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Second Workshop on Alpine Geology: Editorial remarks and results of a round-table discussion about perspectives of geological research in the Alps

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Aims of the conference

This conference with workshop character, held from January 5 to 7 1995 in Basel and attended by some 170 participants, was the second of a series of conferences on Alpine Geology. Our colleagues from Grenoble University took a first initiative in November 1993 by organizing a workshop entitled "Geoatélier Alpin", hoping that a series of similar workshops would be held on a bi-annual basis also in the future. By organizing this second workshop the Basel team gladly volunteered to help to establish what hopefully will become a tradition in the future. We are glad to hear that Guido Gosso from the Università degli Studi di Milano agreed to host a third workshop at some pleasant place near Milano in about two years time.

Alpine geology certainly has a long tradition and the Alps are still regarded as a mountain belt with model character by many earth scientists. The high reputation of Alpine geological research, however, faded away to some extent due to a series of reasons. Modern earth science became more process-oriented. Purely regional studies, although they form an important basis for the process-oriented approach now and in the future, receive less financial support these days. In some European countries it becomes increasingly difficult to convince the funding agencies that research on Alpine geology is worth any financial support. These difficulties are at least partly due to the fact that Alpine research groups often do not succeed in conveying their message to earth scientists active in other mountain belts or to colleagues primarily interested in processes. Furthermore, there is a notable lack of dialogue between the different teams active in Alpine geology. Even Alpine geologists find it hard to keep themselves informed about recent developments in other parts of the chain which they do not know from first hand experience.

How can Alpine geologists expect the non-specialists to become interested in a wealth of data, which lack integration into a coherent picture? Why should the non-specialist get bothered with confusing terminology considering the main tectonic and paleogeographical units? Much of this terminology predates the advent of plate tectonics and

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reflects obsolete concepts of basin formation and orogeny. Additionally, Alpine geology sometimes stops at national frontiers, where terminology abruptly changes due to historical reasons and lack of dialogue.

On the other hand, there are certain signals that Alpine geology might regain the attention it certainly deserves, given the incredible amount of new data obtained by new laboratory and field methods and the excellent 3-D exposure of this orogen. For example, the recent and highly successful efforts on seismic imaging of the deep structure of the Alps have not only shed new light on processes of orogeny. They also have brought different disciplines of earth sciences and earth scientists from different countries into a closer dialogue across disciplines and national boundaries.

Of course, every organizing committee has its own philosophy in organizing such a workshop. Our own intention was to promote review-type presentations for the oral sessions by asking the speakers to put their own research into a broader perspective. A wealth of new data has been presented in the poster sessions which enjoyed lively attention in the afternoons. The interesting comments and statements of a final round table discussion are summarized below. This discussion showed that dialogue and cooperation across borders and across scientific disciplines are the main requirements for the promotion of future Alpine research.

The contributions of this special conference volume

The articles presented in this volume do only represent a small part of the numerous contributions. It was our intention not only to present review-type contributions but also to add to the data basis.

A first group of articles comprises contributions which discuss the **Alps in a greater context**. *R. Trümpy* first looks at the historical development of ideas concerning Alpine research, comments on the present state of the art and very cautiously looks at where we might be going in the future. *G. Stampfli* proposes palinspastic models for the entire western Tethyan realm from Carboniferous to Early Jurassic times. His article discusses the enigmatic time gap between Variscan orogeny and the opening of the Alpine Tethys during which eastern portions of Paleo-Tethys were closed in Eastern Europe. Two contributions discuss high-pressure metamorphism in the Alps which, according to new data, appears not to be restricted to Cretaceous times: *Michard et al.* take a look at the Alps "from the minaret of an Oman mosque", i.e. by directly comparing the Alps with the Oman-Makran transect, while *Froitzheim et al.* propose two separate subduction events (Cretaceous and Tertiary) mainly based on paleogeographical evidence. *Von Blanckenburg and Davies* discuss slab breakoff, related to the closure of oceanic basins and partial subduction of continental lithosphere, which apparently occurred twice during Alpine orogeny. *Puga et al.* provide evidence for the polycyclic character of Alpine orogeny in the Betic Cordillera and *Molli* focusses on the Ligurian ocean of the northern Apennine. Both these contributions are relevant for discussing Alpine geology in a wider context. Two articles look at the eastern prolongation of the Alps in the Carpathians. The study by *Dumont et al.* provides a direct comparison between inverted rift structures found in the Western Carpathians and in the Western Alps; *Dallmeyer et al.* give an overview of new radiometric ages obtained in the Eastern Alps and the Carpathians.

