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Balanced cross-sections in the boundary area between the western and eastern Alps

Michael Zerlauth (1,2), Hannah Pomella (2), Marcel Schulz (1,2), Silvia Aichholzer (1,3), Hugo Ortner (1), and Bernhard Fügenschuh (1)

(1) Institute for Geology and Palaeontology, Leopold Franzens University, Innsbruck, Austria (michael.zerlauth@uibk.ac.at), (2) alpS-Gmbh, Innsbruck, Austria (mz@alps-gmbh.com), (3) Geological Survey, Office of the Tyrolean Regional Government, Innsbruck, Austria

Within the framework of a deep geothermy potential analyses, initiated and funded by the Illwerke VKW, various cross-sections on crustal scale between the Rhine valley in the west and Oberstdorf (Upper Allgäu) in the east were constructed. The geometry of the balanced cross-sections is constrained by surface geology, well and seismic data. Above the basal Alpine thrust, the principal tectonic units are the Subalpine Molasse, Helvetic, Ultrahelvetic, Penninic and Austroalpine nappe complexes. Hinterland-dipping slices with synclinal geometry form the Subalpine Molasse in the investigated area, the connecting anticlines are not preserved. A lateral change from folding to thrusting, sometimes accompanied with facies change is common. On the border between the autochthonous Molasse north of the Alpine basal thrust and the Subalpine Molasse south of it, a large scale triangle structure is visible in the seismic sections. The contact between the Subalpine Molasse and the southerly adjacent Helvetic unit is that of a steep south dipping fault. Across this bedding-parallel fault a contact of the oldest Molasse strata (Lower Marine Molasse) to the youngest Ultrahelvetic, Helvetic or Flysch strata is developed. We interpret this contact as the passive roof-thrust of a triangle-structure, in which a Flysch and Helvetic duplex was underthrust below the southernmost Molasse slice. The base of the Helvetic thrust sheets is a discontinuous reflector in the seismic data. The internal structure remains to a large extent unknown, however at least two Helvetic nappes are interpreted to fill the space between the basal reflector and the surface: the Säntis nappe and a deeper nappe (often termed as ‚Hohenemser Decke'). In the area of Vaduz the thickness of the Penninic units between the Säntis nappe and the hanging Austroalpine units decreases dramatically, compared to the situation further southwards. We interpret this as a result of an E-W trending, late stage out-of-sequence thrust. The Churer lineament, which was formerly thought to have the geometry of a N-S striking extensional fault, is no longer necessary. The Austroalpine units on the top of the nappe pile have the geometry of a shallow westward dipping bowl.

Balanced cross-sections enable to evaluate the amount of shortening in the different units. In the Molasse, shortening was deduced from line length balancing of a horizon 430m above the base of the Lower Freshwater Molasse, as this ist the only one present in all units. The minimum total shortening within the units of the Subalpine Molasse is 32km (64%), if the unexposed units below the Helvetic thrust sheets are not regarded. Including these units, shortening increases to 50km (100%). The shortening decreases to the east (Upper Bavaria) and also to the west (eastern Switzerland). Within the Helvetic unit the Quintener Kalk (Malm) was used for the retrodeformation. The amount of shortening within the Helvetic Unit is around 50% (> 40km), consistent with data obtained from eastern Switzerland.