Ca–Al mica margarite – its occurrences and metamorphic significance in mica schists from the Kutná Hora Crystalline Complex

Ca–Al slída margarit – její výskyt a metamorfní význam ve svorech kutnohorského krystalinika (Czech summary)

(3 text-figs.)

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Margarite, i. e. the Ca–Al brittle white mica, has been identified in the form of inclusions in garnets from mica schists of the Micaschist Zone of the Kutná Hora Crystalline Complex (Central Bohemia). In association with other mineral inclusions like chlorite, quartz, staurolite, clinozoisite and ilmenite, it represents an older metamorphic stage of a prograde evolution of the host rocks, which took place under conditions of greenschists facies transitional to lower amphibolite facies.

Introduction

Margarite, Ca–Al white brittle mica, is not a common mineral for Variscan rocks in the Bohemian Massif. Numerous studies (Frey 1978, Frey et al. 1982, Bucher–Nurminen et al. 1983, Cotkin et al. 1988), however, show that margarite can be relatively important rock–forming mineral, as it was proposed by Winkler (1979). In detail, the occurrences of margarite are described well in rock sequences from Central Alps (Frey et al. 1982, Bucher–Nurminen et al. 1983) as a product of Tertiary Alpine metamorphism. Most frequently margarite participates in calcareous schists (metamarls) often graphitic, in general it can be present in metapelites as well as in metabasites, anorthosites and bauxites, coexisting with a variety of minerals including calcite, quartz, plagioclase, zoisite and clinozoisite, kyanite, chloritoid, garnet, corundum, dolomite, chlorite, paragonite, muscovite and biotite.

This paper is a description of margarite from numerous minute inclusions in garnets from mica schists belonging to the Kutná Hora Crystalline Complex, as well as its coexisting mineral assemblage giving an evidence about the metamorphic history of the rocks.

Geological setting and petrology of host rocks

The margarite–bearing mica schists are important rocks of the Micaschist Zone – the lowermost unit of the Kutná Hora Crystalline Complex, Central Bohemia (Synek – Oliveriová 1992), which has tectonic contact with the underlying Varied Group of the Moldanubian Zone (Fig. 1). The authors suppose that the Micaschist Zone is covered by relics of the Kouřim Nappe in the western part of the Kutná Hora Crystalline Complex and in the East underlies the Gföhl Unit.

The Micaschist Zone is formed by a monotonous sequence of metapelites intercalated by numerous bodies of amphibolites.

The metapelites appear in various forms due to the character of protolith as well as an intensity of their tectonometamorphic reworking. In general they have a character of mica schists with lepidoblastic textures.

The garnet–bearing mica schists show an obvious polymetamorphic character of the whole sequence. The common mica schist constituents are garnet, kyanite, staurolite, muscovite, biotite, plagioclase (oligoclase) and quartz, tourmaline, apatite, zircon, rutile and/or ilmenite as accessories. A younger sillimanite together with micas grew at foliation planes and in pressure shadows close to rotated granet. The youngest tectonic overprinting, operating in narrow strike–slip zones has resulted in alterations such as chloritization, muscovitization and sericitization.

The amphibolites are fine–grained rocks with banded structure, the greenish layers alternate with the blackish ones. The banding of amphibolites has evidently a tectonic origin. These rocks, in which the essential constituents are hornblende, plagioclase (bytownite to anorthite), diopside, Ca–scapolite, clinozoisite and/or epidote together with titanite, are remarkably rich in calcium.

