Thermodynamic modeling and in situ U-Th-Pb geochronology constrain polymetamorphism and a large Eo-Alpine metamorphic gap between the Koralpe-Wölz and Drauzug-Gurktal nappe systems (Austroalpine Unit, Eastern Alps, Austria)

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In metamorphic units where precise thermobarometric and geochronologic data are ambiguous or lacking, the temporal interpretation of metamorphism and the identification of polymetamorphic histories can be challenging. We present new P-T-t-D data from samples collected in two Austroalpine nappes exposed in the Eastern Alps (NE of Graz, Austria): the structurally upper Schöckel Nappe ("Graz Paleozoic", Drauzug-Gurktal Nappe System) and the structurally lower Waxenegg Nappe (Koralpe-Wölz Nappe System). Although polymetamorphism is previously documented in the Waxenegg Nappe, the timing of metamorphism is poorly resolved and only sparse geochronology exists in the Schöckel Nappe. In phyllites and micaschists of the Schöckel Nappe, phase relations between chloritoid, white mica, chlorite, ilmenite and rutile, Raman spectroscopy on carbonaceous material (RSCM) and thermodynamic modeling allow the reconstruction of the main metamorphic event at ~470 °C–3 kbar. REE-epidote porphyroblasts grew together with the peak assemblage and are often partially replaced by small (< 10 µm) monazite and thorite. Insitu LA-ICPMS U-Th-Pb dating of well-preserved REE-epidote yields a U-Th-Pb isochron date of 261.3 ± 4.2 Ma, which is interpreted as the timing of peak metamorphism during the Permian Event. Published Rb/Sr white mica and biotite ages suggests that the Schöckel Nappe was overprinted at ~350–400 °C during the Eo-Alpine Event before 119 Ma and subsequently cooled below 300 °C at c. 113 Ma. In the underlying Waxenegg Nappe, garnet-bearing mica schist contains monazite up to 500 µm in length that exhibits distinct core-rim chemical zoning. LA-ICPMS U-Pb analyses targeting the monazite cores yield a ^{204}Pb-corrected U-Pb date of 270.1 ± 0.7 Ma (Permian Event) whereas the rims yield a ^{204}Pb-corrected U-Pb date of 92.2 ± 0.3 Ma (Eo-Alpine Event). The P-T conditions for both events are reconstructed using careful documentation of phase relations, RSCM and thermodynamic modeling. Pseudomorphs after staurolite and relics of plagioclase and sillimanite indicate peak conditions of ~560 °C–4 kbar for the Permian Event. Garnet and chloritoid formed during the pressure dominated Eo-Alpine Event at ~540 °C–9 kbar. We provide unequivocal evidence for Permian metamorphism in the Schöckel Nappe, which was hitherto unknown in this part of the Austroalpine Unit. Our results demonstrate that the metamorphic overprint during the Eo-Alpine in this nappe is lower grade than previously proposed. Combining the data from both nappes, the implication is a metamorphic gap of at least 240 °C and 5 kbar at the time of peak Eo-Alpine metamorphism in the higher grade Waxenegg Nappe. This aligns with the existence of a major normal fault between the Drauzug-Gurktal Nappe System and the Koralpe-Wölz Nappe System in the easternmost part of the Austroalpine Unit, which is comparable to similar structures in its central and western parts. Maximal temperature data in each nappe alone without detailed petrological and geochronological investigations could not support this conclusion as the difference in absolute maximum temperature between the two nappes is a feature inherited from the Permian Event that has a value lower than 100 °C.