

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

**Band:** 79 (1999)

**Heft:** 1: The new metamorphic map of the Alps

**Artikel:** The new metamorphic map of the Alps : introduction

**Autor:** Frey, Martin / Desmons, Jacqueline / Neubauer, Franz

**DOI:** <https://doi.org/10.5169/seals-60194>

### **Nutzungsbedingungen**

Die ETH-Bibliothek ist die Anbieterin der digitalisierten Zeitschriften auf E-Periodica. Sie besitzt keine Urheberrechte an den Zeitschriften und ist nicht verantwortlich für deren Inhalte. Die Rechte liegen in der Regel bei den Herausgebern beziehungsweise den externen Rechteinhabern. Das Veröffentlichen von Bildern in Print- und Online-Publikationen sowie auf Social Media-Kanälen oder Webseiten ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. [Mehr erfahren](#)

### **Conditions d'utilisation**

L'ETH Library est le fournisseur des revues numérisées. Elle ne détient aucun droit d'auteur sur les revues et n'est pas responsable de leur contenu. En règle générale, les droits sont détenus par les éditeurs ou les détenteurs de droits externes. La reproduction d'images dans des publications imprimées ou en ligne ainsi que sur des canaux de médias sociaux ou des sites web n'est autorisée qu'avec l'accord préalable des détenteurs des droits. [En savoir plus](#)

### **Terms of use**

The ETH Library is the provider of the digitised journals. It does not own any copyrights to the journals and is not responsible for their content. The rights usually lie with the publishers or the external rights holders. Publishing images in print and online publications, as well as on social media channels or websites, is only permitted with the prior consent of the rights holders. [Find out more](#)

**Download PDF:** 17.04.2026

**ETH-Bibliothek Zürich, E-Periodica, <https://www.e-periodica.ch>**

## The new metamorphic map of the Alps: Introduction

by Martin Frey<sup>1</sup>, Jacqueline Desmons<sup>2</sup> and Franz Neubauer<sup>3</sup>

### Abstract

Two new maps describing the pre-Alpine metamorphism (1:1'000'000) and the Alpine metamorphism (1:500'000) of the Alps are presented. The legends are discussed and some comments and conclusions on both maps are given.

*Keywords:* metamorphic evolution, pre-Alpine metamorphism, Alpine metamorphism, Alps, map, review article.

### General remarks

For many years, small scale metamorphic maps have been published by the Subcommittee for the Cartography of the Metamorphic Belts of the World, affiliated to the International Union of Geological Sciences (IUGS). Such maps provide an excellent means of obtaining information on the distribution of metamorphic rocks and facies of entire continents and orogenic belts. The metamorphic map of Europe at a scale of 1:2'500'000 was published 25 years ago (ZWART, 1973). This map included an additional sheet at a scale of 1:1'000'000 displaying the Alps, an area where more extensive knowledge allowed a larger scale (NIGGLI and ZWART, 1973). An explanatory text was published five years later (ZWART et al., 1978). This first map has been an incentive for further research in metamorphic petrology.

In 1983 a proposal, by one of the authors (MF), to compile a new metamorphic map of the Alps was met with enthusiasm. Progress reports were made public at various meetings (DESMONS, 1987; FREY, 1987 b, c; FREY et al., 1989; FRANK et al., 1993; DESMONS et al., 1995, 1996; FREY et al., 1997; FREY et al., 1999). More than 50 collaborators, whose names are listed on the new map, contributed substantially to this long-term project which started at a first meeting in Basel in 1984. Meanwhile, some synthetic cartographic data

have been published (e.g. Geological map of France at 1:1'000'000, CHANTRAINE et al., 1996).

Metamorphic maps rely on high-quality topographic and tectonic maps. To this end we have chosen the Structural Model of Italy (BIGI et al., 1990), modified and completed to the W and SW.

On the first metamorphic map of the Alps (NIGGLI and ZWART, 1973), information on the pre-Alpine and Alpine metamorphism was contained in a single sheet. However, the abundance of facts to be displayed led to a map which was, at least in part, difficult to read. For this reason the editors of the present study decided to print two maps, i.e. a map of pre-Alpine metamorphism at 1:1'000'000 and a map of Alpine metamorphism at 1:500'000.

### The legends of the maps

The map of ZWART (1973) was a facies map, and the timing was indicated by letters corresponding to orogenic cycles (Alpine, Variscan, etc.). Following a proposal by our Austrian colleagues, the emphasis in the new maps is put on the chronology and different colour strengths are used according to the general geological colouring (green for Cretaceous, yellow for Cainozoic, etc.). On the map of pre-Alpine metamorphism we have distinguished between "older than Variscan",

<sup>1</sup> Mineralogisch-Petrographisches Institut, Universität Basel, Bernoullistrasse 30, CH-4056 Basel, Switzerland. <frey@ubaclu.unibas.ch>

<sup>2</sup> C.N.R.S. – C.R.P.G., B.P. 20, F-54501 Vandœuvre-lès-Nancy Cedex, France. <desmons@crpg.cnrs-nancy.fr>

<sup>3</sup> Institut für Geologie und Paläontologie, Universität Salzburg, Hellbrunnerstrasse 34, A-5020 Salzburg, Austria. <franz.neubauer@sbg.ac.at>

"Variscan" and "Permian" ages of metamorphism, on the map of Alpine metamorphism between the "Cretaceous peak" and the "Tertiary peak" of metamorphism. However, the maps are being completed just when the timing of metamorphic imprints in the Western Alps is being reevaluated. Therefore, on the map of Alpine metamorphism, we added "high-pressure metamorphism of partly uncertain, Cretaceous or Tertiary, age".

A simple scheme of metamorphic facies was adopted, following the example of some recent textbooks (e.g. YARDLEY, 1989, Fig. 2.8.; BUCHER and FREY, 1994, Fig. 4.2.). On the map of Alpine metamorphism, "very low-grade metamorphism" is defined mainly on the basis of illite crystallinity data because critical mineral assemblages are rare. Areas containing mineral assemblages in the pumpellyite-actinolite facies are included in "greenschist facies metamorphism". In addition to eclogite, HP/LT metamorphism is subdivided into three facies, namely "lawsonite + albite + chlorite facies" at relatively low pressure, "glaucophane + lawsonite + jadeite facies" at high pressure and low temperature, and "glaucophane + epidote facies" at high pressure and slightly higher temperatures. The nomenclature of the two latter facies follows the proposal of EVANS (1990). This use of four different HP/LT facies turned out to be especially useful in the Western Alps for displaying variations in P and P/T.

