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Margarite in the Upper Austroalpine basement (Western Trentino, Italy)

by S. Martin[1] and L. Santini[2]

Abstract

Coronitic margarite is recorded in kyanite-staurolite-garnet paragneisses outcropping between the Peio and Bresimo valleys (Western Trentino, NE Italy) within the Upper Austroalpine Tonale-Ulten basement nappe.

Margarite occurs as narrow monomineralic rims around pre-Alpine deformed porphyroblasts of kyanite, always confined to the kyanite-quartz, kyanite-muscovite and kyanite-biotite boundaries.

Minor chlorite and sericite (after staurolite and kyanite) are representative of a later non-pervasive retrogression. No definite evidence is available for defining the age of margarite crystallization, which may be referred to either the late-Hercynian or eo-Alpine events.

Keywords: margarite, Austroalpine basement, Western Trentino, Italy.

Introduction

Margarite, a dioctahedral mica, is a well known rock-forming mineral found in many low- to medium-grade metamorphic rocks. Margarite has been recorded in the Central Alps and in the Tauern Window (NIGGLI, 1955; ACKERMAND & MORTEANI, 1973; HÖCK, 1974; FREY, 1978; FREY et al., 1982; FRANK, 1983; BUCHER-NURMINEN et al., 1983, and references therein) as a prograde phase from lower greenschist- to upper amphibolite-facies or blueschist metamorphism of Alpine age. Margarite is also known as a retrograde phase after Al-rich minerals such as andalusite, sillimanite, corundum and, more commonly, as a pseudomorph after kyanite (CHINNER, 1974; GUIDOTTI & CHENEY, 1976; GIBSON, 1979; GUIDOTTI et al., 1979; TEALE, 1979; COOPER, 1980; BALTATZIS & KATAGAS, 1981; COTKIN et al., 1988). It has recently been found in the basement rocks of the Southalpine "Serie dei Laghi", where it is interpreted as a Hercynian retrograde product after kyanite (BORGHI, 1988).

Margarite was formerly unknown in the Austroalpine units of the Eastern Alps, which are largely composed of Hercynian or older basement rocks, slightly to pervasively overprinted by a greenschist- to amphibolite facies tectono-metamorphic event of eo-Alpine age (THÖNI, 1981, 1986; HOINKES, 1986; HOINKES et al., 1987, and references therein).

The present short report records the first finding of margarite in the Austroalpine basement unit of the Italian Eastern Alps, where it develops round porphyroblasts of kyanite or fills fractures within them as monomineralic aggregates.

Abbreviations of mineral names used in the text, tables and figures are according to KRETZ (1983).

GEOLOGICAL SETTING

Margarite occurs in the Ky-St-Grt-bearing paragneisses of the Ulten Series which, together with the underlying Sil-Grt-Bt±Kfs gneisses of the Tonale Series (ANDREATTA, 1948a, 1951a, 1951b), constitute the Uppermost Austroalpine basement nappe exposed between the Giudicarie-Tonale fault system and the Peio Line (ANDREATTA, 1948a; SANTINI et al., 1987).

The nappe was first thrust northwards over the underlying Upper Austroalpine Ortler nappe and later gently backthrust southwards over the Cretaceous Insubric flysch along the Giudicarie Line (SANTINI & MARTIN, 1988).