A second group of articles focusses on the **Western Alps**. *Caby* gives an overview of

the middle Penninic units of the entire Western Alps and proposes a new model of east-directed extrusion of high-pressure rocks, challenging traditional interpretations in terms of backfolding, believed to be characteristic for the internal part of the Western Alps. The article by *Ford* discusses pre-Priabonian uplift and deformation in the Pelvoux massif. Two articles discuss the Pennine frontal zone: *Bertrand et al.* offer a general review including a discussion of the frontal part of the Zone Houillère, while *Cannic et al.* focus on the Versoyen (North-Penninic) unit. The analysis of P-T-paths of the internal Penninic massifs by *Borghi et al.* offers petrological constraints for the thermo-mechanical evolution of these internal domains. The final contribution within this group by *Venturini et al.* offers new data and interpretations on the geochemistry of mafic rocks in the Sesia zone.

Concerning the **central segment of the Alps** *Mosar et al.* offer an up-to-date review of the Préalpes Médianes, incorporating new results. *Niklaus and Wetzel* study fluvial accumulation systems in the Late Paleozoic trough of Salvan-Dorénaz in the external massifs of Western Switzerland. A classical area of the Swiss Alps, the Glarus Alps, is revisited by *Lihou* who offers a new look at the structural evolution of the Infrahelvetic flysch units, integrating new stratigraphic data. A large-scale synthesis of the northern part of the Lepontine dome by *Grujic and Mancktelow* offers insight into how the extremely complicated present-day structure evolved by superposition of structures on all scales. *Sanders et al.* present new age data which, combined with an investigation of the P-T-t-path, shed new light on a Mid-Triassic thermal event predating the onset of passive margin formation in the Southern Alps.

The last series of articles is devoted to the **Eastern Alps**. *Winkler* studies the thermo-mechanical evolution of the northern Adriatic margin from the sedimentological point of view and infers an Oman-type obduction scenario for early stages of convergence. Partitioning of deformation into fold-thrust structures and strike slip faulting during two episodes of Alpine orogeny (Cretaceous and Tertiary) is the subject of a study in the Northern Calcareous Alps by *Eisbacher and Brandner*. The study of *Kurz and Neubauer* postulates that the kinematic development within the Tauern window post-dates the structuration of the Austroalpine nappe pile and concludes that the Alpine orogeny is the result of two continental collisions.

Report on the round table discussion about perspectives of geological research in the Alps

This discussion was introduced by a presentation of R. Trümpy (see article in this volume). This delightful essay on the historical development of ideas set the scene for the discussion on future perspectives. It succeeded in inspiring the participants of the discussion to be as outspoken in what they think about the future of Alpine geology as R. Trümpy was about past developments. His analogy between the opening and closing of gaps between subdisciplines in Earth Sciences and the opening and closing of various Alpine oceans has to be taken seriously. While the historical gap between structural geologists, petrologists and geophysicists has been successfully bridged, a new "ocean" is about to open between "hard rock" and "soft rock" geology. Indeed, only a few Alpine sedimentary geologists did contribute to the workshop, and the decline of Alpine paleontology is disturbing. Paleo-biogeography and biostratigraphical data still provide extremely valuable constraints. The older data still form important cornerstones for kinematic anal-

yses; however relatively little is done these days in adding new data from these fascinating fields to Alpine research.

