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Objekttyp: **Article**

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

Band (Jahr): **74 (1994)**

Heft 1

PDF erstellt am: **10.07.2024**

Persistenter Link: https://doi.org/10.5169/seals-56327

SCHWEIZ. MINERAL. PETROGR. MITT. 74, 3–4, 1994

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Introduction

by *Ivan Mercolli*[1], *Jürgen Abrecht*[1,2] and *Giuseppe Biino*[1,3]

The following collection of papers summarizes an important part of the results of a three year (1989–1992) research project on the pre-Alpine crustal evolution of the Aar-, Gotthard- and Tavetsch massifs carried out at the Institute of Mineralogy and Petrology of Bern University. The project was supported by the Swiss National Science Foundation.

At the beginning of the project, the fundamental question arose, whether it would be possible, with some degree of scientific rigor and without phantasy, to reconstruct the pre-Alpine evolution of the crystalline basement of the central Alps. Although the crystalline basement has been dramatically affected by several orogenic cycles, the answer is positive due to the multidisciplinary approach applied in the following studies.

The strategy of the project was centered on the study of the mafic and ultramafic rock associations occurring in the basement of the three massifs. This choice was dictated by the intrinsic characteristics of these rocks, that are:

– reactions sensitive to the changing metamorphic conditions, recorded in complex but often still definable mineralogical associations,

– geochemical fingerprints that allow to discuss the question of protoliths even after the strong polymetamorphic overprint(s).

Intensive fieldwork and a careful literature study were carried out to relate the evolutionary steps recorded by the mafic-ultramafic associations to well dated geological events as the Ordovician and Carboniferous acid magmatism.

The following papers demonstrate that this approach was fruitful with respect to both fundamental questions concerning the problem of the protoliths and the polymetamorphic evolution.

The first three papers summarize the actual knowledge on the pre-Alpine geology of the massifs.

ABRECHT analyzes the tectonometamorphic structure of the pre-Alpine basement in the Aar massif, presenting a critical review of the different classical subdivisions proposed in the past and integrating recent observations. Lithostratigraphical as well as structural and metamorphic criteria were used to define a coherent zonation of the basement over the whole massif and also to discuss the difficulties and limits of this subdivision. The results are presented on three petrotectonic maps covering key areas of the massif and discussed in terms of their geological evolution.

In a similar manner MERCOLLI et al. propose a revised lithostratigraphical subdivision of the Gotthard massif. The excellent geologic maps available and accurate rock descriptions permitted the compilation of a new map illustrating the distribution of the different units along the entire massif. In the light of new results, the geological evolution of the pre-Alpine basement from the Proterozoic to the Permian is presented.

SCHALTEGGER reviews and discusses the available pre-Mesozoic radiometric age data obtained in different units of both massifs. For approximately 30 years, isotopic investigations have been

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amongst the most meaningful methods of research in Swiss earth sciences. Several research groups using independent techniques have demonstrated the complexity of the central Alpine basement, where the isotopic signatures of three orogenic cycles have been preserved.

The following two papers present the results of two case studies.

ABRECHT and BIINO describe the complex metamorphic history of the gabbroic intrusion of the Kastelhorn area in the Gotthard massif. Based on a careful microscopic description of the mineral assemblages and their textural relationships, together with the chemical characterization of each mineral phase, the authors were able to trace four different metamorphic events. The primary magmatic assemblages are replaced by an eclogitic paragenesis which, in turn, is overprinted first by a granulitic and subsequently by the dominant amphibolite facies mineralogy; the last event mainly represents the retrogression under greenschist facies conditions.

BIINO and MEISEL have investigated major, trace, rare earth and noble elements in four ultramafic bodies of the Aar massif in order to constrain their chemical evolution. They discuss the effects of serpentinization and magmatic impregnation on the distribution patterns of the different elements. A genetic model, mainly based on the distribution of the platinum group elements, is presented for two different types of ultramafics, and the paradigm correlating chemical composition and degree of melting is questioned. A link to similar rocks in the Gotthard massif is proposed.

In the last paper, BIINO describes in detail the pre-Ordovician metamorphic stages in the polymetamorphic metabasic rocks of the Gotthard and Tavetsch massifs. He shows mineralogical and textural evidence for an eclogitic and a granulitic event. With phase petrologic calculations he constrains the P-T-X conditions for each event and utilizes these data to construct an evolutionary model for the two massifs. BIINO discusses some possible sources of errors in the quantitative estimation of P and T of metamorphic events.

The papers presented in this volume are examples of the care required to interpret rock assemblages in polymetamorphic terranes, but several questions still remain unanswered, i.e.:

- How old is the oceanic event? Is it really Riphean as suggested by Nd–Sm (BIINO et al., 1994) and SHRIMP (GEBAUER et al., 1988) data?
- How important is the Alpine and Variscan superposition on the pre-existing structures?
- Are Variscan and Alpine events responsible for the major structuration of the basement?
- Are there structural remnants that can be related to the early high-grade events?
- To what extent is syn-magmatic Late Variscan deformation responsible for some of the "Alpine" structures?
- Is the separation of Variscan and Alpine amphibolite facies metamorphism as readily done as traditionally believed?