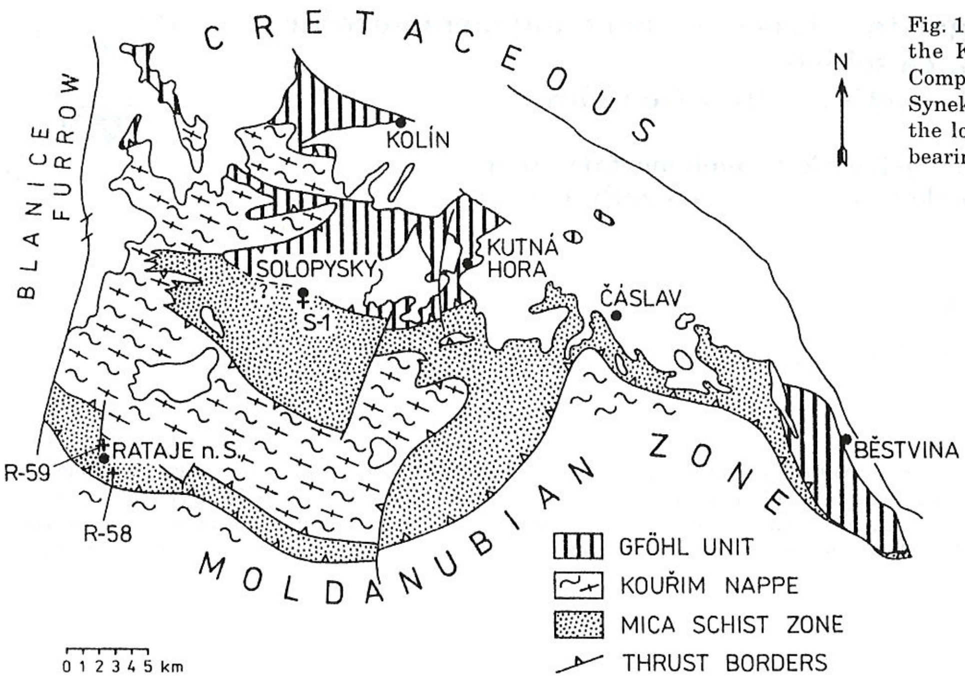

Fig. 1. Geological sketch map of the Kutná Hora Crystalline Complex (modified according to Synek – Oliveriová, 1992) with the location of the margarite-bearing mica schists *(crosses)*

The position of Margarite

Margarite forms inclusions in garnet grains (Fig. 2) from the areas near Solopysky and Rataje. The average garnets are 1–1.5 cm in size. Margarite resembles muscovite under parallel as well as crossed nicols, having only a higher relief, lower birefrigence and angle of extinction. The small subhedral scales of margarite are up to 0.5 mm in size and associate with other included minerals such as Fe-chlorite, clinozoisite, quartz, staurolite, ilmenite, tourmaline. In general the inclusions are randomly distributed and also the garnets are often well crystalographically shaped. These facts indicate that the rock was not affected tectonically very intensively during the conditions of metamorphic peak and that is the reason why the inclusions have been preserved. Margarite occurs also in garnets from mica schists cropping out in several places near Rataje. However, these rocks underwent a stronger tectonic reworking, so margarites are very rare and present only in the garnet core. These garnets include also muscovite sheets in addition to the minerals already mentioned.

Even though the occurrences of the exotic inclusions may appear minor in terms of the mineral assemblage actually forming the rock, their importance consists in their role as a document of the previous rock-forming mineral association formed during the preceeding metamorphic event (Ballevre et al. 1989, El-Shazly el al. 1991 and others).

Mineral chemistry

Margarite inclusions from three localities (S–1, R–58, R–59) were analyzed with electron microprobe JEOL JXA 50A at the Geological Institute ČSAV under the following analytical conditions: 15 kV accelerating voltage and 15–nA beam current on a 10 μm spot. Mineral formulas were calculated by means of program MINCALC written by Melín & Kunst & Machart (GLÚ ČSAV).

The margarite analyses (see Tab. 1) show variations in their Si/Al ratio (0.515–0.571), which is always higher than in the end–member margarite (0.5). The octahedral positions are occupied mainly by Al (3.91–3.97) with minor amounts of Fe (1.16–0.06) and Mg (0.02–0.04), and very small amount of Ti (0.01–0.03) and Mn (up to 0.01). In the interlayer position an appreciable amount of Ca is replaced by Na (11.5–20.5 % of paragonite end–member) but K is always low (up to 2.5 % of muscovite end–member).

When comparing the analyses from Solopysky (S–1, the central part of the Micaschist Zone) and Rataje (R–58, R–59, the Rataje zone) the greatest difference was found in the content of muscovite end–member in margarite: it represents 2–2.5 % in the Rataje Zone in contrast to 0–0.1 % in the central part. Also the paragonite end–member reaches slightly higher values in margarites from the Rataje zone.

