

Alpine high-pressure metamorphism in the Eastern Alps

Autor(en): **Miller, Christine**

Objektyp: **Article**

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

Band (Jahr): **66 (1986)**

Heft 1-2

PDF erstellt am: **23.09.2024**

Persistenter Link: <https://doi.org/10.5169/seals-50888>

Nutzungsbedingungen

Die ETH-Bibliothek ist Anbieterin der digitalisierten Zeitschriften. Sie besitzt keine Urheberrechte an den Inhalten der Zeitschriften. Die Rechte liegen in der Regel bei den Herausgebern.

Die auf der Plattform e-periodica veröffentlichten Dokumente stehen für nicht-kommerzielle Zwecke in Lehre und Forschung sowie für die private Nutzung frei zur Verfügung. Einzelne Dateien oder Ausdrucke aus diesem Angebot können zusammen mit diesen Nutzungsbedingungen und den korrekten Herkunftsbezeichnungen weitergegeben werden.

Das Veröffentlichen von Bildern in Print- und Online-Publikationen ist nur mit vorheriger Genehmigung der Rechteinhaber erlaubt. Die systematische Speicherung von Teilen des elektronischen Angebots auf anderen Servern bedarf ebenfalls des schriftlichen Einverständnisses der Rechteinhaber.

Haftungsausschluss

Alle Angaben erfolgen ohne Gewähr für Vollständigkeit oder Richtigkeit. Es wird keine Haftung übernommen für Schäden durch die Verwendung von Informationen aus diesem Online-Angebot oder durch das Fehlen von Informationen. Dies gilt auch für Inhalte Dritter, die über dieses Angebot zugänglich sind.

Alpine high-pressure metamorphism in the Eastern Alps

by *Christine Miller*¹

Abstract

In the Eastern Alps evidence for a Cretaceous high-pressure metamorphism is preserved in parts of the Pennine Permomesozoic metasediments and metaophiolites: in the Tauern window, the peak conditions of this subduction-related metamorphic event have been estimated as $T = 570^{\circ}\text{C}$, $P = 19.6$ kb. High P/T -conditions ($T = 620^{\circ}\text{C}$, $P \geq 11$ kb) during the Cretaceous are also indicated for parts of the Austroalpine crystalline basement nappe (Koralpe, Saualpe).

Keywords: high-pressure metamorphism, metasediments, metaophiolites, Tauern window, Austroalpine basement.

In the Eastern Alps eclogites and/or blueschists indicating an Early Alpine high-pressure metamorphic event occur in the Pennine series outcropping in the tectonic windows of Unterengadin, Tauern and Rechnitz-Bernstein. Possibly, a Cretaceous high-pressure event is also documented in parts of the Austroalpine thrust sheet east of the Tauern Window (Fig. 1).

The pressure and temperature conditions for lawsonite—and crossite—bearing metabasic rocks of the Unterengadin window have been estimated as 350°C , 4–5 kb (LEIMSER, 1977). Actinic pyroxene, sodic amphiboles, Mg-pumpellyite and lawsonite-pseudomorphs have been recognized in the metaophiolites of the Rechnitz series, suggesting $330\text{--}370^{\circ}\text{C}$ at 6–8 kb (KOLLER, 1985).

In the Tauern window, metabasic eclogites and related rocks recording the earliest Alpine structural and metamorphic events are confined to a narrow zone in the central parts and near the base of the Mesozoic Upper Schieferhülle unit (e.g. MILLER 1977, RAITH et al., 1977, HOLLAND 1979a, DACHS 1985). De-

¹Institut für Mineralogie und Petrographie der Universität Innsbruck, Innrain 52, A-6020 Innsbruck.