Minerals characteristic of a facies shown have not been indicated (e.g., kyanite in medium-pressure amphibolite facies). However, index minerals are indicated if their presence provide additional information on metamorphic grade (e.g., the pressure character of a facies, by indicating the presence of minerals such as andalusite or coesite), or if their presence is exceptional (e.g. relic of an earlier period of the evolution which could not be shown on the map).

This issue of the Swiss Bulletin of Mineralogy and Petrology (SMPM/SBMP) contains 12 articles summarizing our present knowledge on the metamorphism of the Alps. These articles will serve also as explanatory text for the two maps enclosed in this issue. The first five articles are devoted to the pre-Alpine metamorphism of the Alps whereas the following seven contributions focus to the Alpine metamorphism. In these papers, the number of references had to be limited and preference was given to papers with extensive reference lists. Mineral abbreviations are according to BUCHER and FREY (1994).

### **Some comments on the map of pre-Alpine metamorphism**

Metamorphic imprints are indicated according to facies and orogenic cycles. In the literature the term "Variscan" is used in a variety of meanings. The term originally designated the Carboniferous orogenic paroxysm within the Central European orogens. Early stages were considered to represent precursor stages, e.g., Early Variscan for Devonian events and those that occurred at the Devonian/Carboniferous boundary.

It has long been known that the Variscan orogeny, which was of continent-continent collision type, is well-constrained by the presence of Early Carboniferous synorogenic flysch sequences which were deposited on the southern, lower plate (e.g., MATTE, 1986; NEUBAUER, 1988; FLÜGEL, 1990; and references cited therein). No pre-Carboniferous and no Silurian to Devonian orogenic events have been observed in the southern, lower continental plate (now Austroalpine and Southalpine units). In contrast, Silurian to Devonian tectonic, magmatic and metamorphic events occurred at the margin of the northern, upper continental plate (now the External units). These events are interpreted as indicating the accretion of units to the northern margin (e.g., VON RAUMER, 1998; and references cited therein). Consequently, we restrict the term "Variscan" to the Carboniferous continent-continent collisional orogeny. This is corroborated by the age of granitoids which show a syn-orogenic group (ca 360–320 Ma) and a post-orogenic group (ca 320–260 Ma) (see also FINGER et al., 1997).

Permian metamorphism is only shown in a few places, but recent radiometric dating indicates that it may have been more widespread, as explained in several papers of this issue.

"Older than Variscan" includes Pan-African metamorphism. This event is shown as being widespread in the Internal Western Alps, although a consensus has not yet been attained on the age of the pre-Alpine metamorphism in all basement units.

### **Some comments on the map of Alpine metamorphism**

"Folded, non-metamorphic sequences" are shown as light beige coloured areas and their appearance on the map enhances the understanding of the overall metamorphic zonation.

The terms "Eo-, Meso- and Neo-Alpine" were introduced by TRÜMPY (1973) and subsequently have been used by some authors (e.g., HUNZIKER

et al., 1989). In our opinion these terms have to be re-defined and we have preferred not to use them here. Instead, wherever possible, we have distinguished between a Cretaceous and a Tertiary peak of metamorphism.

In the Central Alps, two isograds are shown, the pyrophyllite isograd within the Helvetic zone (FREY, 1987c) and the staurolite isograd bordering the Lepontine area (NIGGLI and NIGGLI, 1965). Within the Lepontine area, some selected isotherms and isobars are shown according to TODD and ENGI (1997). Selected isotherms, mainly according to oxygen isotope thermometry (HOERNES and FRIEDRICHSEN, 1974) were also added to the Tauern window area.

### Conclusions

1. In some tectonic units, e.g. within the South-alpine and some Austroalpine basement units, the pre-Alpine metamorphism is well-constrained because it has not been, or has been only slightly, overprinted by Alpine metamorphism. In these areas, several stages of pre-Alpine metamorphism are recognized including high-pressure and ultra-high pressure metamorphism interpreted as subduction-related. However, there is often uncertainty with some of the age information.

In the Western and Central Alps, the pre-Alpine map displays a contrast between the External Crystalline Massifs with their strong Variscan Barrovian-type metamorphism, and the Internal basement units. There is clear evidence of only pre-Variscan, probably Pan-African, metamorphism in the western Briançon basement. The age of the metamorphism is still debated for the Ligurian Briançon zone and the other Internal basement units, where Late Variscan granitoids are present which may have altered the isotopic ratios in their country rocks.

Furthermore, both geochronological and petrological work has revealed a major metamorphic imprint during Permian time. As explained in the following papers, it is interpreted in the Eastern Alps as being related to the extension due to ongoing post-Variscan lithospheric stretching, and in the Western Alps as accompanying the Ivrea magma underplating related to ocean consumption.

2. On the Alpine map it is shown that there appear to have been three main metamorphic imprints:

(i) In the Eastern Alps the Cretaceous Barrovian facies imprints in the Austroalpine units. This is a striking contribution to the new edition

of the map: the contrast of the metamorphic evolution in the Eastern and the Western-Central Alps during the Cretaceous and Palaeocene. Such a contrast in the T-P regime points to a lithospheric discontinuity such as a transform fault separating both domains at the time. General tectonic and palaeogeographic interpretations of the Alps will have to take this into account.

(ii) High-pressure facies imprints in the Western Alps and also in part of the Central and Eastern Alps. These imprints were considered as partly Cretaceous in age at the time of the first edition of the map. There is now strong radiometric evidence pointing to an Eocene age for all of them, including the eclogite and the lower-grade HP associations, except those of the Sesia zone which are from the Cretaceous-Palaeocene boundary. This is a major difference of the present map with respect to the first edition.

(iii) The thermal culmination of the Central Alps and the Tauern, which are the centers from which low- to very low-grade imprints widely spread in the Western Alps, and in a more limited way in the Eastern Alps. The boundary between domain (ii) and domain (iii) has been transported westward along the Simplon shear zone. Also in the Eastern Alps, breaks in metamorphic grade often coincide with large-scale tectonic boundaries, mainly ductile low-angle normal faults. Along these faults in the Eastern Alps, higher-grade metamorphic units in the footwall were juxtaposed with low-grade to nearly non-metamorphic units in the hangingwall.

Very low-grade areas are related to all three imprints, from the Cretaceous anchimetamorphic areas in the Eastern Alps to the Cainozoic anchimetamorphic areas in the Central and Western Alps, with possibly a Late Cretaceous imprint in the External zones of the Western Alps. In the Southern Alps the Alpine metamorphism has been weak or locally absent.

### Acknowledgements

The authors are grateful to Callum Hetherington for polishing the English.