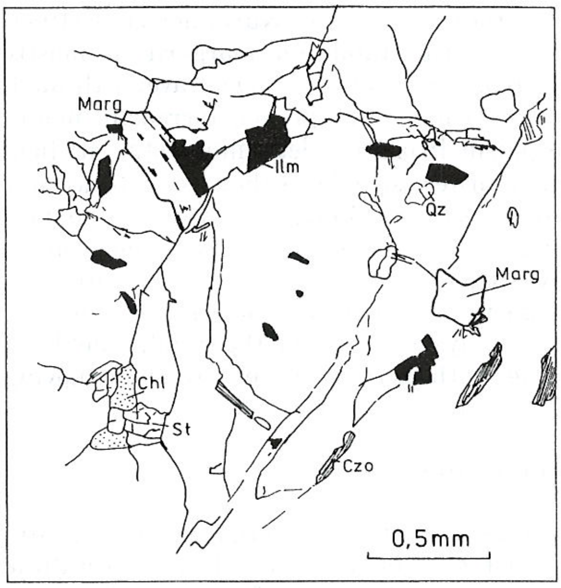

Fig. 2. a) A microscopic detail of a garnet core containing margarite with the other associated mineral inclusions.

b) A position of the inclusions–beraing garnet in surrounding matrix (locality S–1). The main foliation is underlined by kyanite, staurolite and micas, inside tectonic pressure shadows there are biotite intergrown with muscovite nearby plagioclase–quartz network

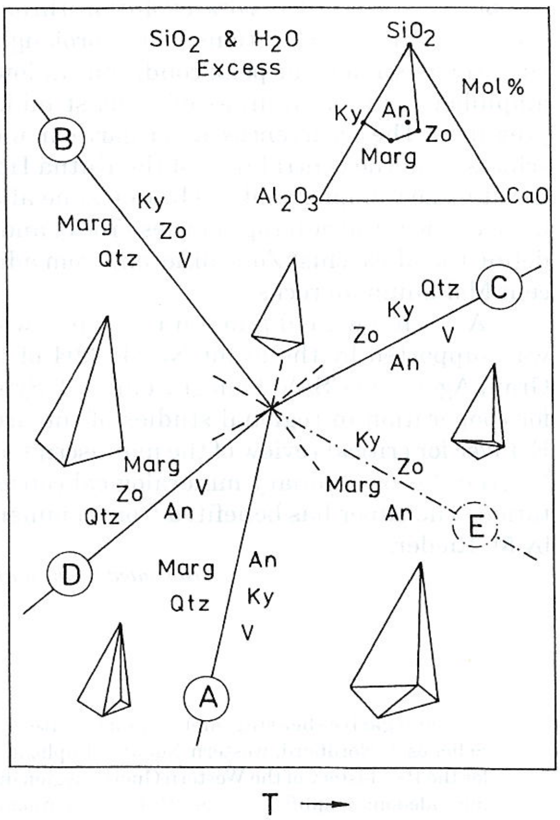

Fig. 3. Univariant curves pertinent to the stability of margarite plus quartz in the system H_2O–CaO–Al_2O_3–SiO_2 according to Storre – Nitsch (1974) and Jenkins (1984). Invariant point involves the phases anorthite (An), kyanite (Ky), margarite (Marg), zoisite (Zo) and H_2O (V). *Dash–dot* boundary is metastable in quartz (Qtz) excess system

Table 1. Representative margarite analyses and structural formulae on a basis of 22 oxygens. Analyzed at GLÚ ČSAV by A. Langrová, M. Kozumplíková and L. Thin. Total Fe is considered as FeO, H_2O is calculated

sample	S–1	S–1	S–1	R–59	R–59	R–58
SiO_2	31.20	30.33	30.29	30.47	30.80	32.56
TiO_2	0.19	0.19	0.01	0.10	0.01	0.26
Al_2O_3	49.52	49.83	49.87	48.40	48.40	48.42
FeO	0.94	0.89	0.92	1.41	1.50	0.54
MnO	–	0.01	0.01	0.07	0.13	0.10
MgO	0.16	0.20	0.11	0.21	0.22	0.17
CaO	11.55	11.66	12.27	11.16	11.20	11.13
Na_2O	1.33	1.31	0.90	1.23	1.30	1.64
K_2O	0.01	0.01	–	0.25	0.27	0.29
H_2O	4.52	4.52	4.51	4.51	4.50	4.53
Total	99.42	98.97	98.89	97.81	98.57	99.64
Si	4.16	4.07	4.07	4.15	4.16	4.33
Al IV	3.84	3.93	3.93	3.85	3.84	3.67
Σ IV	8.00	8.00	8.00	8.00	8.00	8.00
Al VI	3.95	3.96	3.97	3.92	3.92	3.91
Ti	0.02	0.02	0.00	0.01	0.01	0.03
Fe 2+	0.11	0.10	0.10	1.16	0.17	0.06
Mn	–	0.00	0.00	0.01	0.02	0.01
Mg	0.03	0.04	0.02	0.04	0.04	0.03
Σ VI	4.11	4.12	4.09	4.14	4.14	4.04
Ca	1.65	1.67	1.77	1.63	1.62	1.58
Na	0.34	0.34	0.23	0.33	0.34	0.42
K	0.00	0.00	–	0.04	0.05	0.05
Σ int	1.99	2.01	2.00	2.00	2.01	2.05
End–member molecules						
margarite	82.9	83.1	88.5	81.5	80.1	77.1
paragonite	17.1	16.9	11.5	16.5	16.9	20.5
muscovite	0.1	0.1	–	2.5	2.5	2.4

