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Distribution maps of minerals of the Alpine metamorphism in the penninic Tauern window, Austria

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With 3 Figures

Zusammenfassung

Es werden drei Karten mit Mineralzonen des Tauernfensters vorgelegt. Die erste zeigt die Verteilung von Albit und Oligoklas in Gneisen und Metabasiten. Zwei Bereiche können darauf unterschieden werden: Ein Bereich mit Albit (0–5 An) und ein zweiter mit Oligoklas (14–19 An und/oder 20–29 An), der Albit umschließt. Karte zwei zeigt die Mineralverteilung in Metapeliten, wobei Granat, das wichtigste Mineral, etwa dieselbe Verbreitung wie Oligoklas besitzt. Karbonatführende Gesteine (Karte drei) zeigen bemerkenswerte Unterschiede: Biotit ist in den westlichen Hohen Tauern weit verbreitet und kommt in den mittleren Hohen Tauern nur selten vor, demgegenüber scheint Granat und/oder Margarit auf das Großglocknergebiet beschränkt zu sein.

Summary

Three maps of the Tauern Window are presented, the first one dealing with the distribution of albite and oligoclase in gneisses and metabasic rocks. Two areas have been delineated, one with albite (An 0–5) and a second with oligoclase (An 14–19 and/or 20–29) riming albite. Garnet, the most significant mineral in metapelites (second map) has approximately the same distribution area as oligoclase. Carbonate bearing rocks (map three) show a remakable diversity: biotite is abundant in the western Hohe Tauern and rare in the middle part, whereas garnet and/or margarite seem to be restricted to the Großglockner area.

Introduction

Since E. NIGGLI (1960) published his classical work "Mineral-Zonen der Alpinen Metamorphose in den Schweizer Alpen" an increasing number of papers appeared dealing with the distribution of minerals, metamorphic zones and isogrades of the alpine metamorphism in the Swiss Central Alps (helvetic and penninic zone).

Several minerals and mineral assemblages have been used to describe the distribution of different metamorphic conditions:

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Stilpnomelane, chloritoid, staurolite, kyanite, sillimanite (E. NIGGLI & C. R. NIGGLI, 1965), plagioclase (An-content) in carbonaceous matter (WENK, 1962) and in amphibolites (WENK and KELLER, 1969), assemblages in siliceous dolomites (TROMMSDORFF, 1966) and in ultramafic rocks (TROMMSDORFF and EVANS, 1974).

Papers considering the distribution of minerals in the most extensive tertiary metamorphosed penninic area in Austria, the Tauern Window, were published only sporadically (EXNER and FAUPL 1970, CLIFF et al. 1971, HOERNES 1973, HÖCK 1974, MORETANI and RAASE 1974, HÖCK 1975) contrary to the well documented alpine metamorphism in the Swiss Lepontine.

The presented maps of mineral distribution within the Tauern Window are compiled from published data, results of the author's investigations and unpublished data made available by numerous colleagues, especially: H. ALBER, Ch. EXNER, W. FRANK, G. FRASL, G. HOSCHEK, F. KOLLER and Ch. MILLER. My sincere thanks to all of them.

Discussion of the maps

The first map, fig. 1, deals with the increasing An-content dependent on the metamorphic grade in gneisses, schists and metabasic rocks. The distribution of the An-content in the western part of the Tauern Window (W of Großvenediger) is taken from a more detailed paper by MORTEANI and RAASE (1974, fig. 8). Only compositions of plagioclase rims are considered in fig. 1.

The authors distinguish three zones of different An-content, based on optical investigations of plagioclase in amphibole-free epidote-bearing rocks (fig. 1). The highest metamorphic grade is characterized according to MORTEANI and RAASE (1974) by a plagioclase of 15–18% An in the core and 20–30% An at the rims, followed by an intermediate zone with An-contents 0–6% in the core and 14–19% at the rim. In the outermost area the An-content does not exceed 6% and no inverse zone is present.

Similar results were found by CLIFF et al. (1971) in the south-eastern part of the Tauern Window S and E of Reißeck (fig. 1). They observe a break in plagioclase composition between An 5% and An 20% in mafic as well as in pelitic compositions, oligoclase generally riming albite. Within the central gneiss area oligoclase is the common plagioclase, but no systematic variation could be observed.