The round table discussion was split into the following five small sessions, each one headed and introduced by a different chairperson:

1. Geophysics (Stephan Müller)
2. Geochronology (Dave Dallmayer)
3. Petrology (Jane Selverstone)
4. Kinematics (Gerhard Eisbacher)
5. Sediments and Paleogeography (Daniel Bernoulli)

Some of the results of the discussion may be of general interest and therefore a brief summary is given below.

Geophysics: Stefan Müller feels that we all have learned to talk to each other thanks to the recent efforts made in seismic profiling across the Alps. This effort has made it obvious that truly interdisciplinary work (as opposed to just a multidisciplinary approach) yields new and exciting results. All participants of such ventures had to be ready for surprises. For example, the surface information may have mislead us in some cases when interpreting the deep structure: the near-surface tectonic style and the deep structure are not releated to each other in a simple way.

Concerning the revolutionary results achieved by seismic tomography, some specific questions are adressed to M. Wortel and W. Spakmann. For example, the question arises how much the results depend on the choice of a particular reference model to which velocity anomalies are related. According to the experts the main conclusions are very robust and not greatly influenced by this choice.

Finally the discussion proposes a list of topics which did not receive the attention they deserve in the context of geophysical profiling: (1) The Eastern Alps represent a huge gap between reflection seismic profiles in the Central Alps and the Carpathians; (2) The Ivrea geophysical body is still poorly constrained and needs detailed smaller scale studies; (3) The arc of the Western Alps is not yet understood and the Western Alps do not receive enough attention, for example not enough investment went into field studies accompaning the ECORS-CROP profile; (4) The Molasse basin and Jura mountains are an important future target, highly relevant for applied geology, including environmental studies.

Geochronology: Dave Dallmeyer, looking over the Atlantic from an American point of view, tells Europeans that they do not realize how lucky they are in that the Alps are extremely well known compared to other regions. With this remark he may have wanted to allude to some heated discussions during the meeting about the age (or ages?) of high-pressure metamorphism. While some speakers advocate that Alpine high-pressure metamorphism only occurred in Cretaceous times, others advocate more than one subduction event (Cretaceous and Tertiary). Apart from this particular controversy, there is a huge amount of undisputed geochronological data in the Alps, while knowledge is still very poor, though improving, in parts of Eastern Europe. The eastern prolongation of the Alpine chain into the Carpathian and Pannonian domains opens up new ventures thanks to the new political freedom in Eastern Europe.

Concerning methods of dating, Dave Dallmeyer emphasizes that geochronology is just a simple tool which produces numbers. Rocks should not simply be sent off for anal-

ysis to a specialized lab as often is the case in Europe. Instead, there must be an integration of field and laboratory efforts. Data and interpretations need to be more carefully separated. In Alpine research there is a notable lack of attempts to date detrital minerals in sediments.

Dieter Gebauer advocates the use of modern tools (no SHRIMP operates in Europe yet) and he warns against undue dogmatism concerning the expected age of rocks. Friedhelm von Blanckenburg suggests to put priority on high retentivity minerals for dating while Volkmar Trommsdorff misses efforts in experimental geochronology.

Petrology: Jane Selverstone deplores the fact that proposals in petrology are practically not funded in the US anymore and finds that this unfortunate situation may have been caused by the petrologists themselves. She particularly critizises that petrological work is still rarely performed in an interdisciplinary way. Many results have severe tectonic implications ("knowing that rocks have been at 100 km depth changes ideas in tectonics") and these implications have to be explored through an interplay between field work and modelling. The editors would like to add, in defense of the petrologists, that structural geologists and geophysicists still have no convincing kinematic or dynamic model for explaining how those high-pressure rocks rose back to the surface (one of the most prominent open questions world-wide which can probably be best explored in the Alps, given their excellent 3D exposure and excellent geophysical data set concerning the deep structure).

Jane Selverstone also appeals to being more honest with the presentation of quantitative results, particularly concerning P-T-loops. Fact and interpretation are rarely distinguishable. Volkmar Trommsdorff also draws attention to the fact that pressure and temperature may not be "frozen in" at the same instant of time along a P-T-loop. The factor time additionally complicates the interpretation of metamorphic field gradients. Too often mapped isograds are still assumed to represent isotherms, although these isograds merely connect points in space which may have reached a given temperature at different geological times. The longstanding controversy about the exact age of the so-called Lepontine event in the Alps is an example for such misconceptions.