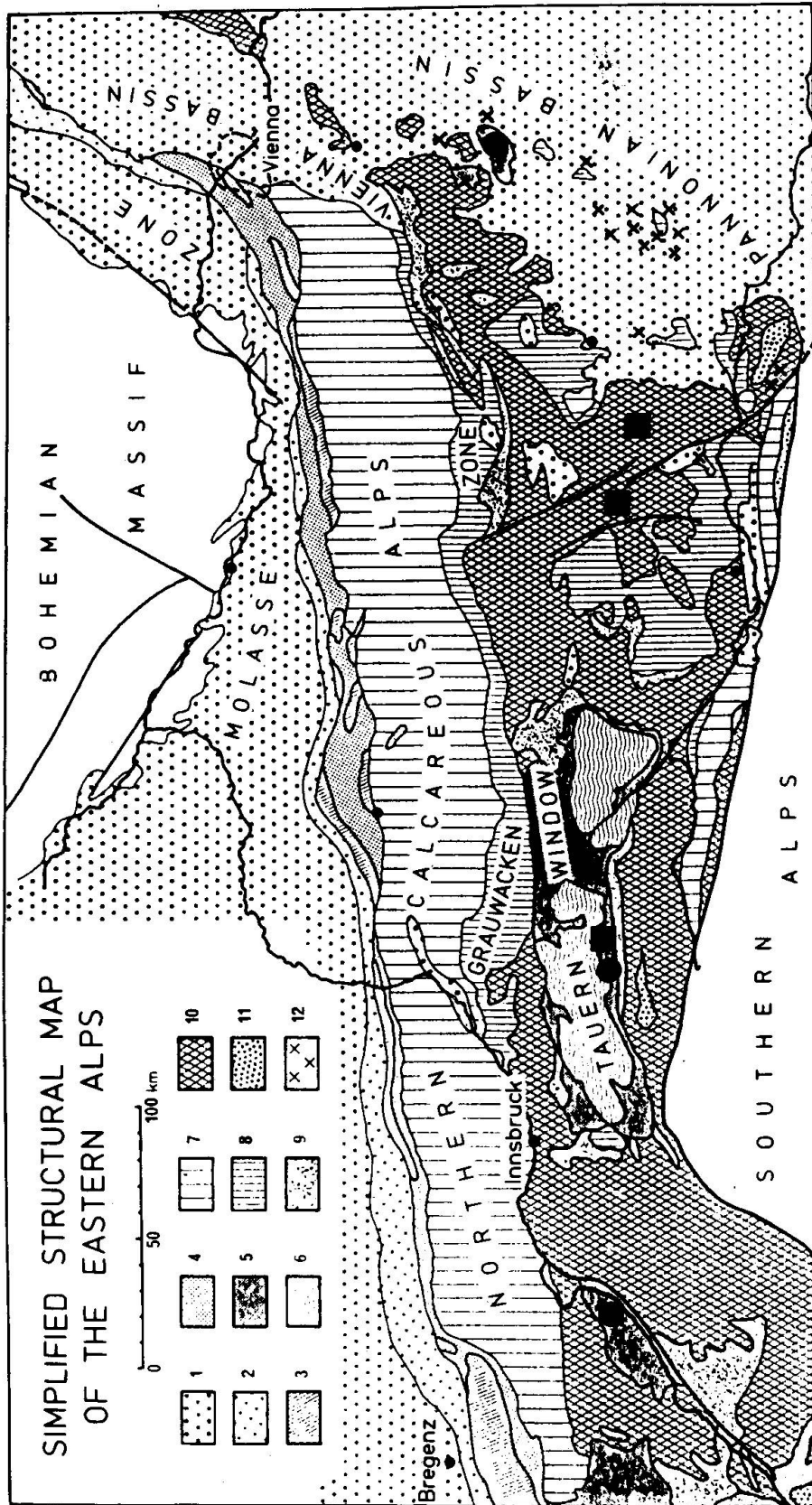


Fig. 1 Sketch map of the geology of the Eastern Alps. 1 = Molasse Zone and Tertiary Basins; 2 = Subalpine Molasse; 3 = Helvetic and Klippen Zone; 4 = Flysch Zone; 5 = Pennine Permomesozoic metasediments and ophiolites; 6 = Pennine Basement complex; 7-10 = Austroalpine nappes; 7 = Permomesozoic; 8 = Paleozoic; 9 = Central Alpine Permomesozoic; 10 = Austroalpine Crystalline; 11 = Tertiary volcanics. Dots: Alpine high-pressure blueschists; squares: eclogites.