### References

- BIGI, G., COSENTINO, D., PAROTTO, M., SARTORI, R. and SCANDONE, P. (1990): Structural model of Italy, scale 1:500'000. C.N.R., Selca Firenze.
- BUCHER, K. and FREY, M. (1994): Petrogenesis of metamorphic rocks. Springer-Verlag, Berlin-Heidelberg-New York, 318 pp.
- CHANTRAINE, J. and 13 Coll. (1996): Carte géologique de la France au millionième, 6<sup>e</sup> édition. Service Géologique National, B.R.G.M.

- DESMONS, J. (1987): The new edition of the metamorphic map of the Alps: the Western Alps. *Terra cognita* 7, 91.
- DESMONS, J., FREY, M. and NEUBAUER, F. (1995): New metamorphic map of the Alps. *Terra Abstracts*, suppl. 1 to *Terra nova* 7, 124.
- DESMONS, J., FREY, M. and NEUBAUER, F. (1996): Map of pre-Alpine and Alpine metamorphism in the Alps. *MinPet 96 – SMPG und ÖMG Tagung, Schwaz*, 23.–28. Sept. 1996. *Mitt. Österr. Mineral. Ges.* 141, 79.
- EVANS, B.W. (1990): Phase relations of epidote-blueschists. *Lithos* 25, 3–23.
- FINGER, F., ROBERTS, M.P., HAUNSCHMID, B., SCHERMAIER, A. and STEYRER, H.P. (1997): Variscan granitoids of central Europe: their typology, potential sources and tectonothermal relations. *Mineral. Petrol.* 61, 67–96.
- FLÜGEL, H.W. (1990): Das voralpine Basement im Alpin-Mediterranen Belt – Überblick und Problematik. *Jb. Geol. Bundesanst.* 133, 181–122.
- FRANK, W., FREY, M., DESMONS, J., NEUBAUER, F., HOINKES, G., HÖCK, V., KOLLER, F., SASSI, F.P. and SCHRAMM, J.M. (1993): The new metamorphic map of the Alps: a preliminary draft. *Terra abstracts*, suppl. 1 to *Terra nova* 5, 257.
- FREY, M. (1987a): New metamorphic map of the Alps. *Terra cognita* 7, 91.
- FREY, M. (1987b): Metamorphic map of the Central Alps. *Terra cognita* 7, 91.
- FREY, M. (1987c): The reaction isograd kaolinite + quartz = pyrophyllite + H<sub>2</sub>O, Helvetic Alps, Switzerland. *Schweiz. Mineral. Petrogr. Mitt.* 65, 1–11.
- FREY, M., COMPAGNONI, R., DAL PIAZ, G., DESMONS, J., FRANK, W., HUNZIKER, J.C. and MONTRASIO, A. (1989): New metamorphic map of the Alps. *Terra abstracts* 1, 132.
- FREY, M., DESMONS, J. and NEUBAUER, F. (1997): Map of pre-Alpine and Alpine metamorphism in the Alps. *Terra abstracts*, suppl. 1 to *Terra Nova* 9, 101.
- FREY, M., DESMONS, J. and NEUBAUER, F. (1999): The new metamorphic map of the Alps. *Terra abstracts*, suppl. 1 to *Terra Nova* 11, in press.
- HOERNES, S. and FRIEDRICHSEN, H. (1974): Oxygen isotope studies of metamorphic rocks of the Western Hohe Tauern area (Austria). *Schweiz. Mineral. Petrogr. Mitt.* 54, 769–788.
- HUNZIKER, J.C., DESMONS, J. and MARTINOTTI, G. (1989): Alpine thermal evolution in the central and the western Alps. In: COWARD, M.P., DIETRICH, D. and PARK, R.G. (eds): *Alpine Tectonics*. *Geol. Soc. London Spec. Publ.* 45, 353–367.
- MAITTE, PH. (1986): Tectonic and plate tectonics model for the Variscan belt of Europe. *Tectonophysics* 126, 329–374.
- NEUBAUER, F. (1987): The Variscan orogeny in the Austroalpine and Southalpine domains of the Eastern Alps. *Schweiz. Mineral. Petrogr. Mitt.* 68, 339–349.
- NIGGLI, E. and NIGGLI, C. (1965): Karten der Verbreitung einiger Mineralien der alpidischen Metamorphose in den Schweizer Alpen (Stilpnomelan, Alkali-Amphibol, Chloritoid, Staurolith, Disthen, Sillimanit). *Eclogae geol. Helv.* 58, 335–368.
- NIGGLI, E. and ZWART, H.J. (1973): Metamorphic map of the Alps, scale 1:1'000'000. Subcommission for the Cartography of the Metamorphic Belts of the World. Sheet 17 of the Metamorphic Map of Europe. Leiden/UNESCO, Paris.
- TODD, C.S. and ENGI, M. (1997): Metamorphic field gradients in the Central Alps. *J. Metamorphic Geol.* 15, 513–530.
- TRÜMPY, R. (1973): The timing of orogenic events in the Central Alps. In: DEJONG, K.A. (ed.): *Gravity and Tectonics*. Wiley & Sons, New York, 229–251.
- VON RAUMER, J. (1998): The Palaeozoic evolution of the Alps: from Gondwana to Pangea. *Geol. Rundschau*, 87, 407–435.
- YARDLEY, B.W.D. (1989): An introduction to metamorphic petrology. Longman, Essex, 248 pp.
- ZWART, H.J. (1973): Metamorphic map of Europe, scale 1:2'500'000. Subcommission for the Cartography of the Metamorphic Belts of the World. Leiden/UNESCO, Paris.
- ZWART, H.J., SOBOLEV, V.S. and NIGGLI, E. (1978): Metamorphic map of Europe, scale 1:2'500'000. Explanatory text. Subcommission for the Cartography of the Metamorphic Belts of the World. Leiden/UNESCO, Paris, 244 pp.

Manuscript received February 6, 1999.

