Tectonometamorphic evolution of the uppermost Upper Austroalpine: Insights from a section across the Gstoder, Bundschuh, Königstuhl, and Stolzalpe Nappes (Gurktal Alps, Austria)

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The Upper Austroalpine (UAA) Unit in the Eastern Alps is a stack of nappes formed during the Cretaceous ("Eoalpine" event), subdivided into nappe systems (NS). While rocks in the central, higher-grade nappes of the Koralpe-Wölz NS are well studied, large parts of the overlying, lower-grade NSs are poorly characterized. We present the results of a mapping project of the Austrian Geological Survey located in the Gurktal Alps. It is a key area for understanding the evolution of the UAA, exposing a continuous section through the upper part of the nappe stack. We here present results and interpretations of Raman spectroscopy on carbonaceous material (RSCM) and zircon (Zrn) U-Pb, garnet (Grt) Sm-Nd, muscovite (Ms) Ar-Ar, biotite (Bt) Rb-Sr, Zrn (U-Th)/-He geochronology as well observations and crosscutting relationships of structures, mineral assemblages, and metamorphic reactions.

From footwall to hangingwall, metasediments in the Gstoder nappe (GN; Koralpe-Wölz NS) are followed by metasediments, M-Ordovician orthogneisses, overlain by Permo-Mesozoic metasedimentary rocks in the Bundschuh nappe (BN; Ötztal-Bundschuh NS). Separated by a jump in metamorphic grade the section continues with metavolcanic rocks and U-Pennsylvanian metasediments in the Königstuhl nappe (KN). This unit is tectonically overlain by metasediments with L-M-Ordovician metaignimbrites, metapyroclastics and U-Ordovician metavolcanics, also covered by U-Pennsylvanian sediments in the Stolzalpe nappe (STN). The latter two nappes belong to the Drauzug-Gurktal NS.

(pre-)Variscan structures are overprinted by a large-scale, isoclinal fold pattern (D1) with NW/SW-SE/NE trending fold axes, superimposed by ENE-verging asymmetric open folds (D2), discordantly covered by post-Variscan sediments in the STN and BN. While garnets-staurolite assemblages in the BN point to amphibolite-facies conditions, the STN reached greenschist-facies conditions, as shown by RSCM. Ar-Ar geochronology demonstrates late Variscan cooling at ~314 Ma in the STN and 156 to 140 Ma mixed ages for the BN, interpreted as incomplete resetting of Variscan ages in the Cretaceous.

Eoalpine tectonics is responsible for the dominant imprint. Isoclinal folds formed coevally with top-to-W/NW thrusts in the BN, KN, and STN and are interpreted as the record of early Eoalpine nappe stacking (D3a). Amphibolite-facies peak conditions in the GN are dated at ~100 Ma by Grt Sm-Nd ages and gives an upper age limit for this event. Open folds in the deepest nappe (GN), isoclinal folds and ductile to brittle normal faults within the overlying nappes (BN, KN, STN) represent late Eoalpine structures during exhumation (D3b). The formation of a large detachment with top-to-E/SE kinematics between the BN and KN is linked to this event. Ms Ar-Ar deformation ages in the BN cover are at ~ 90 Ma and post-dated by Bt Rb-Sr ages at ~85 Ma, indicating rapid cooling through ~300°C. These give a lower limit for the onset of Eoalpine exhumation and normal faulting. Bt Rb-Sr cooling ages in the GN at ~75 Ma are coeval with Zrn (U-Th)/-He ages in rocks of the KN and STN. This indicates that they had already an upper crustal position, while the GN was still exhuming and sets an upper limit for the termination of the Eoalpine exhumation.