employ a three-dimensional numerical model with linear and non-linear viscous rheology to investigate the control of the lateral variation in the thickness of a weak detachment horizon on the transition from folding to overthrusting during bulk shortening.

The lateral variation of the thickness of the detachment horizon mimicks the lateral variation of the pre-Alpine half-graben depth. Our model configuration is based on published work based on 2D numerical simulations and consists of a stiff viscous layer, with a pre-existing weak zone, resting within a weaker viscous matrix. The thickness of the stiff layer H_L is constant at 1 km, the detachment horizon thickness H_D ranges from 0.2 to 1 km. The reference viscosity ratio μ_L/μ_M(for the same strain rate) between the layer and matrix is 100 and both of the units employ a power-law stress exponent of n = 3. We consider two different initial geometries. In the first configuration the detachment horizon thickness is increased linearly throughout the model domain. In the second configuration the increase of detachment horizon thickness is restricted to a certain width in the model domain, creating a flat ramp geometry. Additionally to the geometrical analysis we compute the finite strain and finite stress ellipsoids at any point in the model domain. These ellipsoids help to study the transition zone in detail and to monitor any variations in the local tectonic regime e.g. quantifiying strike-slip components.