Allochthonous salt and the formation of overturned to recumbent thrust sheets in the Northern Calcareous Alps

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The Northern Calcareous Alps (NCA) formed as a salt-detached fold-and-thrust belt during two main stages of shortening: in a foreland position on the lower plate during the Middle Jurassic to Early Cretaceous closure of the Meliata ocean and as part of the upper plate during continent-continent collision between Adria and Europe from Eocene times. The Permo-Mesozoic sedimentary succession involved in the fold-and-thrust belt is dominated by thick non-metamorphic Triassic to Jurassic platform carbonates, underlain by a Permian-Triassic layered evaporitic sequence (i.e., Haselgebirge and Reichenall Fms.) and covered by mid Cretaceous to Miocene synorogenic deposits.

A prominent feature of the NCA is the existence of large panels of inverted stratigraphy. These structurally overturned panels extend up to 10 km across strike and have been traditionally regarded as inverted thrust sheets. Their kinematics, however, are poorly constrained. From temperature data, there is no evidence for syn-folding metamorphic conditions and the overturned sections do not show intense strain as in well documented examples of recumbent forelimbs, e.g. in the Helvetic nappes of the Western Alps. Published cross sections from the NCA either show isoclinal folds with long overturned limbs, or fault related folds involving a layer-cake stratigraphy but avoiding those areas with overturned panels.

The extent and geometry of these overturned panels and their contacts have been critically examined for the Sulzbach "nappe" in the area between Göstling and Annaberg. Coherent panels with an inverted stratigraphy have a typical to maximum extent of 2 to 3 km. More extensive inverted panels are actually separated by steeply dipping faults, which have been previously interpreted as strike-slip faults that dissect formerly coherent overturned panels. Instead, panels with a normal sedimentary polarity are more extensive and made up by a thicker Triassic to Lower Cretaceous stratigraphic succession. We found that: a) remnants of Permian salt (Haselgebirge Fm.) mark the trace of the contacts between these units; b) the Triassic stratigraphic thickness of overturned panels is reduced compared to neighboring non-inverted panels; and c) significant variations in thickness and facies do occur across salt-bearing contacts.

According to these observations, these contacts are interpreted as secondary welds between salt-controlled mini-basins, where the thick non-inverted panels correspond to the subsiding mini-basins and the thinner stratigraphic units to the roof top of salt inflated areas. The lateral extent of both panels is controlled by the original amount of Permian salt, the dimensions and aspect ratio of the inflated salt areas, and the ratio between salt rise and sedimentation rates. An initial rotation of the thin roof cover is related to salt evacuation triggered by downbuilding and extensional deformation of the continental margin, and later during early shortening, and was controlled by the thickness of both the inflated salt and the overburden. Orogenic shortening leads to squeezing of inflated salt walls and diapirs, and to further rotation of the thinned stratigraphy to produce the overturned panels or megaflaps.