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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 °C, P = 19.6 kb. High P/T-conditions (T = 620 °C, P ≧ 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). Acmitic pyroxene, sodic amphiboles, Mg-pumpellyite and lawsonite-pseudomorphs have been recognized in the metaophiolites of the Rechnitz series, suggesting 330–370 °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-

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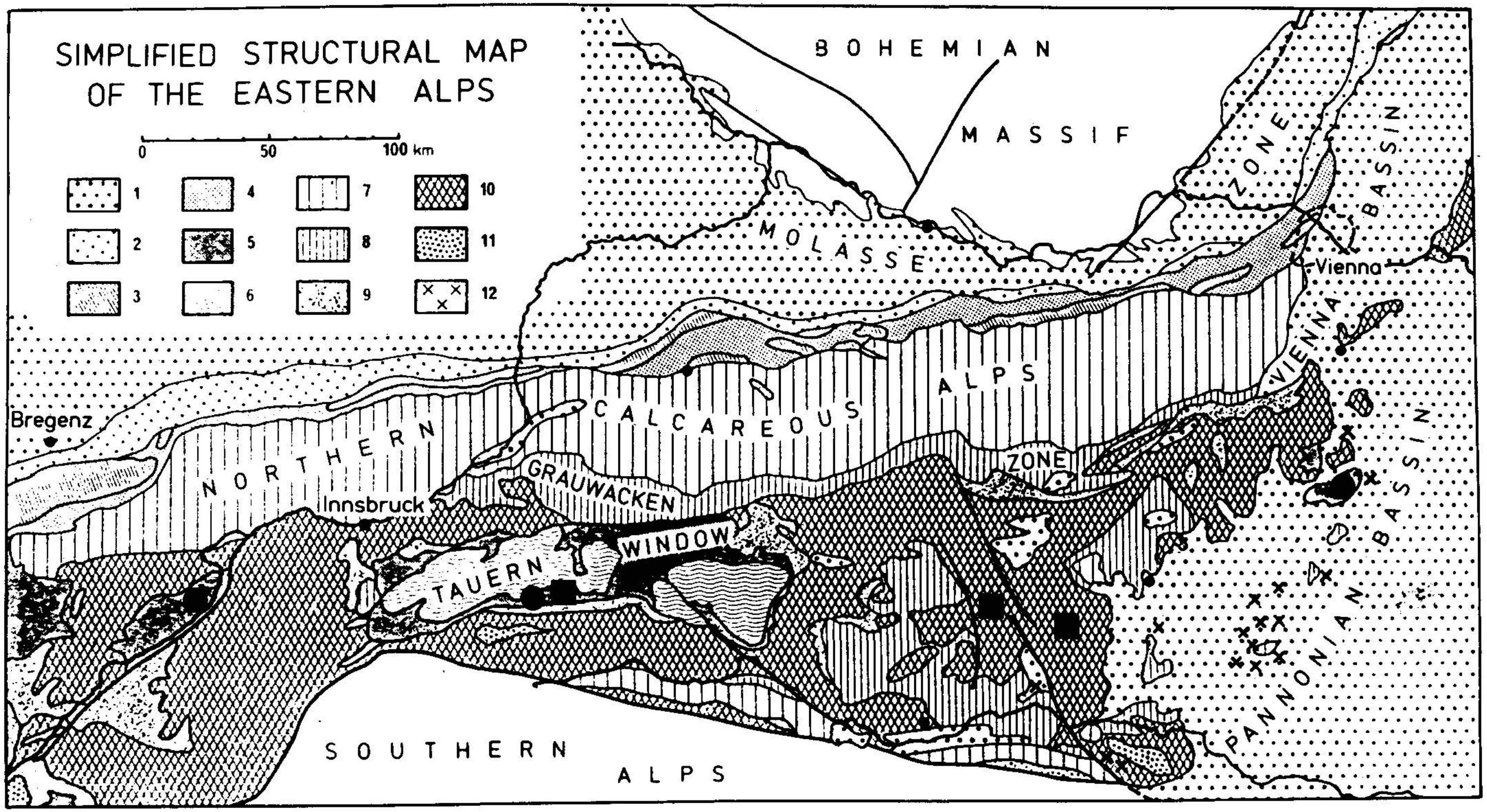

Fig. 1 Sketch map of the geology of the Eastern Alps. 1 = Molasse Zone and Tertiary Basins; 2 = Subalpine Molasse; 3 = Helvetic and Klippen Zone; 4 = Flysch Zone; 5 = Pennine Permomesozoic metasediments and ophiolites; 6 = Pennine Basement complex; 7–10 = Austroalpine nappes; 7 = Permomesozoic; 8 = Paleozoic; 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 + H_2O (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_{H_2O}~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_2O_3	22.46	12.01	39.60	44.03	.65	21.34	62.13
Cr_2O_3	.04	.03	.12	.04	.00	.01	.18
Fe_2O_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_2O	.00	7.22	7.55	.00	.00	.00	.00
K_2O	.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		-	-	-	-	-

*Fe^{3+} calculation based on stoichiometric requirements

lar values (T = 590 °C, P = 19 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 480–550 °C at 12–15 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 350–400 °C and pressures of about 9 kb are indicated by sodic amphi-

Tab. 2 Eclogite T 588 Frosnitztal, 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_2O_3	12.54	12.05	.74	62.88	32.23
Cr_2O_3	.06	.00	.02	.07	.04
Fe_2O_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_2O	7.32	6.95	.00	.00	.00
K_2O	.00	.00	.00	.00	.00
TOTAL	99.85	97.82	95.11	100.42	98.22
XMG	.89	.85	0.95	-	-
XNA	.50	.90	-	-	-

*Fe^{3+} calculation based on stoichiometric requirements.

boles (glaucophane, barroisite, crossite), lawsonite-pseudomorphs and phengite 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 strechting 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 $^{40}Ar/^{39}Ar$ dating (RITTMANN, 1984).

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