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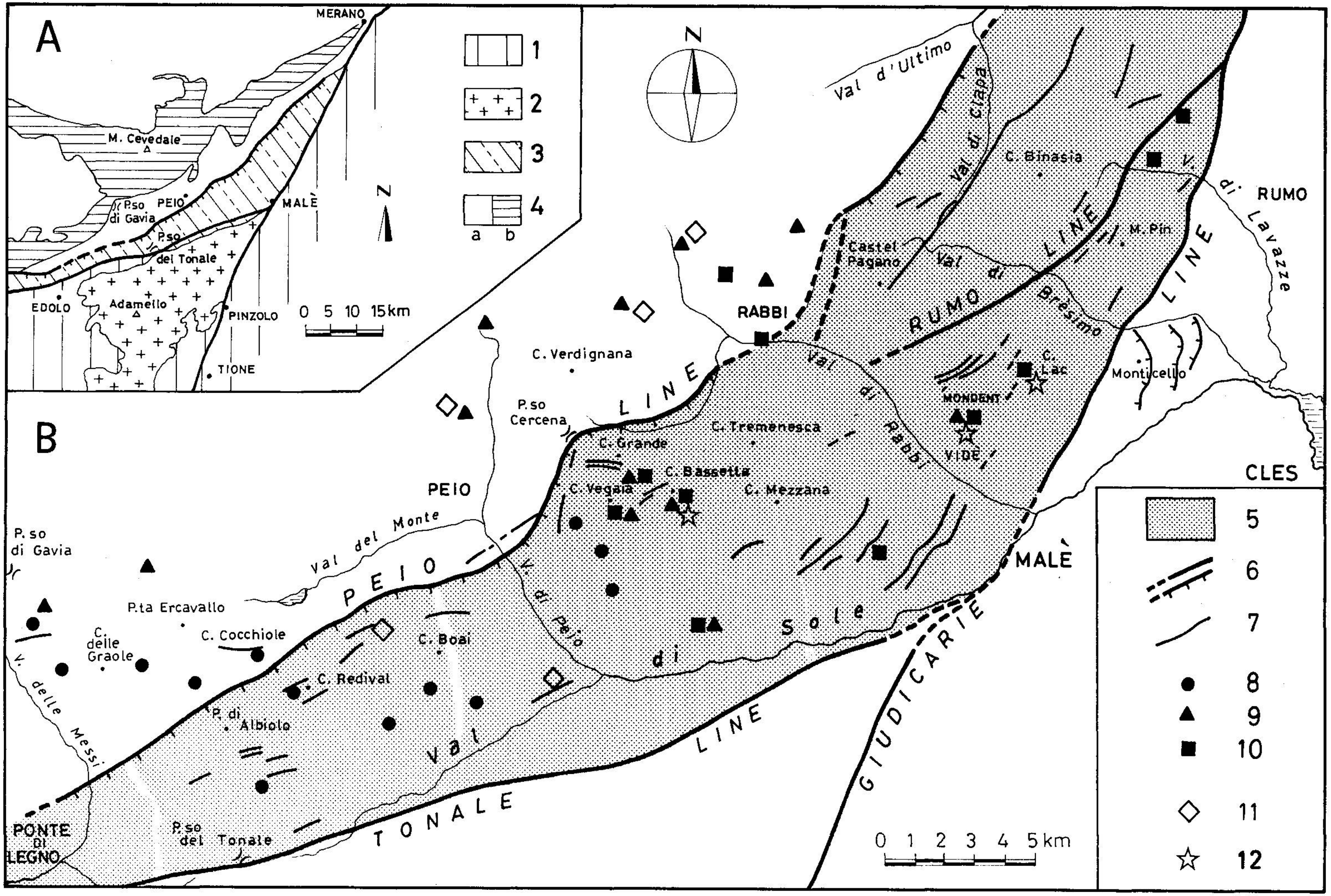

Fig. 1 (A) insert: Geological sketch-map of Western Trentino and Eastern Lombardy, Northern Italy. 1) Southern Alps; 2) Adamello Tertiary batholith; 3) Uppermost Austroalpine Tonale-Ulten basement nappe; 4) Upper Austroalpine Ortles nappe, including retrogressed medium-grade paraschists and Mesozoic sedimentary cover (a) and quartz-phyllites (b). (B) Map of Tonale Pass-Rumo area: 5) Tonale-Ulten basement nappe; 6) major tectonic lines and thrusts; 7) minor mylonitic bands; pre-Alpine minerals: 8) sillimanite, 9) staurolite, 10) kyanite; 11) Alpine chloritoid; 12) margarite.

The high-grade paragneisses of the Ulten unit include Grt-orthogneisses, amphibolites and slices of more or less serpentinized spinel-garnet lherzolites (OBATA & MORTEN, 1987, and references therein). Internal mylonitic to cataclastic strips are widespread.