pending on bulk composition the following high-pressure assemblages developed in the mafic rocks:

- (1) Omp-Gar-Kya-Tal(-Par)-Qtz-Rut
- (2) Omp-Gar-MgCtd-Kya(-Chl)-Tal
- (3) Omp-Gar-Epi-Mag/Dol/Cal-Phe/Par-Qtz

Temperatures of 540–580°C are indicated by garnet-clinopyroxene geothermometry and by stable isotope data (FRANK et al., 1986a). The equilibria

- (5) Par = Omp + Kya + H₂O (HOLLAND, 1979b) and
- (6) Chl + Kya = MgCtd + Tal (CHOPIN & SCHREYER, 1983)

define the stability conditions for coexisting omphacite, kyanite, paragonite, talc, Mg-chloritoid, chlorite (Tab. 1) in one of the eclogites as T = 570°C, P = 19.6 kb, a_{H₂O} ~ 1.0. This supports the evidence presented by HOLLAND (1979a) for eclogite crystallization under conditions of high water activity and very high pressures which can only be explained by subduction processes. Simi-

Tab. 1 Eclogite T 522, Weissspitze, Hohe Tauern: EMS analyses and compositional data of the assemblage used in P/T-evaluation of the eclogite event in the Tauern Window.

	GAR	OMP	PAR	MgCTD	TAL	CHL	KYA
SiO ₂	39.83	56.62	46.70	26.10	61.94	29.23	36.88
TiO ₂	.00	.01	.06	.00	.00	.00	.00
Al ₂ O ₃	22.46	12.01	39.60	44.03	.65	21.34	62.13
Cr ₂ O ₃	.04	.03	.12	.04	.00	.01	.18
Fe ₂ O ₃ *	.14	.32	-	-	-	-	.34
FeO	20.13	1.61	.28	11.25	2.85	8.40	-
MnO	.15	.00	.00	.04	.00	.02	.00
MgO	10.41	9.32	.13	11.47	29.53	28.92	.04
CaO	6.86	12.55	.31	.00	.03	.00	.00
Na ₂ O	.00	7.22	7.55	.00	.00	.00	.00
K ₂ O	.00	.00	.54	.00	.00	.00	.00
TOTAL	100.02	99.69	95.29	92.93	95.00	87.92	99.57
XMG	.48	.90	-	.64	.95	.86	-
XNA	-	.51	.93	-	-	-	-
XCA	.18	-	-	-	-	-	-

*Fe³⁺ calculation based on stoichiometric requirements

lar values ($T = 590^{\circ}\text{C}$, $P = 19 \text{ kb}$) are reported by SPEAR et al. (1985) based on phase equilibria in metasediments such as

- (7) Gar-Ctd-Kya-Phe-Qtz
- (8) Gar-Omp-Kya(-Tal)-Phe/Par-Zoi-Qtz
- (9) Kya-Zoi-Dol-Qtz
- (10) Cal-Omp-Zoi-Qtz

A second major phase of Alpine age deformation occurred under blueschist facies conditions. The pressure and temperature values are not well constrained. Coexisting

- (11) Glc-Omp-Tal and
- (12) Glc-Zoi-Kya

seem to indicate a range of $480\text{--}550^{\circ}\text{C}$ at $12\text{--}15 \text{ kb}$ for the blueschist overprint of the eclogites (Tab. 2). In other metabasites and metasediments of the Upper Schieferhülle unit that had not been highly metamorphosed before, temperatures of $350\text{--}400^{\circ}\text{C}$ and pressures of about 9 kb are indicated by sodic amphi-

Tab. 2 Eclogite T 588 Frosnitzal, Hohe Tauern: EMS mineral analyses and compositional data referring to the post-eclogitic blueschist event in the Tauern Window.