# METAMORPHIC MAPS OF THE ALPS

# Map of Alpine

Edited by M. Frey, J. Desmons and F. Neubauer

with contributions of

J. Aprahamian, S. Bogdanoff, A. Boriani, G.G. Biino, C. Chopin, A. Colombo, R. Compagnoni, L. Cortesogno, G.V. Dal Piaz, M. Engi, R. Ferreiro-Mählmann, W. Frank, D. Gebauer, B. Goffé, G. Gosso, A. Gregnanin, R. Hännly, V. Höck, G. Hoinkes, J.C. Hunziker, R. Kienast, F. Koller, V. Köppl, L. Latouche, B. Lombardo, M. Maggetti, G. Martinotti, H. Masson, R.P. Ménot, B. Messiga, A. Montrasio, A. Mottana, J. Mullis, P. Nievergelt, A. Pêcher, H.R. Pfeifer, G.B. Piccardo, U. Pognante, R. Polino, R. Potenza, F. Purtscheller, J. von Raumer, R. Sacchi, R. Sandrone, F.P. Sassi, J.M. Schramm, A. Steck, R. Steiger, M. Thöni, V. Trommsdorff, A. Tunesi, M. Vanossi, G. Vivier

CAD Compilation: W. Heidinger (Salzburg)

Cartography: Institute for Cartography, Dresden University of Technology, Germany

Design: S. Kirschenbauer, M.F. Buchroithner (Dresden)

Cartographic Work (using Ocad 6.0): S. Kirschenbauer

Reproduction and Print: c-macs publishingservice, Dresden

## Published 1999

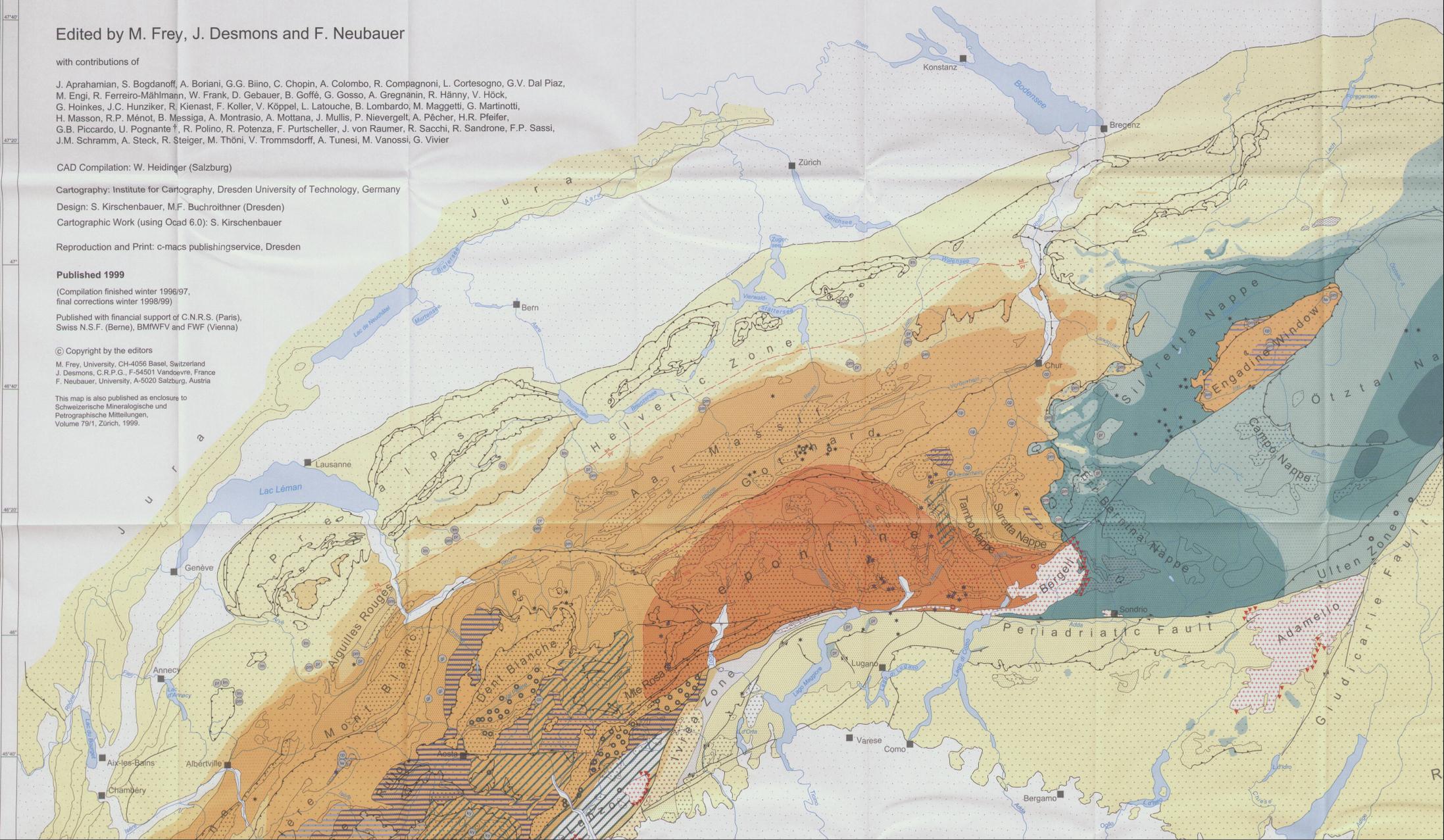
(Compilation finished winter 1996/97,  
final corrections winter 1998/99)

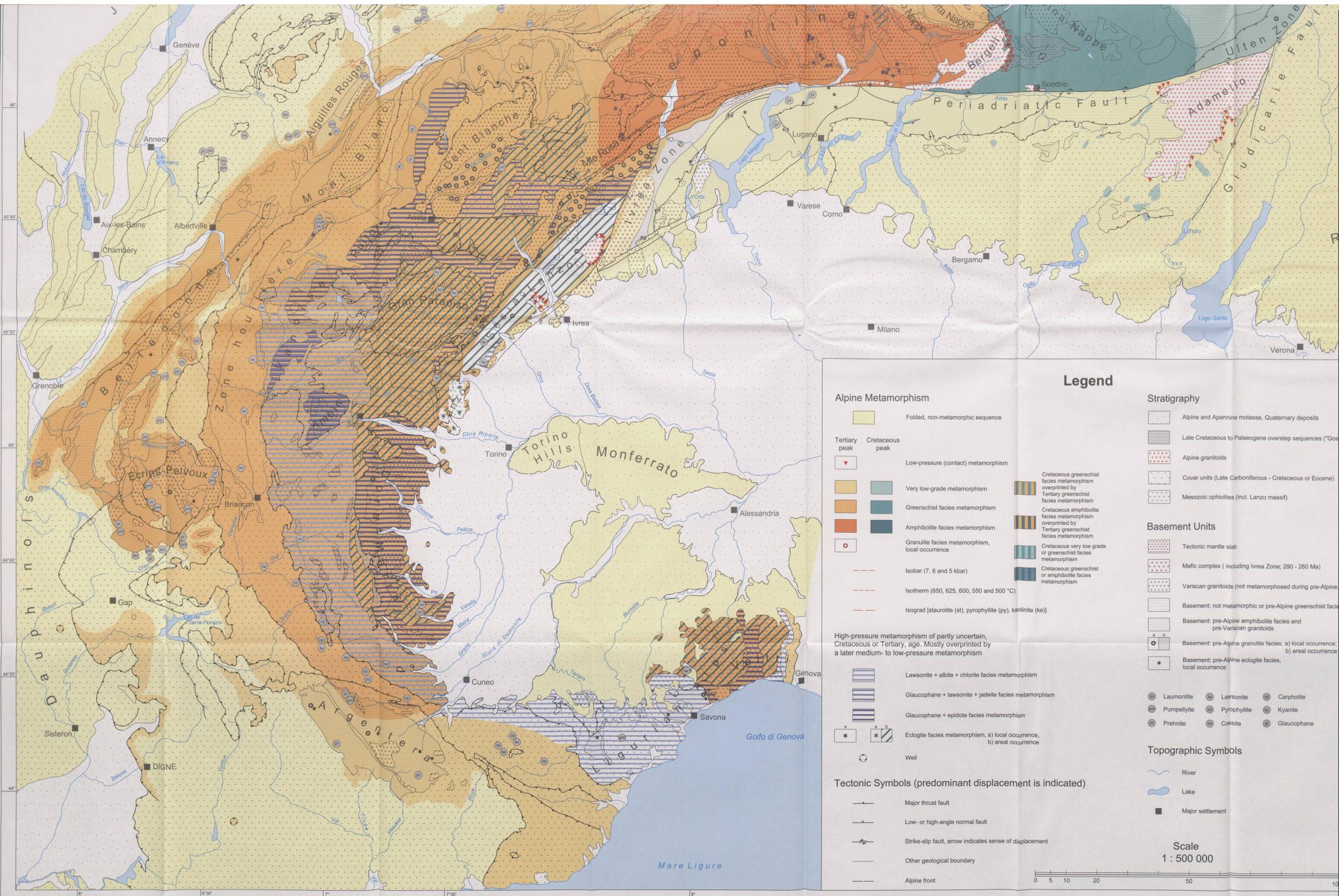
Published with financial support of C.N.R.S. (Paris),  
Swiss N.S.F. (Berne), BMWFV and FWF (Vienna)