The margarite-bearing gneisses were collected in the area between the Peio and Bresimo valleys, on the northern side of the Sole valley (province of Trento), and in particular: i)along the Cima Vegaia-Cima Bassetta ridge, ii) between the villages of Vide and Mondent, north of Malé; iii)near the Cima Lac (Fig. 1).

The high-grade regional schistosity in general dips south to south-east in the Ulten unit from the Peio valley to the Cima Mezzana-Cima Tremenesca ridge, where it is involved in a large-scale "Schlingen" structure. The latter was considered to be representative of a single deformation phase of pre-Alpine age (SCHMIDEGG, 1936; ANDREATTA, 1948b), although similar structures occurring in the Upper Austroalpine Ötztal-Stubai basement are interpreted as due to the interference of the pre-Alpine D2-D3 deformation phases (VAN GOOL et al., 1987).

East of the Rabbi valley, the regional schistosity dips north-west, probably related to the late-Alpine backthrusting.

FRAMEWORK OF METAMORPHISM

The Austroalpine basement rocks exposed between the Rabbi and Bresimo valleys show a strong lithological affinity with the basement of the Ötztal complex (HAMMER, 1931; GREGNANIN & PICCIRILLO, 1972, 1974; HOINKES et al., 1972; THÖNI, 1981). They are characterized by the occurrence of staurolite, kyanite and garnet porphyroblasts. The high-grade fabric, which predates eo-Alpine mylonites (THÖNI, 1981), is commonly referred to the pre-Alpine polymetamorphic transformations, developing under amphibolite-facies conditions, whose age is debated. Some authors (ANDREATTA, 1954; MILLER, 1970; PURTSCHELLER & SASSI, 1975; BÖGEL et al., 1979; FRISCH et al., 1985, and references therein) suggest a Caledonian event developing around 450 Ma under P exceeding 10kbar and T near 700°C, and followed by a lower-P Hercynian metamorphism varying from amphibolite- to greenschist-facies conditions. On the contrary, GREGNANIN & PICCIRILLO (1974) and THÖNI (1986) hypothesize the occurrence of a single polyphase cycle of Hercynian age.

A pervasive to scattered and poorly recorded eo-Alpine overprint on the Austroalpine basement between the Tauern and Engadine Windows was documented by SATIR (1975) and THÖNI (1981, 1986). It grades from the amphibolite-(Schneebergzug) to greenschist-facies conditions (HOINKES, 1981; THÖNI, 1981; THÖNI & HOINKES, 1987, and references therein). The metamorphic overprint and related deformations predate the emplacement of the Oligocene dikes and plutons of the Ortler-Cevedale massif (DAL PIAZ et al., in press).

MARGARITE-BEARING GNEISSES

The coarse (Cima Vegaia-Cima Bassetta)- to fine-grained (lower Rabbi valley) margarite-bearing paragneisses of the Ulten sheet are formed of biotite, muscovite, garnet, oligoclase, kyanite, staurolite and accessory K-feldspar

Tab. 1 Petrographical and structural features of the margarite-bearing paragneisses. (Se = sericite)

Sample	Location	Fabric	Pre-Alpine Amphibolite-facies mineral assemblage	Retrogressive phases
A1511	Vide`- Mondent Canet river q.1760	fine-grained paragneiss, crenulated S2	Bt,Ms,Grt St,Ky,Pl, Kfs,Rt,Tur	Mrg,Chl,Se,Tur
A1513	Vide`- Mondent Canet river q.1525	coarse-grained paragneiss, crenulated S2	Bt,Ms,Grt Ky,St,Pl,Rt	Mrg,Ilm,Se
A1558	C.ma Lac	fine-grained paragneiss, crenulated S2	Bt,Ms,Grt,Ky Pl	Mrg,Chl,Se,Tur
A1640	C.Bassetta	coarse-grained paragneiss, crenulated S2	Bt,Ms,Grt,St Ky,Pl,Py ?	Mrg,Se

