Viscous overthrusting versus folding: 2D numerical modeling and application to the Helvetic and Jura fold-and-thrust belts

Jaquet, Y., Bauville, A. & Schmalholz, S.M.

Institute of Earth Sciences, University of Lausanne, Géopolis, 1015 Lausanne, Switzerland
(yoann.jaquet@unil.ch)

The geometry of the Helvetic and Jura fold-and-thrust belts has been studied in detail since more than 100 years. However, the dynamics of the combined folding and thrusting are still incompletely understood. Two types of nappes have been described in the Alps: fold nappes and thrust nappes. While fold nappes are characterized by continuous sedimentary layers that can be traced back to their root (parautocthonous), thrust nappes exhibit a basal thrust (allochtonous). Detailed mapping in the Alps has shown that the tectonic style can vary laterally from fold to thrust type. Moreover thrust planes in the Helvetic nappe system and in the Jura are often folded and thrust nappes often exhibit considerable internal ductile deformation. It has been proposed that the pre-Alpine stratigraphy, especially the alternation between shales (weak) and limestone (strong), control the tectonic style of the nappes in the Helvetic and Jura fold-and-thrust belts.

We use 2-D numerical simulations of viscous flow to simulate the layer-parallel shortening of a strong viscous layer embedded in a weak viscous matrix, and above a flat detachment plane. A thin weak zone exists initially in the layer representing an initial discontinuity (e.g. thrust plane). We investigate systematically the control of (1) the ratio of the layer thickness to the matrix thickness (between the layer and basal detachment), (2) power-law versus linear viscous rheology and (3) the viscosity ratio between layer and matrix, on the deformation style. When the matrix is linear viscous, only thickening or folding of the layer occurs. When the matrix is power-law viscous (n=5), deformation occurs mainly by folding when the thickness ratio is >~1 and the viscosity ratio is >~10. Overthrusting of the layer occurs when the viscosity ratio is >~100 and the thickness ratio is <~1. Both overthrusting and folding can occur simultaneously for thickness ratios >~1 and viscosity ratios >~50.

Our simulations show that overthrusting is mechanically possible during dominantly viscous flow. The results support the interpretation that many structures in the Helvetic and Jura fold-and-thrust belt resulted from an effectively and dominantly ductile deformation. The results further show that for the same rheology but varying thickness ratio the deformation style can vary from folding-dominated to overthrusting-dominated, which is in agreement with observations in the Helvetic and Jura fold-and-thrust belts.

Orogen-parallel exhumation and topographic gradients east of the Tauern window: a possible clue for shear strength at depth and intra-orogenic raft tectonics

Keil, M. & Neubauer, F.

Geology Division, Dept. Geography and Geology, University of Salzburg, Hellbrunner Straße 34, A-5020 Salzburg, Austria.
(Melanie.Keil2@sbg.ac.at; Franz.Neubauer@sbg.ac.at)

The interplay of indentation by the Southalpine indenter, surface uplift and exhumation of the Tauern window characterizes the post-collisional Late Oligocene to recent evolution of the central sectors of the Eastern Alps. Strong Miocene E-W extension, basement subsidence in the Pannonian realm and surface uplift in the Tauern window area created an E-W topographic and exhumation gradient allowing the brittle upper crust to move along the mid-crustal ductile decollément level towards the east. The purpose of this study is to estimate the critical topographic angle of the brittle upper crust to move along the basal viscous layer. Subject of research is the area between the viscously behaving Penninic zone