reheating. The Early to Middle Miocene period (TS4; ~20–13 Ma) is characterized by uncovering of the Veporic domain after the deposition of the Late Palaeogene to Early Neogene sedimentary sequences. The Early to Middle Miocene denudation of the Veporic domain almost completely removed the Palaeogene sedimentary sequence before the creation of the Sarmatian Veporic volcano-plutonic complex. The obtained apatite FT data of Palaeogene cooling ages from the Slávča and Hrdzavá valleys near the Tisovec intrusive complex revealed that the wider area was not regionally reheated by the mid-Miocene thermal event. The volcanic activity at the centre of the Veporic volcano-plutonic complex occurred during the Middle Miocene (TS5; ~13–11 Ma), according to $^{40}Ar/^{39}Ar$ dating results. The mid-Miocene thermal event was revealed also by zircon FT age of 13 Ma. However, the extent of contact aureole did not exceed more than 1 km, according to maintain of low-thermal Palaeogene record in its neighbourhood. The final exhumation of the Veporic domain occurred in the Neogene to Quaternary times (TS6; ~11–0 Ma). An intensive denudation processes were documented by removing of at least the 1500 m of volcano-sedimentary rocks of upper stratovolcanic structure (cone) during the last 10 Ma. In addition, preservation of the planation surfaces suggests a relatively young (Pliocene and Quaternary) but most probably not so intensive exhumation of the mountains.

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Permian metamorphism and magmatism in the internal Western Alps: Constraints from high spatial resolution U-Th-Pb geochronology

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Evidence of the late Paleozoic HT-evolution in the Western Alps remains a controversial issue. As in other parts of the Alps, magmatic and metamorphic effects in the basement reflecting the Variscan HT-orogeny are well known, but the situation is not so clear for the subsequent Permian evolution. Permian extension in the Adriatic lithosphere has been linked to asthenosphere upwelling, causing high temperature metamorphism at medium pressure and widespread partial melting, which led to upper crustal magmatic activity (e.g. MAROTTA & SPALLA, 2007). However, the relation of the magmatism to the associated metamorphism is well documented in a few areas only, and age control is generally poor. This is particularly true for the Western Alps, where Permian metamorphism has long been proposed, but so far radiometric age data are lacking.

In this study, the use of high spatial resolution geochronology (SHRIMP and LA-ICP-MS U/Th-Pb dating) in combination with structural and petrological methods has proved successful to fill some of the gaps in the current knowledge on the pre-Alpine metamorphic evolution of several Austroalpine units of the Western Alps.

In the SW part of the Sesia Zone, in the II DK unit, upper amphibolite to granulite facies metamorphism was dated at ~277 Ma and at ~270 Ma in metapelites. A leucosome dates at ~290 Ma.

In the eclogitic micaschist complex (EMC), the Corio-Monastero metagabbro contains zircon with rims that crystallized at HT metamorphic conditions and date at ~277 Ma. Local recrystallized rims yield ages at ~230 and ~190 Ma, indicating two (fluid-induced?) episodes. During exhumation this gabbro was intruded by dikes. In one of these zircon shows two age populations at ~270 and ~235 Ma. Two intermediate to felsic intrusions in the EMC yield ~277 and ~266 Ma.

In the Valpelline Series of the Dent Blanche unit, three stages of amphibolite to granulite facies metamorphism are evident: The age data show ~287 Ma, ~274 Ma, and ~263 Ma. These metamorphic stages clearly postdate the Variscan metamorphic cycle, which occurred around 350 Ma, as confirmed by this study.

In the Emilius Klippe preliminary results indicate a Permain HT evolution as well: Basic intrusives have been dated at ~290 Ma (compare BUSSY et al., 1998) and a granitic intrusive at ~283 Ma. Zircon and allanite, both interpreted to be of metamorphic origin, cover an age range clustering at ~276 Ma.

These ages, together with petrological data, evidence that the middle and lower crust in several Austroalpine units in the internal Western Alps experienced a regime of high temperature in Permian times. The time span recorded in zircon ranges between ~290 and ~260 Ma. Age relics of the Variscan orogeny are sparse, and so far no evidence has been found of the regional HT metamorphism at ~310 Ma, known in the Ivrea Zone (e.g. EWING et al., 2013). It remains to be explored whether the differences among age data are due to differences in the Permian metamorphic history of these units or whether they merely reflect chemical differences (e.g. in the growth of zircon) due to local compositional differences or the structural position of the samples analyzed.

BUSSY, F., VENTURINI, G., HUNZIKER, J.C., MARTINOTTI, G. (1998): U-Pb ages of magmatic rocks of the Western Austroalpine Dent-Blanche-Sesia Unit. Schweizerische Mineralogische und Petrographische Mitteilungen, 78:163-168

EWING, T.A., HERMANN, J., RUBATTO, D. (2013): The robustness of the Zr-in-rutile and Ti-in-zircon thermometers during high-temperature metamorphism (Ivrea-Verbano Zone, northern Italy). Contributions to Mineralogy and Petrology, 165: 757-779

MAROTTA, A.M. & SPALLA, M.I. (2007): Permian-Triassic high thermal regime in the Alps: Result of late Variscan collapse or continental rifting? Validation by numerical modeling. Tectonics 26 (4).

3D FEM modeling of fold nappe formation in the Western Swiss Alps

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Many three-dimensional (3D) structures in rock, which formed during the deformation of the Earth's crust and lithosphere, are controlled by a difference in mechanical strength between rock units and are often the result of a geometrical instability. Such structures are, for example, folds, pinch-and-swell structures (due to necking) or cuspate-lobate structures (mullions). These structures occur from the centimeter to the kilometer scale and the related deformation processes control the formation of, for example, fold-and-thrust belts and extensional sedimentary basins or the deformation of the basement-cover interface. The 2D deformation processes causing these structures are relatively well studied, however, several processes during large-strain 3D deformation are still incompletely understood. One of these 3D processes is the lateral propagation of these structures, such as fold and cusp propagation in a direction orthogonal to the shortening direction or neck propagation in direction orthogonal to the extension direction. Especially, we are interested in fold nappes which are recumbent folds with amplitudes usually exceeding 10 km and they have been presumably formed by ductile shearing. They often exhibit a constant sense of shearing and a non-linear increase of shear strain towards their overturned limb. The fold axes of the