© Copyright by the editors

M. Frey, University, CH-4056 Basel, Switzerland  
J. Desmons, C.R.P.G., F-54501 Vandœuvre, France  
F. Neubauer, University, A-5020 Salzburg, Austria

This map is also published as enclosure to  
Schweizerische Mineralogische und  
Petrographische Mitteilungen,  
Volume 79/1, Zürich, 1999.





### Legend

#### Alpine Metamorphism

- Folded, non-metamorphic sequence
- Tertiary peak
- Cretaceous peak
- Low-pressure (contact) metamorphism
- Very low-grade metamorphism
- Greenschist facies metamorphism
- Amphibolite facies metamorphism
- Granulite facies metamorphism, local occurrence
- Isobar (7, 6 and 5 kbar)
- Isotherm (650, 625, 600, 550 and 500 °C)
- Isoograd [staurolite (st), pyrophyllite (py), kyanite (ka)]

#### High-pressure metamorphism of partly uncertain, Cretaceous or Tertiary, age. Mostly overprinted by a later medium- to low-pressure metamorphism

- Lawsonite + albite + chlorite facies metamorphism
- Glaucophane + lawsonite + jadeite facies metamorphism
- Glaucophane + epidote facies metamorphism
- Eclogite facies metamorphism, a) local occurrence, b) areal occurrence
- Well

#### Tectonic Symbols (predominant displacement is indicated)

- Major thrust fault
- Low- or high-angle normal fault
- Strike-slip fault, arrow indicates sense of displacement
- Other geological boundary
- Alpine front

#### Stratigraphy

- Alpine and Apennine molasse, Quaternary deposits
- Late Cretaceous to Palaeogene overstep sequences ("Gosau")
- Alpine granitoids
- Cover units (Late Carboniferous - Cretaceous or Eocene)
- Mesozoic ophiolites (incl. Lanzo massif)

#### Basement Units

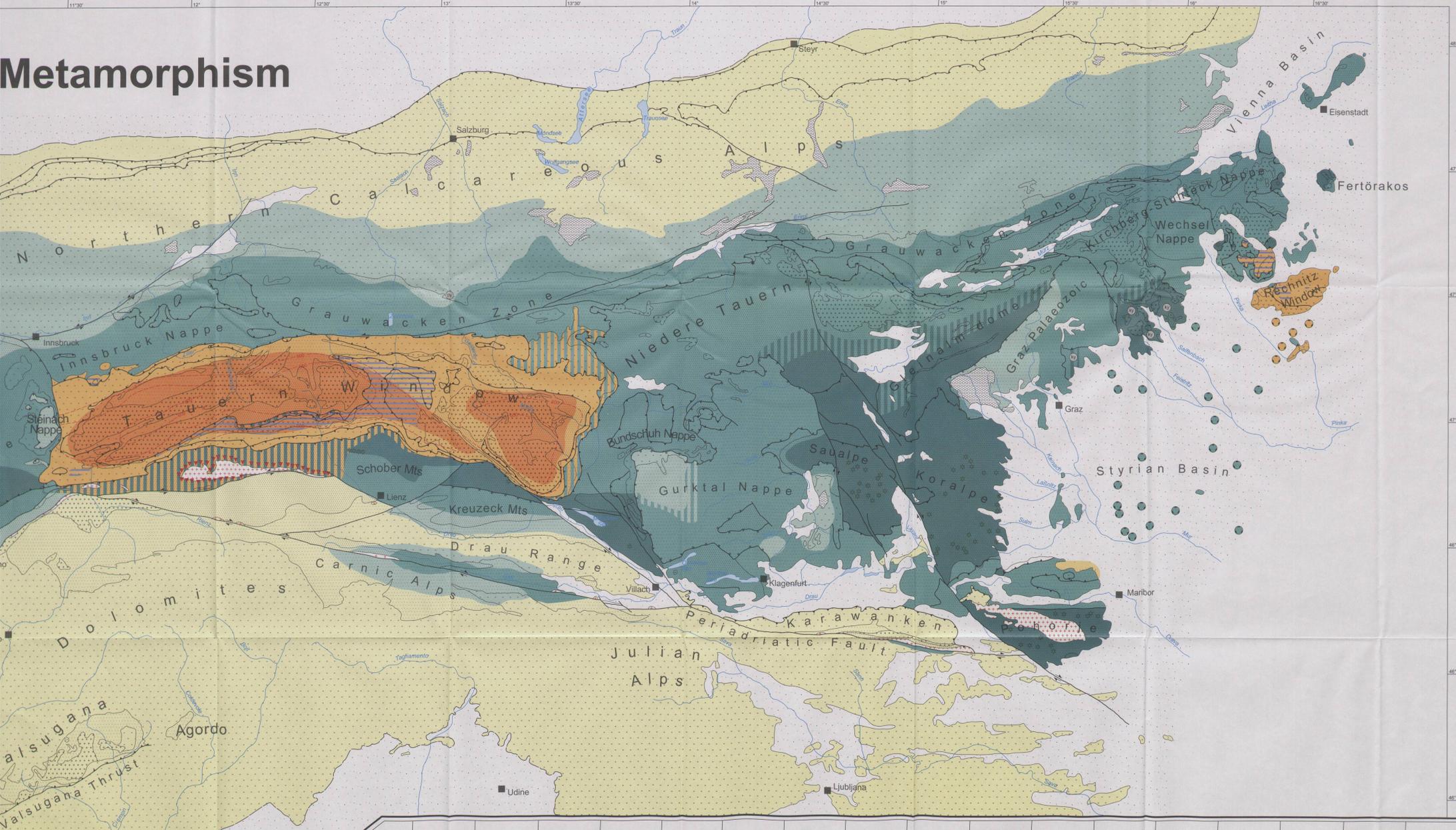
- Tectonic mantle slab
- Mafic complex ( including Ivrea Zone; 290 - 260 Ma)
- Variscan granitoids (not metamorphosed during pre-Alpine)
- Basement: not metamorphic or pre-Alpine greenschist facies
- Basement: pre-Alpine amphibolite facies and pre-Variscan granitoids
- Basement: pre-Alpine granulite facies, a) local occurrence, b) areal occurrence
- Basement: pre-Alpine eclogite facies, local occurrence

