Extent and age of metamorphism of the central Grauwacken Zone, Eastern Alps: a $^{40}Ar/^{39}Ar$ study

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Previously reported, scattered K-Ar and Rb-Sr white ages of the Grauwacken Zone display a large variety of ages ranging from Late Carboniferous/Variscan, via Permian to eo-Alpine/ Cretaceous times. Consequently, the main goals of this study are: (1) to find the extent and exact age of pervasive metamorphic overprint of the Grauwacken zone from base to top and of the Upper Palaeozoic base of Northern Calcareous Alps in a complete cross-section through these units; (2) to find a possible Tertiary metamorphic overprint at the base of the Grauwacken zone (as previously postulated), and the extent of Variscan relics in that section in comparison to the Hochkönig–Dienten and Salzach valley cross sections; and (3) to find possible evidence for relics of Variscan metamorphism, respectively of the enigmatic Permian thermal event. The strategy was to collect samples along a N-S cross-section in which variable ages could be expected (Wagrain – Annaberg section). Only samples with a single-stage, simple metamorphic fabrics have been collected for dating white mica making use of the $^{40}Ar/^{39}Ar$ technique. A further strategy was to sample a few specimens of greenish phyllites from the post-Variscan Alpine Verrucano Formation of the basal Northern Calcareous Alps from which only a Cretaceous metamorphic age could be expected.

Ductile deformation structures in the investigated section include a mainly N-dipping foliation and a NW-plunging stretching lineation. Synmetamorphic ductile structures are documented by the recrystallization of quartz and the new-grown sericite, and allow direct dating of metamorphism within greenschist facies and of associated ductile deformation. The temperature by the metamorphism was by ~ 400 °C, which is also documented by nearly complete overprint of argon isotopic patterns in white mica (see below).

Surprisingly, the new $^{40}Ar/^{39}Ar$ ages (nine investigated samples) show several particular features: (1) full Cretaceous-aged overprint on the Grauwacken zone basement which erased nearly all signs of pre-Alpine metamorphism in this section; (2) the strong, greenschist facies overprint on basal successions of the Northern Calcareous Alps, which also include pervasive ductile overprint; and (3) a hitherto unknown, late-stage low-grade thermal overprint on Cretaceous ductile synmetamorphic fabrics.

$^{40}Ar/^{39}Ar$ patterns of syntectonic white mica from nearly all samples display plateau with an eo-Alpine age at ca. 100 Ma (98–102 Ma). Some samples show a staircase argon release pattern and a younger, second Cretaceous-aged heat pulse at ca. 70 Ma reaching ca. 300 °C, which was

not known until now. This event may relate to post-tectonic growth of some minerals like chloritoid, which are widely known at the base of the Northern Calcareous Alps.
Our new $^{40}Ar/^{39}Ar$ white mica ages indicate the timing of the Alpine metamorphic overprint at ~ 98 to 102 Ma. The age refines the results on recently reported ages of fine-grained micas from the area to the NE of our working area (Frank and Schlager, 2006, Int. J. Earth Sci., DOI: 10.1007/s00531-005-0045-7). These authors published a number of conventional $^{40}Ar/^{39}Ar$ ages from the base of the Northern Calcareous Alps adjacent to the east and north of our working area. They did choose mainly new-grown fine-grained white mica fractions (fractions <2 μ, 2–6 ?, resp. 6–11 μ) from rocks of the Northern Calcareous Alps and found plateau ages scattering between 102 and 169 Ma. In the grains size fraction of 6–11 μ from phyllites of the Grauwacken zone, they found plateau ages ranging from 94 to 103 Ma.
The age group at ~ 98 to 102 Ma is slightly older than those previously reported from the eastern sectors of the Grauwacken Zone. Therefore, lateral migration of the metamorphic front seems likely. Because of the syntectonic growth of dated white mica we suggest that the age dates the age of ductile thrusting. The fabrics and the orientation of stretching lineation are similar to that from the eastern Grauwacken Zone. Determination of shear sense was not in the scope of this study because of the late stage overprint by folding, which makes shear sense not fully reliable. So, we assume that the fabrics date the age of ductile nappe stacking, which must be proofed in other areas.
There is nearly no relic of Variscan metamorphism, which underlines previous data showing increasing metamorphic overprint from west (Hochkönig section) to the east. Going west, the Grauwacken Zone virtually preserves Permian to lowermost Triassic fabrica (ca. 240–260 Ma). The surprising further result is the until now undetected heat pulse likely in Late Cretaceous (~ 70 Ma), which overprint the main stage metamorphic fabric at 98 to 102 Ma. Several alternatives could explain this age. The most reliable explanation would be that a low-temperature thermal pulse overprinted ductile, syn-metamorphic fabrics. This is in line with the observation of a post-tectonic growth of chloritoid aggregates. We assume that heat advection during exhumation of high-grade metamorphic successions in the footwall might have been the cause of thermal pulse. Such amphibolite-grade metamorphic units are exposed to the SE of the study area, e.g., in the amphibolite-grade Bundschuh and Wölz nappes.