Tab. 2 Composition of margarite and fine-grained white mica (sericite)

	MARGARITE								SERICITE	
	1	2	3	4	5	6	7	8	9	10
SiO2	31.53	29.50	29.35	30.21	29.03	29.32	29.87	30.41	46.32	46.52
TiO2	--	0.07	0.03	0.07	--	--	--	0.24	0.08	0.12
Al2O3	48.58	50.67	51.03	50.54	51.73	50.73	51.82	51.94	32.71	31.95
FeO	0.35	0.39	0.44	0.69	0.39	0.32	0.17	0.34	2.43	1.87
MnO	--	--	0.01	--	--	--	--	0.03	0.04	--
MgO	0.27	0.17	0.23	--	0.08	0.09	--	0.13	1.82	1.85
CaO	10.62	10.96	10.96	11.19	10.46	11.62	12.23	11.63	--	--
Na2O	1.04	1.48	1.63	1.24	1.46	1.13	0.59	1.24	0.17	0.22
K2O	0.72	0.01	0.03	0.05	0.27	0.05	--	0.02	9.77	10.56
Tot	93.11	93.25	93.71	93.99	93.42	93.26	94.28	95.98	93.34	93.09
Si	4.268	3.994	3.960	4.060	3.923	3.974	3.995	4.001	6.299	6.357
AlIV	3.732	4.006	4.040	3.940	4.077	4.026	4.005	3.999	1.701	1.643
AlVI	4.022	4.083	4.078	4.068	4.166	4.079	4.103	4.058	3.543	3.504
Ti	--	0.007	0.003	0.007	--	--	--	0.024	0.008	0.012
Fe	0.040	0.044	0.050	0.078	0.044	0.036	0.019	0.037	0.276	0.214
Mn	--	--	--	--	--	--	--	0.003	0.005	--
Mg	0.054	0.034	0.046	--	0.016	0.018	--	0.025	0.369	0.377
Ca	1.540	1.590	1.585	1.612	1.515	1.687	1.753	1.640	--	--
Na	0.273	0.389	0.426	0.322	0.383	0.297	0.153	0.316	0.045	0.058
K	0.124	0.002	0.005	0.008	0.047	0.009	--	0.003	1.695	1.841
Tot	14.053	14.149	14.194	14.095	14.171	14.126	14.028	14.106	13.941	14.006
Ms	6.4	0.1	0.3	0.4	2.4	0.4	--	0.1	97.4	97.0
Pa	14.1	19.6	21.1	16.6	19.7	14.9	8.0	16.1	2.6	3.0
Mrg	79.5	80.3	78.6	83.0	77.9	84.6	92.0	83.8	--	--

Micas normalized to 22 oxygens on anhydrous basis.

Margarite: 1) in contact with Ky and sericite; 2) filling fractured Ky; 3) in contact with Ky and Bt; 4) in contact with Ky, Qtz, Ms and Chl; 5) in contact with Ky and Ms; 6) in contact with Ky and Bt; 7) in contact with Ky and Qtz; 8) in contact with Ky and Bt.
Sericite: 9) internal rim, in contact with Mrg; 10) external rim.
1, 2, 3, 9 and 10=sample A1640; 4 and 5=sample A1511; 6,7=sample A1558; 8=sample A1513.

(Tab. 1). They display a planar to crenulated regional schistosity (S2) in which muscovite and garnet are stable, while staurolite is rimmed by sericite, biotite replaced by chlorite, and kyanite sometimes rimmed by margarite or sericite. Margarite, in turn, is rarely rimmed by sericite. Millimetric porphyroblasts of tourmaline, which include all the other minerals, is a peculiar minor component of the margarite-bearing paragneisses.

The absence of a Mesozoic sedimentary cover on the Ulten basement and of radiometric data do not allow the high-grade regional metamorphism to be dated, as regards the margarite growth (Hercynian or Alpine?) and later slightly-developed transformations. By comparison with the underlying Ortler nappe, which includes a low-grade sedimentary cover, and on the basis of radiometric data on surrounding areas (Thöni, 1981), the amphibolite-facies regional metamorphism may be referred to the Hercynian orogeny.