Outside the central gneiss cores and their cover of pelitic and gneissic compositions mainly of Paleozoic age, plagioclase is common in the carbonate-free or -poor metabasic schists (prasinites) of the Bündnerschieferserie (FRASL 1958) and in the accompanying calcschists. The latter are not considered here because of the influence of varying XCO_2 on the anorthite content in plagioclase (FREY and ORVILLE 1974).

Anorthite content in plagioclase of prasinites was measured by optical, x-ray and microprobe methods (HÖCK 1976, HÖCK and ZIMMERER 1978). The data delineate an "oligoclase" zone between Kitzsteinhorn – N Sonnblick – Heiligenblut and S Großglockner, bordered on both sides by the "albite" zone. Oligo-

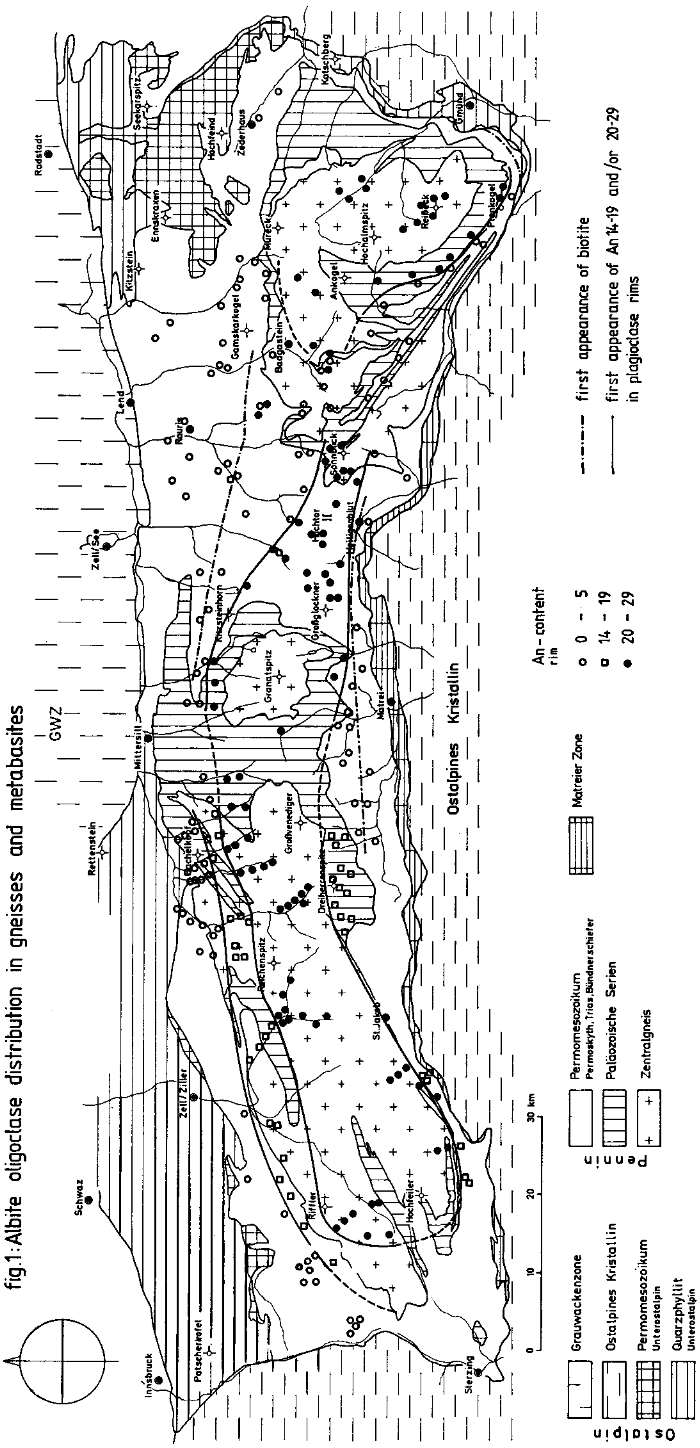


fig.1: Albite oligoclase distribution in gneisses and metabasites

clase (An 21–24) is partly mantling albite, partly coexisting as distinct grains with almost pure albite (An 0–2) in a similar manner as described by CRAWFORD (1966) and STRECKEISEN and WENK (1974). These plagioclases are covering the peristerite gap and their coexistence may serve as an isograde (FREY 1974). It seems, that the albite-oligoclase transition line in the Großglockner–Sonnblick area can be connected with the limits of the area of plagioclase rims with 20–30% An in the western Hohe Tauern, but the region in between is insufficient sampled so far, as indicated by the dashed connection lines. The relation between the oligoclase-bearing zone near the Sonnblick and the Hochalm–Reißeck region is not clear at all and should be subject to further intense investigations. The overall increase in An-content, however, can be attributed mainly to a breakdown reaction of epidote in all areas (MORTEANI & RAASE 1974, CLIFF et al. 1971, HÖCK and ZIMMERER 1978), though the differences in bulk chemistry of gneisses and pelitic rocks on the one hand and metabasic rocks on the other are evident. The contribution of amphibolite to the oligoclase formation in prasinites is not clear yet; preliminary investigations by HÖCK and ZIMMERER (1978) indicate neither systematic core/rim variation of amphibole composition in respect to their Na_2O and CaO content nor significant changes in modal abundance of amphibole and plagioclase (cf. WENK et al. 1974).

