Special issue "Central Alps" : editorial

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Objekttyp: **Article**

Zeitschrift: **Schweizerische mineralogische und petrographische Mitteilungen = Bulletin suisse de minéralogie et pétrographie**

Band (Jahr): **85 (2005)**

Heft 2-3: **Central Alps**

PDF erstellt am: **27.04.2024**

Persistenter Link: https://doi.org/10.5169/seals-1656

Special Issue "Central Alps"

Editorial

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This special issue "Central Alps" assembles a new map and six papers which document some of the current research aimed at unravelling the tectonometamorphic structure and evolution of this collisional orogen. It may come as a surprise to geologists not working in the Alps that an area as classical as the Lepontine should still hold sufficient scientific novelty to deserve such a volume. However, a glance at the contents of this special issue is likely to convert the sceptic.

Geological work in the Lepontine Alps spans well over a century and has produced an array of excellent maps. However, detailed tectonic maps for the entire area, in which the complete nappe stack present in the Central Alps is depicted, have curiously been lacking. Recent maps by Steck et al. (2001) cover the western parts at 1:100'000 scale, and the central Lepontine is now presented in the map sheet "Sopra Ceneri", compiled by Berger and Mercolli, which is included as part of the first paper of this volume. The explanatory notes by Berger et al. (2005) introduce the tectonic units represented on this new map and characterize their major lithotypes. The vast literature integrated includes a wealth of old maps and studies, dozens of PhD theses and specialized papers. Various tectonic schemes, countless local names, and different paleogeographic terms have been used in the literature and on small-scale maps. Readers uninitiated to the plethora of these terms will welcome the authors' effort to minimize and unify them; in turn Alpine aficionados may miss some of their favorite categories (e.g. the Pennine with its confusing subcategories), see Fig. 1.

The first contribution of this volume thus presents an up-to-date regional inventory. Beyond that, it summarizes – based on the primary references – the wide spectrum of research results regarding each of the crystalline thrust sheets, their polyphase deformation, and regional metamorphism. Parts of the polymetamorphic puzzle remain to be resolved, and notably many age data from the Central Alps could not be unequivocally interpreted. By incorporating the geochronological and petrological constraints in their regional context of structural and stratigraphic information, Berger et al. attempt to separate the pre-Tertiary orogenic history from those pertaining to the early-Alpine high-pressure evolution, the main Alpine Barrovian phase, and finally the late-Alpine overprint. One merit of this compilation is its exposure of weak or conflicting data, pointing the direction for future work.

Any tectonic map aims to depict a consistent interpretation of geological observations and data, hence disputed points and recognized discrepancies demand decisions. For the map sheet "Sopra Ceneri", the decisions are documented by Berger et al., who largely based them on a few unifying concepts. For example, it has been recognized that Alpine eclogite relics appear to be confined to an ensemble of tectonic slices with mélange character, which are interpreted as remnants of a tectonic accretion channel (TAC), i.e. a fossil plate boundary (Engi et al., 2001). This superunit on the new map comprises an established, major thrust sheet (the Adula nappe), a substantial part of the Southern Steep Belt (the "root zone" of early studies), as well as several tectonic slivers (e.g. the Cima Lunga and Someo zone), which act as nappe separators between several of the polycyclic gneiss sheets. In the Central Alps such separators are critical within the nappe stack (Wenk, 1953), and the mélange units should be integrated in modern tectonic reconstructions as well (compare Maxelon and Mancktelow, 2005).

High pressure fragments widespread in these mélange units are the topic of the second paper in this volume. Brouwer et al. (2005) document the spatial distribution and field relations of eclogite relics attributed to the TAC. Petrological data presented for select samples document their P-T evolution to eclogite facies, with maximum pressures indicating remarkably different depths of formation (from <60 to >100 km), prior to decompression; the subsequent regional Barrovian over-