Among the retrogressive minerals, which are poorly represented in the Ulten basement, sericite and chlorite probably belong to the Alpine event. Only along internal mylonites is retrogression more pervasive, although no new significative minerals developed.

On the contrary, the Alpine low-grade overprint is widespread in the underlying Tonale basement, as recorded by abundant sericite after sillimanite and large white mica, chlorite replacing garnet and biotite, and growth of chloritoid (Santini et al., 1987).

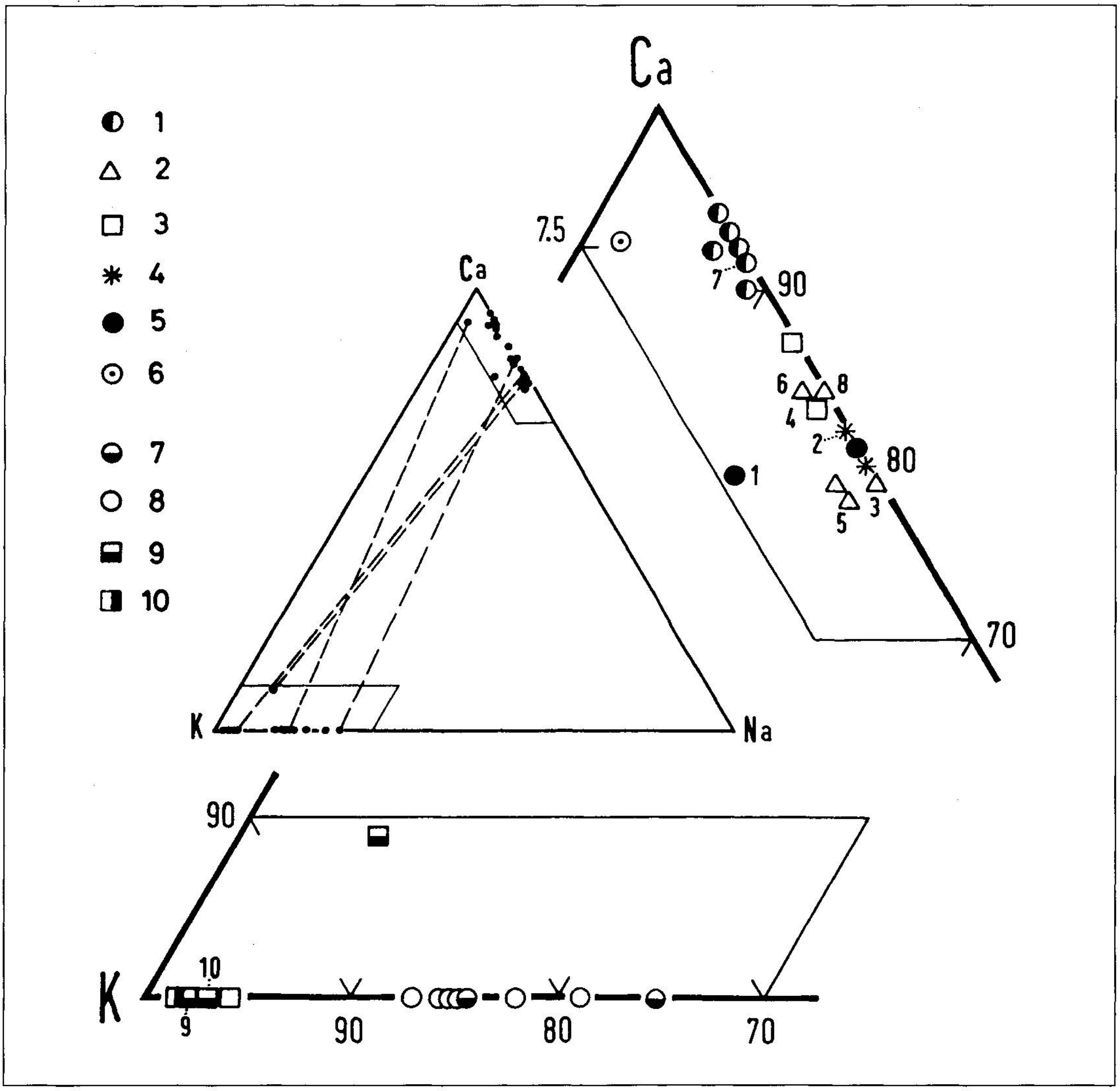

Fig. 2 Ca-Na-K plot of analyzed white micas. Tie-lines connect grains in contact, but they do not mean necessarily chemical equilibrium. Margarite in contact with Qtz (1), Bt (2) and Chl (3); margarite filling fractured Ky (4); margarite in contact with fine retrogressional sericite (5) and large muscovites (6). Large muscovites along high-grade schistosity in contact (7) or not (8) with Mrg; retrogressional sericite in contact with Mrg (9) and rimming Ky (10). Numbered symbols refer to analyses listed in table 2.

MARGARITE

Margarite forms narrow rims around some kyanite porphyroblasts in contact with quartz, biotite, muscovite, chlorite and sericite. In particular, kyanite is generally rimmed by margarite (Cima Lac area), margarite and late sericite (Cima Bassetta, Vidé-Mondent area), or single sericite. Margarite or a second generation of kyanite fill the fractures cutting the kyanite porphyroblasts.

19 spot analyses on margarite and 14 on muscovite and sericite from 4 selected margarite-bearing samples (Al511, Al513, Al558, Al640) were performed using a 6 spectrometres ARL-SEMQ electron microprobe at Milano University. Instrumental conditions were 15 KV accelerating voltage, 20 nA specimen current and 20 s

counting time for a single analysis. Natural silicates and oxides were used as standards: omphacite (USNM 110607, JAROSEWICH et al., 1980) for Ca, Al, Mg, Na, Si, a well-analyzed kaersutite for Fe, Ti, K. Correction procedure Magic IV (COLBY, 1972) was employed.