#### Topographic Symbols

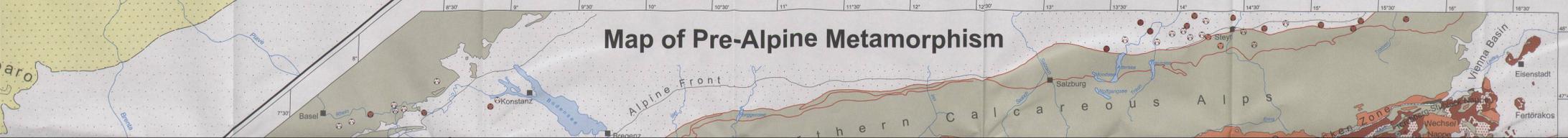
- River
- Lake
- Major settlement

Scale  
1 : 500 000

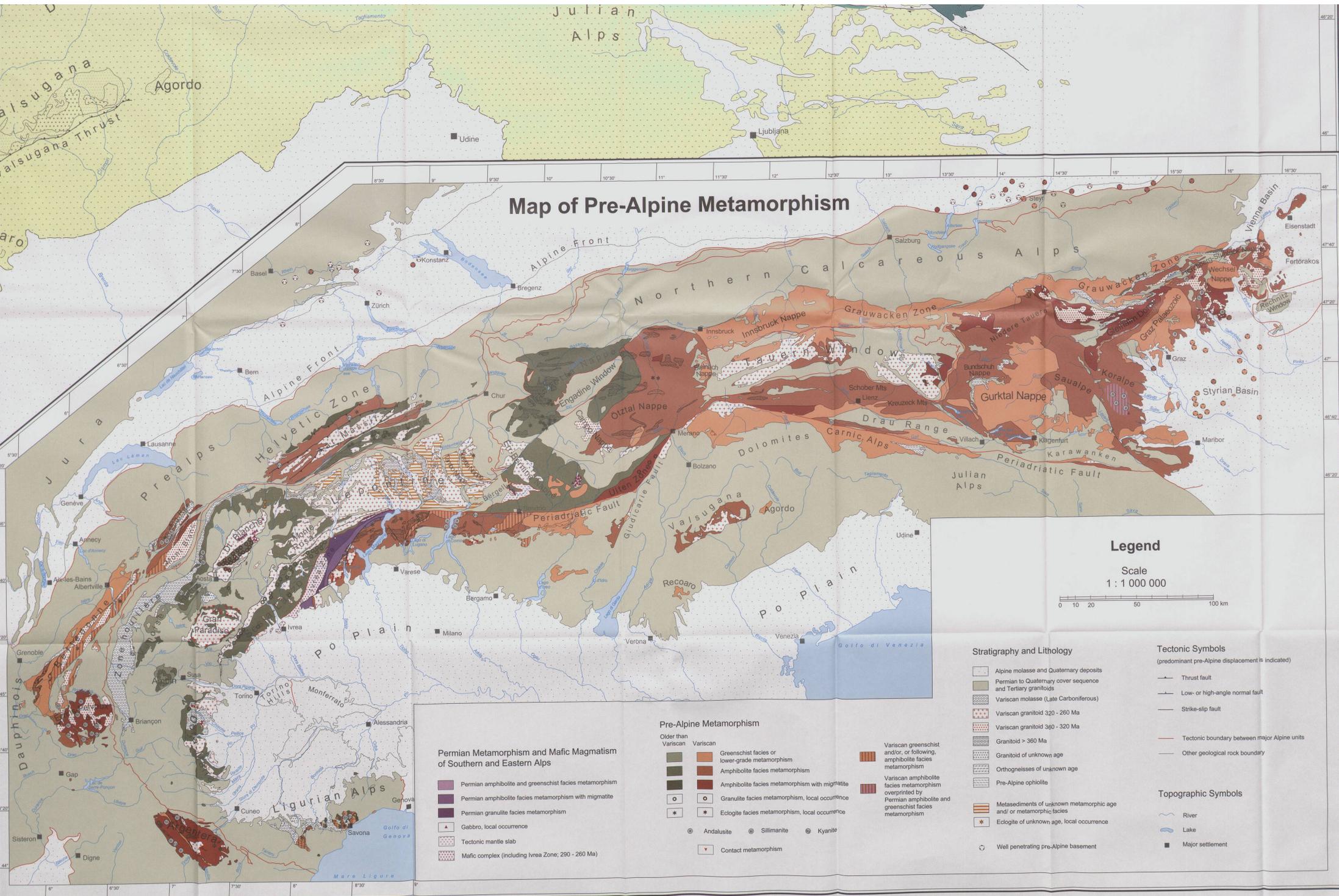
# Metamorphism



Map of Pre-Alpine Metamorphism

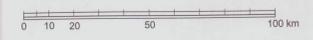


# Map of Pre-Alpine Metamorphism



## Legend

Scale  
1 : 1 000 000



### Stratigraphy and Lithology

- Alpine molasse and Quaternary deposits
- Permian to Quaternary cover sequence and Tertiary granitoids
- Variscan molasse (Late Carboniferous)
- Variscan granitoid 320 - 260 Ma
- Variscan granitoid 360 - 320 Ma
- Granitoid > 360 Ma
- Granitoid of unknown age
- Orthogneisses of unknown age
- Pre-Alpine ophiolite
- Metasediments of unknown metamorphic age and/or metamorphic facies
- Eclogite of unknown age, local occurrence
- Well penetrating pre-Alpine basement

