Late Oligocene to Miocene exhumation and cooling history of the Tauern Window (Eastern Alps) – new age constraints

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The Tauern Window exposes a nappe stack of Subpenninic (European lower plate) and ophiolite-bearing Penninic units. It is surrounded by overthrusted Austroalpine nappes (Adriatic upper plate). After nappe stacking and metamorphic overprinting the units within the Tauern Window were refolded and exhumed in Miocene time in response to Adriatic indentation. The western and eastern margins of the window are characterized by two ductile extensional fault zones, the Brenner- and Katschberg shear zone systems (BSZS, KSZS), respectively. Amount of exhumation is greatest in the footwalls of these Neogene shear zone systems.

Rapid exhumation (≥ 1mm/a) in the footwall of the BSZS lasted from 20-15 Ma and was triggered by sinistral transpression along the Guidicarie Belt beginning at 23-21 Ma. Rapid cooling (≥ 25° C/Ma) from 550-270° C lasted from 18-12 Ma (VON BLANCKENBURG et al., 1989; FÜGENSCHUH et al., 1997). In contrast, the exhumation and cooling history of units in the footwall of the KSZS was still poorly constrained. New 40Ar/39Ar laser ablation ages on white micas from the KSZS indicate that mylonitic shearing started at an unknown time before 20 Ma and ended before 17 Ma, as supported by the following arguments: (1) post-kinematic white mica located at the base of the KSZS overgrow the main Katschberg foliation and yields similar ages as found in white mica oriented parallel to the foliation (20.05 ± 0.19 Ma and 19.5 ± 0.17 Ma, respectively) and hence, is interpreted as a cooling age; (2) a sample from the top of the KSZS yields almost identical ages for re-folded and foliation-parallel white mica (17.34 ± 0.16 Ma and 16.48 ± 0.25 Ma, respectively) and are interpreted to date cooling below 400° C. Hence, mylonitic shearing that exhumed the footwall of the KSZS must have ended before 17 Ma. Rb/Sr cooling ages of white mica indicate that cooling from c. 550° C began at c. 22.5 Ma or earlier (Favaro & Schuster et al., in prep.). The end of rapid cooling is poorly constrained owing to the large range of the zircon fission track ages (16-11 Ma; DUNKL et al., 2003; BERTRAND et al. in prep.), which most likely reflects the long time spent within the partial annealing zone of zircon (BERTRAND et al., in prep.).

The age data suggest that Adriatic indentation (23-21 Ma, according to stratigraphical constraints) rather than extension in the Pannonian Basin (starting after 20 Ma) triggered the onset of rapid exhumation in the Tauern Window. The data also suggest that there was a delay in time between the onset of rapid exhumation and rapid cooling in the west, in contrast to the east. The later onset of rapid cooling in the west (BSZS) is probably due to the greater contribution of upright folding and hence, erosional exhumation to total exhumation. In the east the contribution of normal faulting predominates, allowing for a shorter delay time between the onset of rapid exhumation and cooling.

However, an onset of rapid exhumation before 23-21 Ma cannot be excluded in the case of the eastern Tauern Window. An onset of exhumation before Adria indentation would necessitate an alternative trigger for exhumation, e.g., the counterclockwise rotation of the northwards subducting Adriatic slab beneath the Eastern Alps, as inferred from the obliquity of the trace of the slab tip at 150 km depth to the Tauern Window (LIPPITSCH et al., 2003).

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Crystalline nappes in the Cental Alps: case study Suretta nappe and Bernhard nappe complex

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The Suretta nappe in the Grisons (eastern Switzerland) and the Bernard nappe complex in the Valais (western Switzerland) are both part of a major basement-bearing nappe stack attributed to the Middle Penninic nappe system of the Swiss Alps which is derived from the Briançon swell. They formed in the course of Alpine southward subduction of the Briançon swell beneath the Piemont-Ligurian ocean and the Adriatic continental margin and subsequent collision with the European continental margin. Their present-day shape intrigued Emile Argand who reconized much of their structure and kinematics.

The *Suretta nappe* is exposed on the eastern flank of the Lepontine dome in eastern Switzerland. The general axial plunge of about 30° towards the ENE of all units in this area together with the Alpine topography provides an oblique section through the entire Suretta nappe. The Suretta nappe was detached by a basal thrust within the crystalline basement. Its internal structure is governed by a major thrust fault and several folds in the upper part of the nappe. A Permian shallow intrusion (Rofna Porphyry complex) occupies the frontal part of the nappe.

The *Bernard nappe complex* is exposed on the western flank of the Lepontine dome in western Switzerland. It consists of an imbricate stack of basement slices and Permian-Triassic clastics. A large-scale fold is associated with an inverted Permian basin.

The structure of both nappes is controlled by pre-existing structures, leading to regional complexities and differences between and within the study areas, which are difficult to predict in any general model. In the case of the Suretta nappe, Jurassic normal faults probably served as a trigger for the localization of early folds and thrusts, and the occurrence and shape of the Rofna Porphyry complex influenced the level of basal detachment of the Suretta nappe. In the case of the Bernard nappe complex, a Permian graben structure largely controlled the deformation style, i.e. fold versus thrust relationships.

The structural architecture of both the Suretta nappe and the Bernard nappe complex can be interpreted as being basically the result of three main deformation phases:

(1) The Avers phase and the Evolène phase respectively are responsible for the northward detachment of Briançon cover units (e.g. Schams nappes, Klippen nappe) and for the contemporaneous emplacement of Piemont-Liguria rocks (e.g. Avers nappe, Tsaté nappe) onto Briançon basement and its adhered cover. This is a typical example for cover substitution. Relics of brittle deformation features at thrust contacts point to an early brittle thrusting stage, marking the onset of a continuous thrusting history during the Paleocene and Eocene.