The mica analyses were normalized to 22 oxygens on anhydrous basis and iron is reported as total Fe. It produces for margarite an excess of octahedrally coordinated Y cations (4.12-4.23 p.f.u. is the range for analyses listed in Tab. 2) and understimates the twelve coordinated X ions (1.90 to 2.0 p.f.u.). Minor amounts of Mg (0.0-0.05) and Fe (0.02-0.08) also occur. No chemical zoning was detected through the margarite rims.

Margarite generally displays a negligible muscovite end-member content (<1%, Fig. 2). Only two analyses of margarite in contact with quartz and muscovite or sericite show an unusually high content of muscovite end-member (up to 6%), probably representing a mixture of margarite and muscovite (SCHREYER et al., 1981).

The amount of paragonite end-member in margarite is extremely variable (6-21%, Fig. 2). Variations in the paragonite content appear to be related to the compositions of the surrounding grains, ranging from 5 to 10% when margarite is in contact with quartz, from 12 to 16% when with chlorite, and up to 21% when with sericite and biotite. High paragonite content (20%) is also found in margarite filling fractured kyanite. Moreover, the margarite crystals which are continuously rimmed by sericite display greater paragonite and muscovite contents than the unaltered ones.

Sericite, as a retrogression product of staurolite, kyanite and margarite consuming reactions (Tab. 2), shows variable celadonitic substitution (Fig. 3).

The composition of fresh and partly altered margarite is plotted in a Na-K-Ca diagram (Fig. 2) together with that of the sericite rims and large muscovite crystals which mark the regional schistosity. The high content of paragonite end-member in margarite is probably due to the absence of plagioclase and paragonite in the textural sites where margarite grows. Obviously paragonite may be intergrown with margarite on a smaller scale than that of the electron beam.