The line indicating the first appearance of biotite in prasinites within the albite zone is not a sensitive indicator of increasing metamorphism, because the occurrence of biotite depends strongly on the enrichment or depletion of K in the host rocks.

In fig. 2 mineral occurrences in pelitic rocks mainly of Mesozoic age and minor of Paleozoic age are compiled. Apart from yet unpublished investigations mineral data and locations are taken from ANGEL and STABER (1952), CLIFF et al. (1971), CORNELIUS and CLAR (1939), EXNER (1957, 1964, 1967, 1971 a, b), FRASL (1958), FRASL et al. (1975), HÖCK (1969, 1974) and HOERNES (1973).

Kyanite is widely distributed and often associated with chloritoid. It is not restricted to the area of higher temperature i.e. the field of garnet (see below) and oligoclase. Pyrophyllite as potential precursor of kyanite has not yet been detected so far as constituent of the country rock. Chloritoid is found all over the Tauern Window whereas stilpnomelane is restricted to some rocktypes in the outermost part of the Tauern Window.

The most interesting feature is the first appearance of garnet in pelitic schists in the middle part of the Hohe Tauern. The shape of the area with garnet occurrences ("garnet" zone) is very similar to the distribution field of oligoclase in metabasic rocks (fig. 1), especially in the northern part. S and SE of Großglockner the garnet zone extends further S into the albite field. Because of the complex composition of the garnet and its large chemical variability (CLIFF et al. 1971, HÖCK 1974) no reaction leading to the formation of garnets expressing a "garnet" isograde in pelitic rocks has been formulated so far. The distribution pattern of garnet, however, indicates the existence of such an isograde.

Staurolite has been found only in several localities in the eastern part (S of Sonnblick, "Mallnitzer Mulde" E of Reißeck, Ankogel area, "Silbereck Mulde" SE fig.2 : Mineral distribution in metapelites