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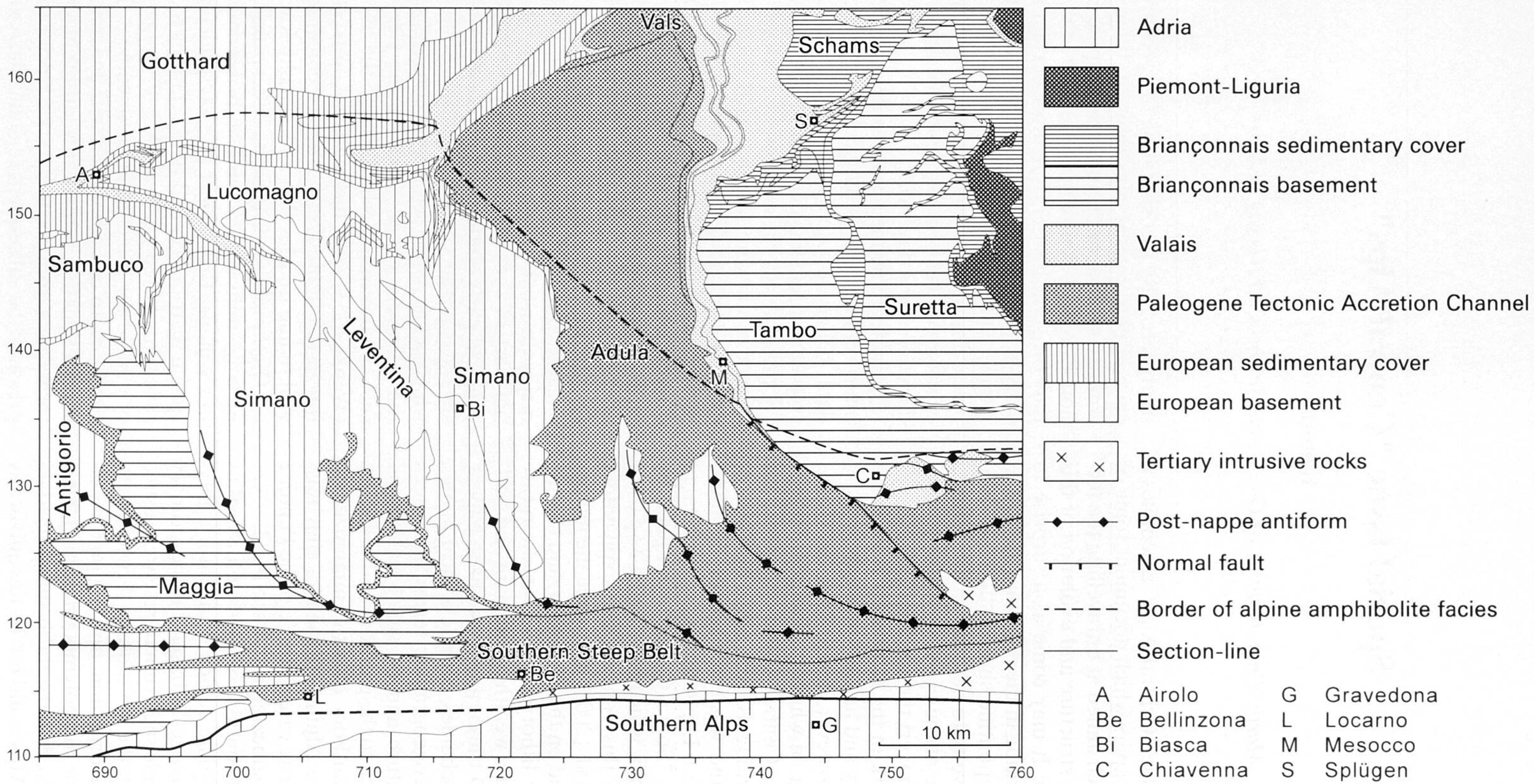

Fig. 1 Tectonic map of the Central Lepontine Alps, simplified from the 1:100'000 map, see Berger and Mercolli (2006) and Berger et al. (2005). Coordinates refer to the Swiss kilometric grid. Map and explanatory notes are available from the Federal Office of Topography, Berne, www.swisstopo.ch.

print reached peak temperatures at mid-crustal depths (~20 km). A long disputed problem addressed by Brouwer et al. is the age of the high-pressure evolution. New Lu-Hf data by Brouwer et al. (2005) document a protracted history of these HP-relics, but no pre-Alpine eclogites. Prograde garnet growth started before 70 Ma ago in some parts of the TAC and continuing as late as 36 Ma in others. Taken together with the structural data presented in this paper, the diversity of peak pressures and ages found in mafic lenses reflects the internal mobility of this mélange belt and its long and complex evolution.