Discussion

The margarite-quartz assemblage is commonly recorded in low- to medium-grade metamorphic rocks, under relatively low PH_2O (CHATTERJEE, 1976; CHATTERJEE et al., 1984 p. 11). Its stability field, referring to the CaO-Al_2O_3-SiO_2-H_2O system (300-560°C up to a maximum PH_2O of 8.6 kbar), was earlier depicted by CHATTERJEE (1976) and successively reinvestigated by PERKINS et al. (1980),CHATTERJEE et al. (1984) and JENKINS (1984) According to GUGGENHEIM (in GUIDOTTI, 1984) the margarite + quartz assemblage is stable up to approximately 600°C when PH_2O = P tot, for systems lacking a gas component other than water. T and P may be lowered if the presumed fluid phase is diluted with some other fluid component (CHATTERJEE, 1976). The paragonite component in margarite may offset the PH_2O reduction (JENKINS, 1984, p. 337) while, according to BUCHER (pers. comm.), the presence of sodium in the system (paragonite, albite) could also decrease the thermal stability of the assemblage.

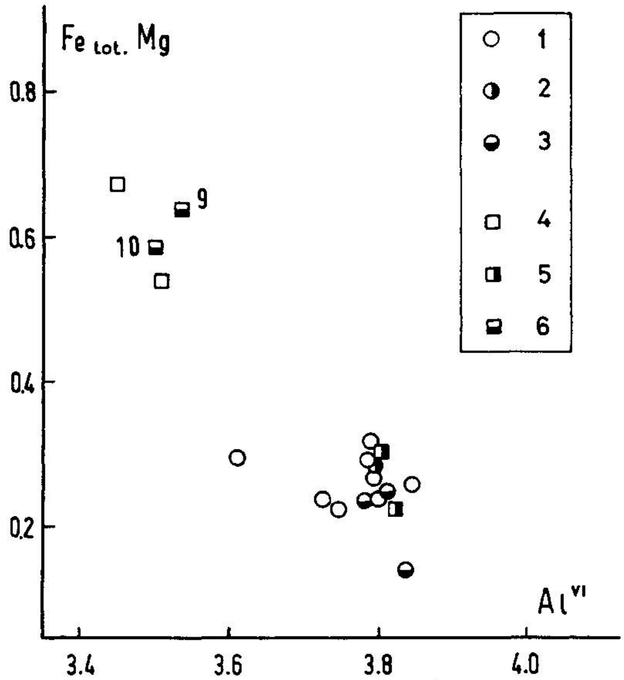

Fig. 3 Celadonitic substitution [Si(MgFe)=Al^{IV} Al^{VI}] in muscovites from margarite-bearing paragneisses. Large lamellae defining high-grade regional schistosity (1) in contact with Ky (2) and Mrg (3); retrogressional sericite after St (4), Ky (5) and Mrg (6). Numbered symbols refer to analyses listed in table 2.

The absence of plagioclase in the Ky-Mrg sites of Ulten paragneisses suggests that the growth of margarite rimming Ky was assisted by the local break-down of plagioclase, according to the closed system reaction An + Ky+ + H_2O = > Mrg + Qtz (CHATTERJEE, 1976).

On the contrary, margarite filling fractures of Ky porphyroblasts developed by open system reactions (with respect to small size local textures) which involve some mass transfer as $Ky + Ca^{2+} + 2H_2O \Rightarrow Mrg + 2H^+$.

Textural features indicate that the margarite-producing event postdates the Hercynian (or older) high-grade fabric of the Ulten paragneisses and predates the Alpine sericite and chlorite alteration products.

If margarite crystallized from kyanite in pre-Alpine times, as a late phase of the Hercynian amphibolite-facies metamorphism, the margarite+quartz-producing reaction still developed within the stability field of kyanite (CHATTERJEE, 1976; COTKIN et al., 1988) under a minimum P of 4-5 kbar and T around 500°C, similar to the estimates of FREY et al. (1978) in the Lukmanier area.

If margarite is referred to the Alpine event, which retrogressed the amphibolite-facies regional metamorphism of suggested Hercynian age (THÖNI, 1981), the physical conditions allowing its growth cannot have reached those discussed above. If Alpine, margarite developed under low-grade conditions incapable of producing a new pervasive fabric. Its growth was assisted by water activity and Ca^{++} supplying.

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