### Tectonic Symbols

- (predominant pre-Alpine displacement is indicated)
- Thrust fault
  - Low- or high-angle normal fault
  - Strike-slip fault
  - Tectonic boundary between major Alpine units
  - Other geological rock boundary

### Topographic Symbols

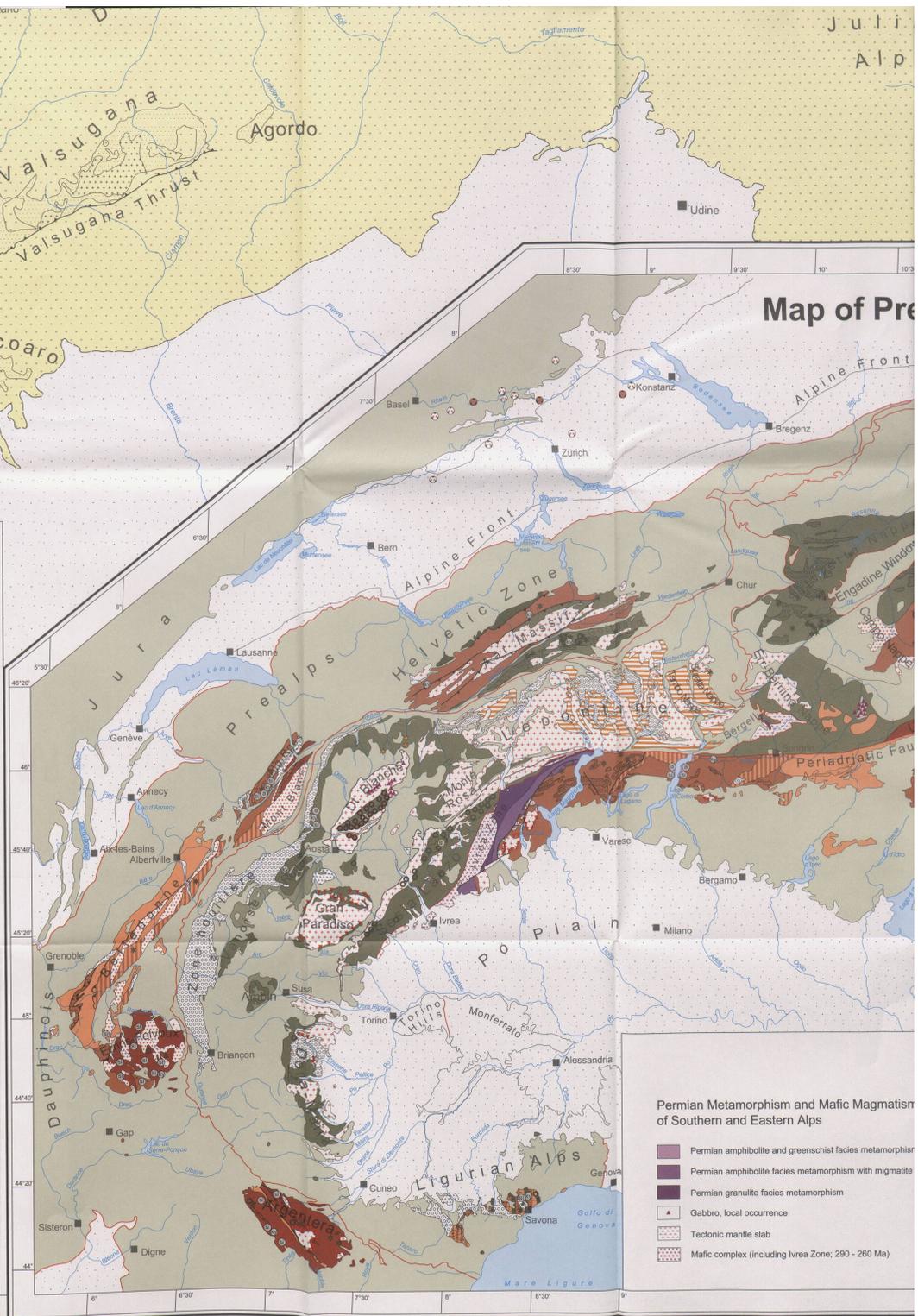
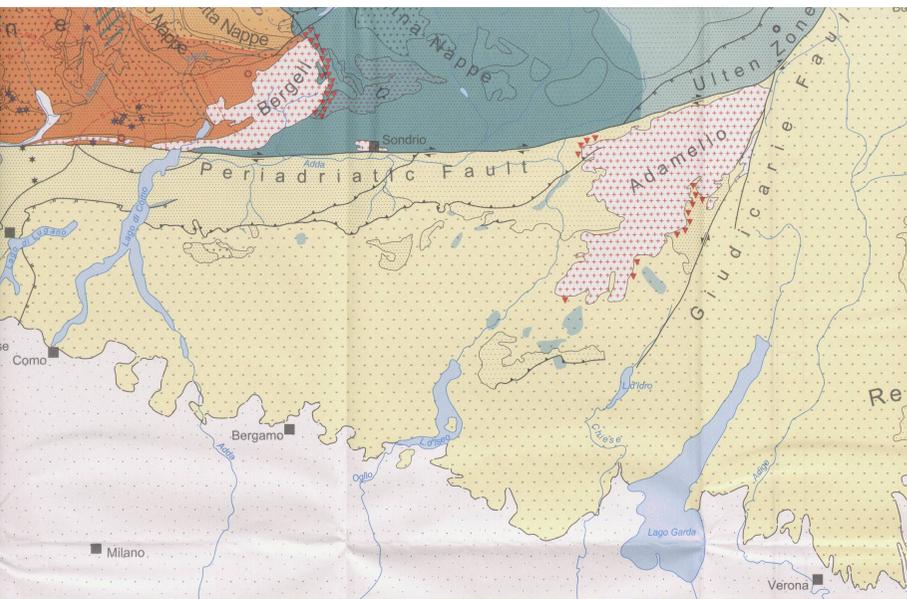
- River
- Lake
- Major settlement

### Permian Metamorphism and Mafic Magmatism of Southern and Eastern Alps

- Permian amphibolite and greenschist facies metamorphism
- Permian amphibolite facies metamorphism with migmatite
- Permian granulite facies metamorphism
- Gabbro, local occurrence
- Tectonic mantle slab
- Mafic complex (including Ivrea Zone, 290 - 260 Ma)