	OMP	GLC	TAL	KYA	CZO
SiO ₂	56.47	59.34	61.95	37.18	39.43
TiO ₂	.03	.04	.00	.00	.02
Al ₂ O ₃	12.54	12.05	.74	62.88	32.23
Cr ₂ O ₃	.06	.00	.02	.07	.04
Fe ₂ O ₃ *	.11	.51	-	.29	1.98
FeO	1.91	4.15	2.96	-	-
MnO	.02	.00	.00	.00	.02
MgO	8.53	13.42	29.44	.00	.05
CaO	12.86	1.36	.00	.00	24.45
Na ₂ O	7.32	6.95	.00	.00	.00
K ₂ O	.00	.00	.00	.00	.00
TOTAL	99.85	97.82	95.11	100.42	98.22
XMG	.89	.85	0.95	-	-
XNA	.50	.90	-	-	-

*Fe³⁺ calculation based on stoichiometric requirements.

boles (glaucophane, barroisite, crossite), lawsonite-pseudomorphs and phen-gite I (Si = 3.4). K/Ar data of 60–90 Ma for crossitic amphiboles (RAITH et al., 1980) suggest an early Alpine age for the blueschist overprint. HOLLAND & RICHARDSON (1979) correlate this event with the onset of overthrusting of the Austroalpine nappe system onto the Penninic realm.

After the overthrusting and its intense deformational imprints, all units in the Tauern window were affected by the syn- to postkinematic Mesoalpine metamorphism of 45–30 Ma ago. In a cross section through the central Tauern Window greenschist facies conditions are reported for the southern (460–480°C) and the northern (380–400°C) margins. Temperatures increase towards the central parts, reaching about 550°C at the base of the Upper Schieferhülle unit (FRANK et al., 1986a). Minimum pressure estimates based on the occurrence of kyanite are 4 kb, pressure values estimated from

(13) Gar-Kya-Plag(-Bio)

are 7 kb (DACHS, 1985).

Pre-Alpine eclogites and eclogite-amphibolites make up a small fraction in different levels of the Koralpe and Saualpe, a part of the Austroalpine nappe system east of the Tauern Window. According to FRANK et al. (1983, 1986b) large parts of this polymetamorphic crystalline have been affected by a Cretaceous metamorphic event, locally accompanied by an intense deformation. During this event the blastomylonitic Plattengneisses characterized by a prominent stretching lineation developed in shear-zones in the Koralpe gneiss complex. The equilibrium conditions for the Cretaceous Plattengneiss assemblage

(14) Gar-Kya-Plag-Bio-Mus-Qtz-Rut

are 600–620°C, 10–12 kb (WIMMER-FREY, 1984). Boudinaged layers of amphibole-eclogite within the Plattengneiss are characterized by a strong preferred orientation of [001] of omphacite and magnesiohornblende parallel to the stretching lineation of the Plattengneiss (WIMMER-FREY, 1984). As the minimum pressure and temperature conditions inferred from garnet-omphacite-quartz are in the same range as those for the enclosing Plattengneisses (MILLER, 1985), this seems to indicate that at least some pre-Cretaceous eclogites have deformed and recrystallized during a high-P/T Cretaceous shearing event. Also, a Cretaceous mineral forming event for a Saualpe eclogite is indicated by $^{40}\text{Ar}/^{39}\text{Ar}$ dating (RITTMANN, 1984).

References

- CHOPIN, CH. & SCHREYER, W. (1983): Magnesio-carpholite and magnesio-chloritoid: two index minerals of pelitic blueschists and their preliminary phase relations in the model system $\text{MgO}-\text{Al}_2\text{O}_3-\text{SiO}_2-\text{H}_2\text{O}$. *Am. J. Sci.* 283A, 72–96.