John Wheeler takes up the hot subject of the exhumation of high-pressure terrains. He claims that most of this exhumation takes place under greenschist facies conditions and proposes that we should invest more effort into studying retrograde greenschist facies metamorphism. Typically, only mafic boudins preserve eclogite facies mineral assemblages. More attention should be given to the retrograde overprint of the matrix surrounding these boudins. Berndt Lammerer asks how sure we are about the pressure estimates for eclogite facies rocks, alluding to problems like the role of kinetics and the influence of deviatoric stresses on the stability fields of mineral assemblages.

Tectonics: Geri Eisbacher, being asked to comment on kinematic data presently available in the Alpine orogen, feels a need to integrate information obtained at very different scales: kinematic indicators, microstructures, retrodeformation of cross sections, geophysical data, paleogeographical reconstructions. This is not an easy task given the possibility that displacement vectors within an orogen may be largely influenced by gravitational forces created by an overthickened orogen, as discussed in an oral presentation by John Platt. This contribution showed that local transport directions are not related to plate movement vectors in a straightforward way. They may vary according to the crustal level and in time. Precise dating of specific structures is critical in this respect.

Geri Eisbacher's main message, however, is of a different nature. He focusses his discussion on the applied aspects of research in tectonics: structures resulting from brittle deformation, for example, are extremely important in applied geology and this link has largely been neglected for many years. Since our students need to make a living after graduating, the applied aspects of earth science have to be integrated in our teaching activities. According to Geri Eisbacher the links into geomorphology are also much neglected and represent a great challenge for academic and applied research. Both brittle structures and geomorphology are of great relevance for society (i.e. nuclear waste repositories, groundwater-flow, slope stability and regional earthquake hazard).

The discussion amongst the audience focusses on the importance of large and small scale dynamics in understanding the kinematics of deformation. In this context the role of experimental rock deformation coupled with dynamic modelling is crucial. There is a need for additional laboratory data (calibration of paleopiezometers, flow laws) in order to deduce the magnitudes of differential stresses required for mountain building.

Sedimentology: Daniel Bernoulli deplores that we did not hear much about sediments at this conference. Very few contributions only focussed on foreland tectonics. He defines four fields of research, which have a high potential for advancing our knowledge in Alpine geology: (1) Paleogeographical reconstructions should also consider the movement of small crustal blocks, kinematic inversion and seismics being the most powerful tools for achieving this goal. Methods such as paleomagnetics, radiometric age determination and geochemical signature alone often lead to ambiguous or imprecise results if stratigraphic constraints are not taken into account. (2) Paleotectonics in sedimentary basins is a fascinating field to be jointly investigated by sedimentologists, structural geologists and geochronologists (dating detrital grains!). (3) The modelling of foreland basins is also important for applied aspects in geosciences (e.g. oil fields, water recources, waste repositories). (4) The late tectonic history of orogens deserves more attention; erosion, valley formation, mass transport processes and budgets involve geomorphological studies which should not be exclusively left to geographers.

The following discussion addresses a general problem in Alpine research: data are not readily available, correlative work is scarce, good modern maps are lacking over large areas in the Alps in spite of the fact that such areas have been intensively studied by generations of earth scientists. Data, if available, often tend to be hidden away due to nationalism and protectionism. At least in Switzerland, the production of maps is extremely slow, and available maps very often lack indications on elementary features such as strike and dip of beds and the nature of major faults.

Concluding remarks

The organizers would like to thank all the participants of this conference for their valuable contributions. We think that the organization of this conference was certainly worth the effort. In particular we would like to thank all the contributors to this volume for their work. We also thank the chief-editor of Eclogae, Dr. H. Funk, for providing a forum for these publications and for his great effort concerning the final editing and the handling of all technical aspects during the preparation of this volume.