### Pre-Alpine Metamorphism

- |                     |          |  |
|---------------------|----------|--|
| Older than Variscan | Variscan | Variscan greenschist and/or, or following, amphibolite facies metamorphism |
|                     |          |  |
|                     |          |  |
|                     |          |  |
|                     |          |  |
|                     |          |  |



**Legend**

**Alpine Metamorphism**

- Folded, non-metamorphic sequence
- Low-pressure (contact) metamorphism
- Very low-grade metamorphism
- Greenschist facies metamorphism
- Amphibolite facies metamorphism
- Granulite facies metamorphism, local occurrence
- Isobar (7, 6 and 5 kbar)
- Isotherm (850, 625, 600, 550 and 500 °C)
- Isograd [staurolite (st), pyrophyllite (py), kaolinite (ka)]

**Stratigraphy**

- Alpine and Apennine molasse, Quaternary deposits
- Late Cretaceous to Palaeogene overstep sequences ("Gosau")
- Alpine granitoids
- Cover units (Late Carboniferous - Cretaceous or Eocene)
- Mesozoic ophiolites (incl. Lanzo massif)

**Basement Units**

- Tectonic mantle slab
- Mafic complex (including Ivrea Zone; 290 - 260 Ma)
- Variscan granitoids (not metamorphosed during pre-Alpine times)
- Basement: not metamorphic or pre-Alpine greenschist facies
- Basement: pre-Alpine amphibolite facies and pre-Variscan granitoids
- Basement: pre-Alpine granulite facies, a) local occurrence, b) areal occurrence
- Basement: pre-Alpine eclogite facies, local occurrence

**Topographic Symbols**

- River
- Lake
- Major settlement

**Tectonic Symbols (predominant displacement is indicated)**

- Major thrust fault
- Low- or high-angle normal fault
- Strike-slip fault, arrow indicates sense of displacement
- Other geological boundary
- Alpine front

**High-pressure metamorphism of partly uncertain, Cretaceous or Tertiary, age. Mostly overprinted by a later medium- to low-pressure metamorphism**

- Lawsonite + albite + chlorite facies metamorphism
- Glaucophane + lawsonite + jadeite facies metamorphism
- Glaucophane + epidote facies metamorphism
- Eclogite facies metamorphism, a) local occurrence, b) areal occurrence
- Well

**Mineral Symbols**

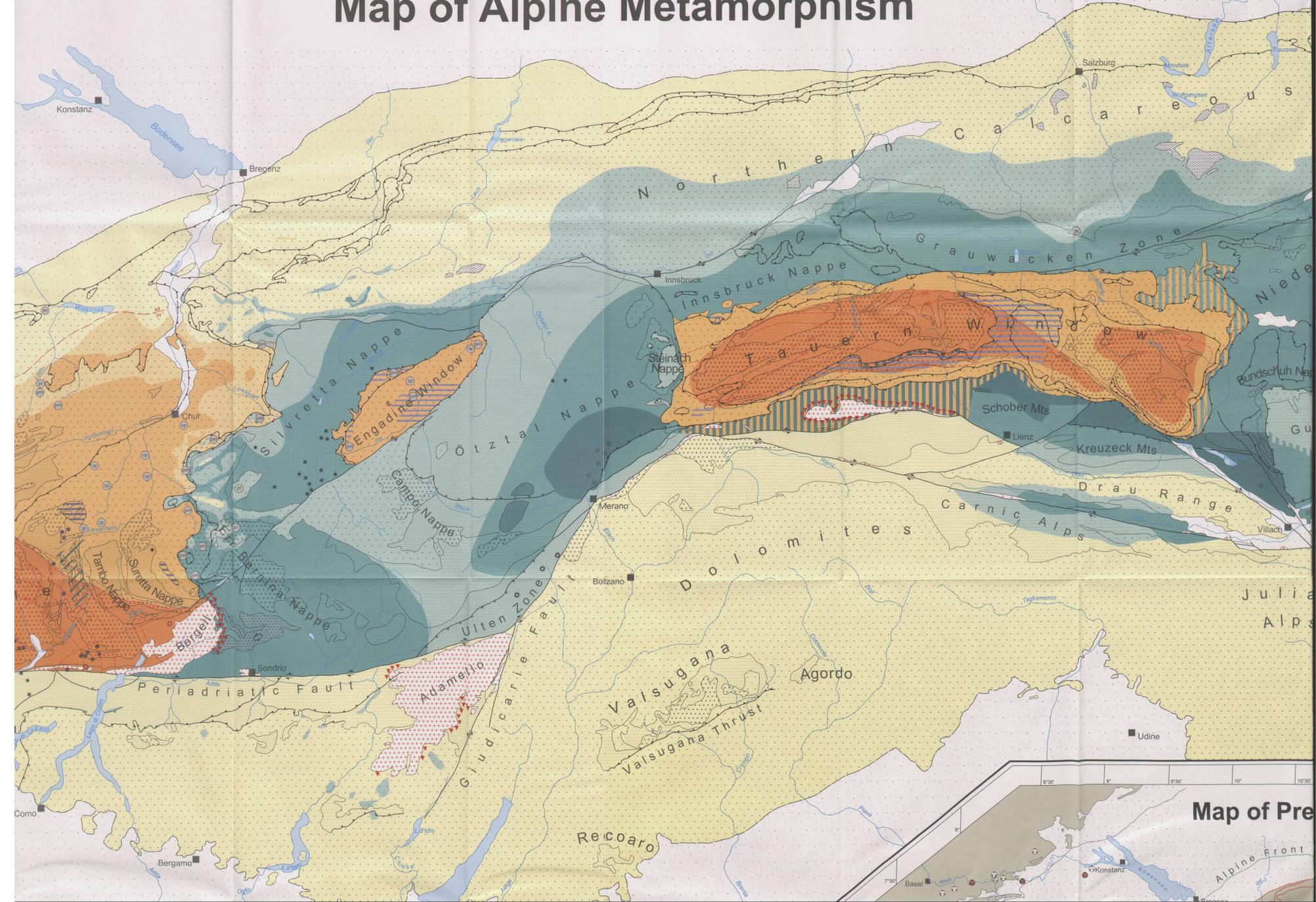
- Laumontite
- Lawsonite
- Carpholite
- Pumpellyite
- Pyrophyllite
- Kyanite
- Prehnite
- Coesite
- Glaucophane

**Scale**  
1 : 500 000

**Permian Metamorphism and Mafic Magmatism of Southern and Eastern Alps**

- Permian amphibolite and greenschist facies metamorphism
- Permian amphibolite facies metamorphism with migmatite
- Permian granulite facies metamorphism
- Gabbro, local occurrence
- Tectonic mantle slab
- Mafic complex (including Ivrea Zone; 290 - 260 Ma)

# Map of Alpine Metamorphism



Map of Pre