- DACHS, E. (1985): Petrologische Untersuchungen im südlichen Tauernfenster und Bemerkungen zur Geobarometrie der Paragenese Plagioklas-Biotit-Granat-Muscovit \pm Al_2SiO_5 -Quarz unter Berücksichtigung einer experimentellen Bestimmung des Gleichgewichtes: Almandin + Grossular + Muscovit = 3 Anorthit + Annit. Unpublished thesis, Univ. Innsbruck, 163 p.
- FRANK, W., ESTERLUS, M., FREY, I., JUNG, G., KROHE, A. & WEBER, J. (1983): Die Entwicklungsgeschichte von Stub- und Korallenkristallin und die Beziehung zum Grazer Paläozoikum. *Jber. Hochschulforschungsschwerpunkt S15*, 4, 263-293.
- FRANK, W., HÖCK, V. & MILLEK, CHR. (1986a): Metamorphic and tectonic history of the central Tauern Window. In: *Geodynamics of the Eastern Alps* (in press).
- FRANK, W., ESTERLUS, M., JUNG, G., KROHE, A., MILLER, CH., TEMMEL, R., WEBER, J. & WIMMER-FREY, I. (1986b): Structure, petrography, geochronology and geological evolution of the Koralm crystalline (Styria/Carinthia, Eastern Alps). In: *Geodynamics of the Eastern Alps* (in press).
- HOLLAND, T. J. B. (1979a): High water activities in the generation of high pressure kyanite eclogites in the Tauern Window, Austria. *J. Geology* 87/1, 1-27.
- HOLLAND, T. J. B. (1979b): Experimental determination of the reaction paragonite = jadeite + kyanite + H_2O , and internally consistent thermodynamic data for part of the system $\text{Na}_2\text{O}-\text{Al}_2\text{O}_3-\text{SiO}_2-\text{H}_2\text{O}$, with applications to eclogites and blueschists. *Contrib. Mineral. Petrol.* 68, 293-301.
- HOLLAND, T. J. B. & RICHARDSON, S. W. (1979): Amphibole zonation in metabasites as a guide to the evolution of metamorphic conditions. *Contrib. Mineral. Petrol.* 70, 143-148.
- KOLLER, F. (1985): Petrologie und Geochemie der Ophiolite des Penninikums am Alpenostrand. *Jb. Geol. B.-A.* 128, 83-150.
- LEIMSER, W. (1977): Untersuchungen zur Petrographie und Metamorphose der Gesteine des Unterengadiner Fensters, österr. Anteil. Dissertation Univ. Innsbruck, 122 p.
- MILLER, CH. (1977): Chemismus und phasenpetrologische Untersuchungen der Gesteine aus der Eklogitzone des Tauernfensters. *TMPM* 24, 221-277.
- MILLER, CH. (1985): Eclogites within the Koralm und Saualm crystalline complex. *Terra Cognita*, 5, 411-412.
- RAITH, M., HÖRMANN, P. K. & ABRAHAM, K. (1977): Petrology and metamorphic evolution of the Penninic ophiolites in the western Tauern Window (Austria). *Schweiz. mineral. petrogr. Mitt.* 57, 187-232.
- RAITH, M., MEHRENS, CH. & THÖLE, W. (1980): Gliederung, tektonischer Bau und metamorphe Entwicklung der penninischen Serien im südlichen Venediger Gebiet, Osttirol. *Jahrb. Geol. B.-A.* 123, 1-37.
- RITTMANN, K. L. (1984): Argon in Hornblende, Biotit und Muskowit bei der geologischen Abkühlung - $^{40}\text{Ar}/^{39}\text{Ar}$ -Untersuchungen. Diss. Naturwiss.-Mathemat. Fak. Univ. Heidelberg, 231 p.
- SPEAR, F. S., FRANZ, G. & THOMAS, S. (1985): Evolution of metasediments from the eclogite zone (EZ), Tauern Window, Austria. *Terra cognita*, 5, 425.
- WIMMER-FREY, I. (1984): Gefüge- und Metamorphoseuntersuchungen am Plattengneis der zentralen Koralm, W-Steiermark. Diss. Univ. Wien, 127 p.

Manuscript received February 14, 1986; accepted June 6, 1986.