Metamorphic significance of margarite

Margarite represents a mineral, which can occur in rocks metamorphosed in PT regime of greenschist and lower amphibolite facies (Storre and Nitsch 1974, Winkler 1979, Perkins et al. 1980, Frey et al. 1982, Bucher–Nurminen et al. 1983, Jenkins 1984, Cotkin et al. 1988 and others. Under conditions of the upper amphibolite facies this mica can be stable only when the rock is undersaturated in SiO_2 (Jenkins 1984, Cotkin et al. 1988).

The stability of the mineral pair margarite + quartz in the system $CaO - Al_2O_3 - SiO_2 - H_2O$ (CASH) is the main object of studies by Storre and Nitsch (1974) and Jenkins (1984). According to them margarite + quartz can participate in the following reactions (Fig. 3):

Marg + Qtz	=	An + Ky + H_2O	(A)
Marg + Qtz	=	Ky + Zo + H_2O	(B)
Marg + Qtz + Zo	=	An + H_2O	(D)

Reaction D is limited by the absence of an Al_2SiO_5 phase. Reaction B takes place at higher pressures and lower temperatures while reaction A is restricted to the field of low to middle pressures and slightly higher (but in fact still at lower to middle values) temperatures (see Fig. 3). Reinvestigation made by Jenkins (1984) revealed dP/dT slope of the reaction B to the less steep than according to calculation of Storre and Nitsch (1974), while the determination of the reaction A in PT space was confirmed by Jenkins (1984).

Taking into account the assemblage enclosed in the garnet and comparing it with the assemblage in the matrix it is obvious that the reaction A is the most real for determination of the rock early evolution. According to Perkins et al. (1980) and Cotkin et al. (1988) this reaction can take place in pressure range approximately from 1.9 kbar to 8.2 kbar and temperatures from about 410 °C to 610 °C (the upper limits are coordinates of invariant point I).

Studies by Bucher–Nurminen et al. (1983) concerned the stability of margarite in mostly calcareous metapelites along a traverse through Alpine series with progradely increasing metamorphism. In order to determine a stability field of margarite assemblages they took into account the composition of fluid phase. According to their isobaric TX_{CO2}–phase diagrams in the systems $CaO–Al_2O_3–SiO_2$–(C–O–H) the stability of margarite is restricted to lower values of X_{CO2} (maximally 0.65 X_{CO2}) and the stability field decreases with increasing pressure while moving to higher temperatures.

Conclusions

The Ca–Al brittle mica margarite from the Micaschist Zone of the Kutná Hora Crystalline Complex probably is the first example of this mineral in the Czech part of Bohemian Massif. The margarite position i.e. inclusions inside garnet grains proves the earlier prograde evolution of the micaschists, which were suggested to be a result of a retrograde reworking of Moldanubian paragneisses (Suess 1926, Koutek 1933). The margarite–bearing assemblage documents the oldest stage of the rock evolution through greenschist facies conditions which prolongated to the metamorphic peak conditions at lower amphibolite facies in areas of at least middle pressures. The occurrences of margarite in mica schists from the central part of the Kutná Hora Crystalline Complex and the Rataje Zone allow us to connect the outcrops of these rocks and to define the Micaschist Zone different from adjacent Moldanubian rocks.

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Ca–Al slída margarit – její výskyt a metamorfní význam ve svorech kutnohorského krystalinika

Margarit, křehká světlá Ca–Al slída, byl nalezen v podobě uzavřenin v granátech metapelitů náležejících svorové zóně kutnohorského krystalinika. Vyskytuje se v asociaci s ostatními minerálními uzavřeninami. tj. chloritem, křemenem, sturolitem, klinozoisitem, ilmenitem, a dokumentuje tak starší metamorfní stadium prográdního vývoje horniny, které se odehrávalo za podmínek svrchní facie zelených břidlic na přechodu do spodní amfibolitové facie.