The paper by Kuhn et al. (2005), reporting mineral assemblages in calc-schists derived from post-Variscan clastic sediments, is in the tradition of classical metamorphic studies in the Central Alps. The emphasis is on phase relations involving scapolite. Mapped spatial distributions at low to middle amphibolite facies include clinozoisite ± plagioclase, followed by scapolite-bearing assemblages; at slightly higher grade scapolite + K-feldspar is a common pair in the central Lepontine, whereas clinopyroxene appears at the highest metamorphic grade only. The observed sequence of critical assemblages in the Barrovian metamorphic field gradient is shown to be in good agreement with the succession in computed phase diagrams. Scapolite-bearing assemblages allow T-X(CO2) evolutions to be monitored, but appear to be relatively insensitive to pressure.

The evolution of aluminosilicate-bearing quartz veins (known as "Knauern") from the central Lepontine (Simano nappe) is the topic of the paper by Allaz et al. (2005). The hydrothermal transport of aluminous species required to form these veins is shown to be associated with extensional (D3) deformation, which postdates the main penetrative schistosity. Metapelite assemblages affected by D3 contain kyanite + staurolite + garnet + biotite, TWQ-thermobarometry yields 8.5 ± 1 kbar and 630 ± 20 °C. This temperature is within error of oxygen isotopic equilibration at 670 ± 50 °C for kyanite-quartz pairs in this assemblage, and at 645 ± 20 °C for the same pair in the hydrothermal veins. This implies hydrothermal mass transfer of aluminum near peak metamorphic temperature. Andalusite is missing in the bulk rock assemblage, but common in the Al-rich veins. If andalusite formed near Tmax as well, pressures must have been substantially less than lithostatic.

A major effect of fluid infiltration is one of the main results of the paper by Burri et al. (2005), who report on the spatial distribution and tectonic significance of Tertiary migmatites, and on their genetic conditions. Whereas pre-Alpine migmatites are very widespread in the Central Alps, partial melting during the Alpine orogeny was confined to the southernmost Lepontine. Alpine migmatites essentially occupy the central portion of the Southern Steep Belt – the E-W transpressional shear belt immediately north of the Insubric Line – within the unit interpreted as a TAC remnant. Burri et al. (2005) document two main melt-forming processes, (1) infiltration of hydrous fluid into granitoid gneisses, and (2) muscovite-breakdown induced melting in metapelitic schists; both account for the inferred in-situ melting. Process (1) was far more effective, commonly producing 10-25 vol-% leucosome; process (2) yielded but a few percent. Amphibole-bearing leucosomes allow mid-crustal conditions (700 ±2 5 °C, 6–8 kbar) to be calculated, and these conditions for partial melting overlap with those documented for the regional Barrovian metamorphism (Todd and Engi, 1997), hence they are likely to be coeval. Important feedback mechanisms are documented by Burri et al. (2005) for the Southern Steep Belt: Observations in the migmatites indicate that the focussed transpressional deformation in the shear belt lead to episodic infiltration of hydrous fluid, which triggered the production of partial melts, and these in turn facilitated strain partitioning into the partially molten bands. Leucosomes are quite variably deformed and commonly crosscut, suggesting that many such cycles of "prostatic melting" may have occurred. The overall duration is not clear, but robust chronometers indicate a time window between 30 and 25 Ma, when the Insubric belt experienced rapid exhumation (Hurford, 1986).

A much later stage of Alpine exhumation is documented in the last paper of this volume. Rahn (2005) presents apatite fission track ages for the Adula nappe and discusses these in a regional context. The data indicate relatively old ages in the southern parts, where track lengths imply rapid uplift to that time (8–11 Ma). Apatite FT data within the Adula nappe show no uniform spatial gradient in map view or regional profiles, but metasediments adjacent to the thrust sheet, i.e. in the Misox and Splügen zones, yield contrasting FT ages. Rahn attributes this to normal faults, which displaced the Adula from the Tambo nappe, thereby heating the intervening Misox zone. The vertical distribution of apatite FT ages show a distinct pattern for samples from the main stream valleys. This constrains the timing of valley incision in the Central Alps and confirms a shift in the main water divide since the Miocene proposed by Kühni (1999).

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