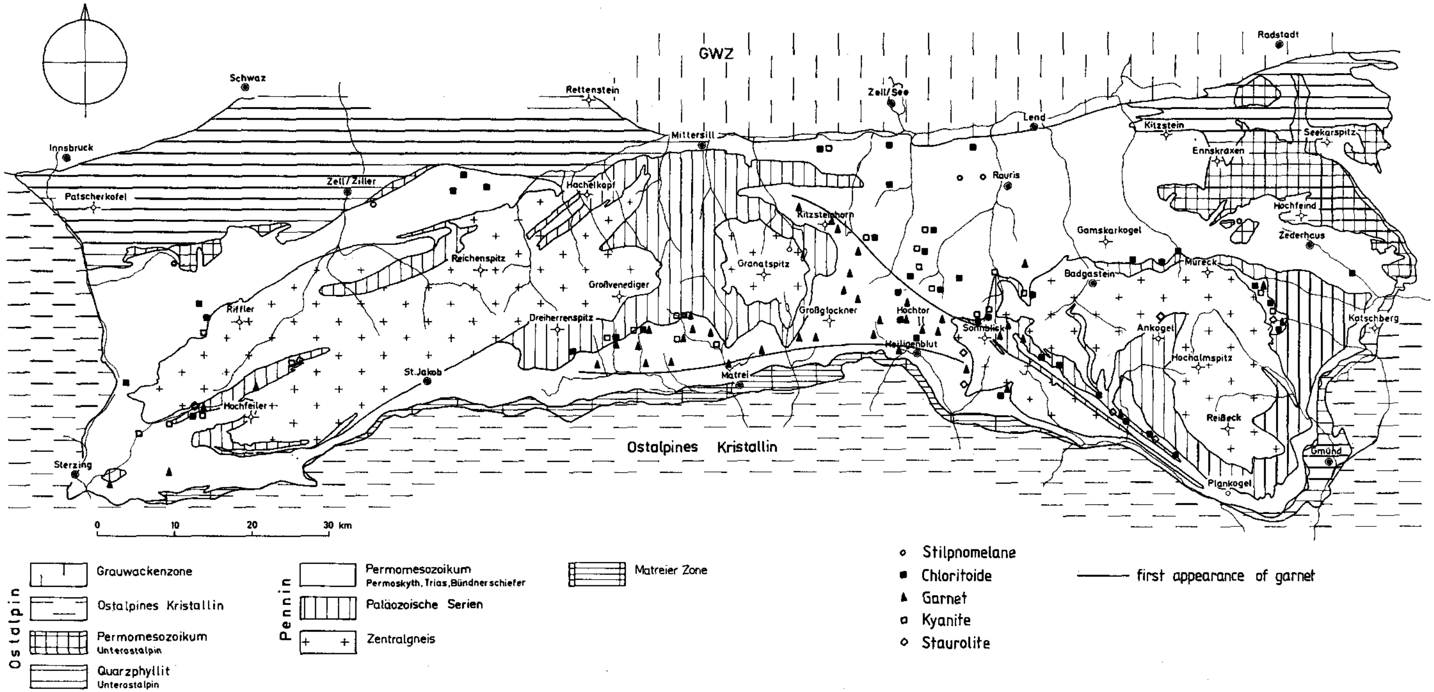
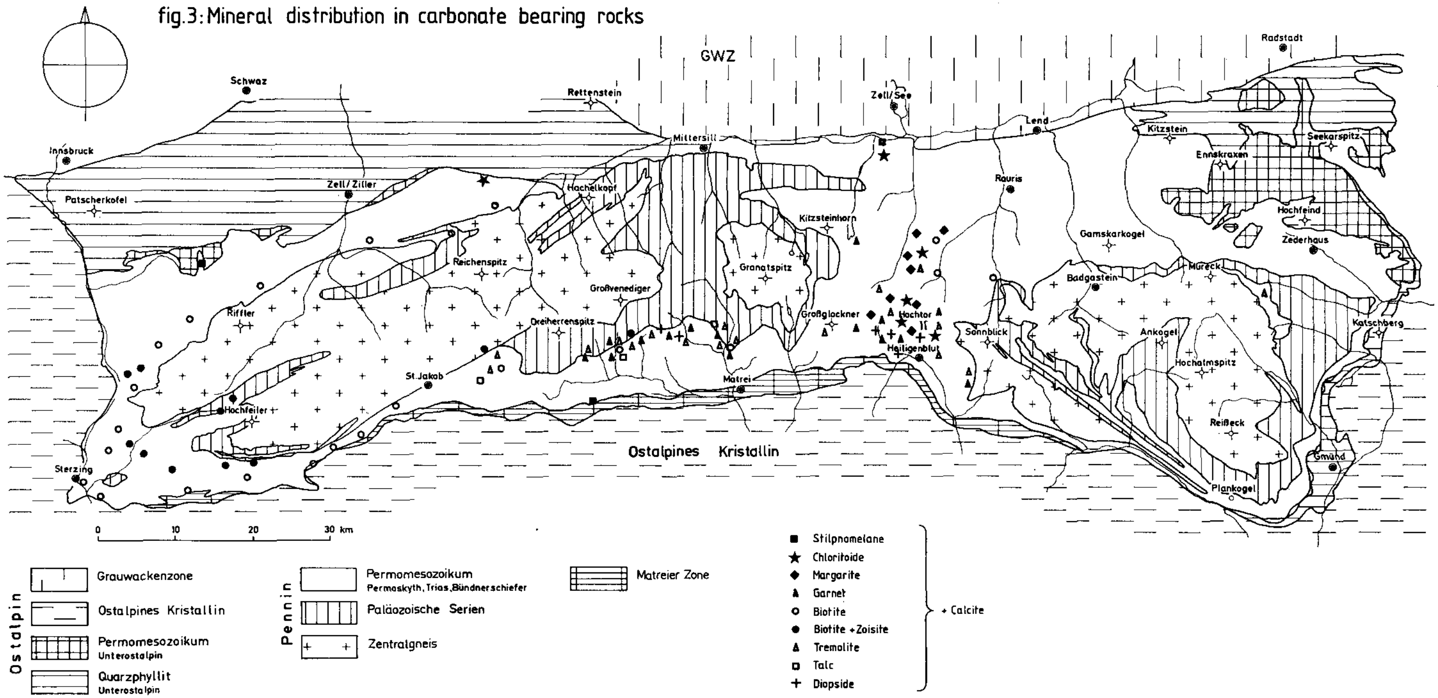