RECENZE

Geologie Moravy a Slezska – Sborník příspěvků k 90. výročí narození prof. Dr. Karla Zapletala. Sestavili A. Přichystal, V. Obstová a M. Suk. Vyd. Moravské zemské muzeum a sekce geologických věd PřF MU, 168 str. Brno, 1993.

Devadesáté výročí narození významného moravského geologa a zakladatele brněnské geologické školy prof. K. Zapletala se stalo vhodnou příležitostí nejen k zamyšlení nad osobností a dílem K. Zapletala (1903–1972), ale i velmi včasnou pobídkou k rekapitulaci a bilanci současných vědomostí o geologii Moravy a Slezska.

Recenzovaný sborník přináší souhrnné stati o geologii Moravy a Slezska v nevšední úplnosti. Po krátké úvodní stati o osobnosti K. Zapletala jsou příspěvky seřazeny v geologicko-chronologickém pořadí od prekambria po kvartér: v souhrnných statích je zastoupen brněnský masív (P. Mitrenga, L. Rejl), západomoravské krystalinikum (I. Stárková a kol.), silesikum (B. Koverdynský), moravské paleozoikum (J. Dvořák), vulkanismus od paleozoika po kvartér (A. Přichystal), vulkanosedimentární ložiska železných rud (J. Tomšík),metalogenetické poměry Moravy a Slezska (B. Fojt), permokarbon boskovické brázdy (L. Malý), křída Českého masívu (V. Müller), flyšové pásmo Západních Karpat, autochtoní mezozoikum a paleogén (Z. Stráník, E. Menšík, M. Eliáš, J. Adámek), karpatská předhlubeň (R. Brzobohatý, I. Cicha), vídeňská pánev (Š. Buchta), a geologický vývoj Moravy a Slezska v kvartéru (R. Musil). Stati o problémech regionálního geologického členění Moravy a Slezska (M. Suk) a o nejzajímavějších mineralogických lokalitách (M. Novák) sborník uzavírají.

Je zřejmé, že geologie Moravy a Slezska skýtá mnoho nevyřešených problémů od prekambria po kvartér, přičemž jde mnohdy o problémy zásadní (např. stáří mnohých krystalinických komplexů, styl tektonické stavby ve variscidách, poměr mezi autochtonním a allochtonním mezozoikem a terciérem, aplikace chronostratigrafických schémat v kvartéru). I když jednotlivé příspěvky ve sborníku nutně přinášejí v mnohých případech názory a koncepce ovlivněné subjektivním přístupem autorů, který bývá jinými pracovníky kritizován (to platí zvláště o některých tektonických koncepcích variscid a hodnocení stáří i stavby krystalinických jednotek), jsou přinášené souhrnné stati přehledné a obecně velmi užitečné.

Autorům i editorům se podařilo obsáhnout ve sborníku téměř všechny hlavní geologické jednotky Moravy a Slezska, a to v únosném a kvantitativně odpovídajícím rozsahu příspěvků. Z významných geologických jednotek chybí pouze bližší hodnocení Králického Sněžníku a Rychlebských hor, variských granitoidů a karbonu hornoslezské pánve. Obsah jednotlivých prací je celkově vyvážený – osobně mne nejvíce zaujaly stati o geologických problémech silesika, moravského paleozoika, vulkanismu a kvartéru, které shrnují v ucelené formě poznatky jinak rozptýlené v rozsáhlé domácí a příp. zahraniční literatuře. Totéž ovšem platí i o naprosté většině ostatních příspěvků, takže jsem přesvědčen,že sborník bude užitečný všem, kteří se zabývají nebo budou zabývat geologií Moravy a Slezska.

Srovnáme-li kvalitativní i kvantitativní úroveň poznatků o geologii Moravy a Slezska se Zapletalovou "Geologií a petrografií země Moravskoslezské" z roku 1932, máme před sebou nejen názorný příklad všestranného pokroku, ale i stále přetrvávajících problémů, řešených již řadou generací geologů (je škoda, že právě otevřené otázky většinou autoři neuvádějí, což bývá obecným znakem souhrnných spisů). Je nesporné, že realizací sborníku naplnili autoři i editoři nejlépe odkaz prof. Karla Zapletala – nejvýraznější osobnosti moravské geologie prvé poloviny 20. století.

Objednávky na knihu, vydávanou v dotisku, přijímá Katedra geologie a paleontologie, Přírodovědecká fakulta Masarykovy univerzity, Kotlářská 2, 611 37 Brno. Cena 72,– Kč je vzhledem k obsahu i rozsahu více než solidní.

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