fig.3: Mineral distribution in carbonate bearing rocks



of Mureck) and in the western part of the Hohe Tauern (Greinermulde, N of Hochfeiler).

The formation of staurolite especially in the eastern part of the Hohe Tauern is not clear in detail. It might be possible, that some staurolite represent relics of an older, prealpine metamorphism.

The third map (fig. 3) finally deals with the distribution of minerals in calcareous sediments, calcschists and siliceous dolomites. As can be seen from the map, biotite and biotite + zoisite together with calcite in calcareous schists are abundant in the western part of the Hohe Tauern, whereas calcschists in the Großglockner area are characterized by margarite or garnet. Biotite is restricted to rare occurrences S and SW of Rauris. The calcschists S and SE of the Großvenediger comprising garnet and biotite may represent an intermediate region.

Tremolite, talc and diopside in carbonaceous rocks have approximately the same distribution field as garnet.

A detailed description of the areas investigated in this respect (middle part of the Hohe Tauern N and NE of Großglockner and western Hohe Tauern) is given by HÖCK (1977) and HÖCK and HOSCHEK (this volume).

In the high grade metamorphic area ("oligoclase" zone, "garnet" zone) of the western Hohe Tauern the temperature estimation based on oxygen isotopes studies yielded 550–575° C according to HOERNES and FRIEDRICHSEN (1974). These temperatures seem to be in accordance with some calc-silicate reactions (G. HOSCHEK in HÖCK and HOSCHEK, this volume) and the formation of staurolite (HOERNES 1973). Towards the east the temperature decreases to about 500° C (HÖCK 1974, BICKLE & POWELL 1977) around the Hochtor area. It increases again in the eastern Hohe Tauern, where CLIFF et al. (1971) estimated the temperatures near 550° C based on the formation of staurolite.

A minimum pressure of 4–6 kb is inferred from the overall occurrence of kyanite according to the experimental results by ALTHAUS (1967), RICHARDSON et al. (1969) and HOLDAWAY (1971).

The maps of mineral distribution presented here are a first step towards a more general description of alpine metamorphism in the Tauern Window. Additional fieldwork was started already to fill up the white spots in the maps (eastern and northeastern part of the Tauern Window) with mineral data.

Special attention is drawn to work out potential isogrades, as indicated by the mineral distribution, and their geometry. A three dimensional picture of the alpine metamorphism would represent a major contribution to the geodynamic interpretation of the Eastern Alps.

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