CALCITE-ANDRADITE MICROCLINITE FROM MARKVARTICE NEAR TŘEBÍČ, WESTERN MORAVIA

KALCIT-ANDRADITOVÝ MIKROKLINIT Z MARKVARTIC U TŘEBÍČE NA ZÁPADNÍ MORAVĚ

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Abstract

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In the paper submitted, the basic geological, petrological and mineralogical data about calcite-andradite microclinites at Markvartice are presented. These rocks are a part of the Varied Group of the Moravian Moldanubicum and originated by metasomatism of gneisses and marbles along the tectonic line of the E-W direction.

Key words: metasomatite, microcline, andradite, calcite, alkali-feldspar gneiss, tectonic line, Moldanubicum, Czechoslovakia.

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Introduction

In the broader vicinity of Markvartice, alkali-feldspar leucocratic gneisses with calcite-andradite microclinites occur in the Varied Group of the Moravian Moldanubicum. Outcrops and rare isolated blocks of these rocks can be found in the forested terrain north of Markvartice in the vicinity of the Kopec Hill (541 m). Alkali-feldspar gneisses without calcite and alkali-feldspar syenite are exposed in quarries on the Markvartice Hill (607 m) and SW of Čechočovice. In the hitherto geological maps, these rocks are termed leucocratic granites.

Geological situation

The region studied is included in the Varied Group of the Moravian Moldanubicum. In the territory depicted in fig. 1, the prevailing rocks are biotite paragneisses. They are more or less affected by migmatization and pass into leucocratic gneisses with garnet and sillimanite or into cordierite migmatites. Marbles, which chemical composition varies from calcite marbles to dolomites, are significantly represented in gneisses. The intercalations of marbles are up to 20 metres thick and are penetrated by pegmatite dikes. Their contact effects on marbles are insignificant and they are manifested only by narrow rims of diopside and titanite. In pegmatites K-feldspar predominates over plagioclase. Irregular impregnations of magnetite accompanied by small amount of amphibole and epidote and nests of chalcopyrite, chalcosine, and bornite have been found already sooner in marbles on the Bílá hora Hill (Burkart 1953, Houzar 1984). The characteristic minerals in dolomitic marbles are spinel, forsterite and phlogopite. In gneisses are frequent also intercalations of pyroxene gneisses and amphibole-pyroxene gneisses passing into amphibolites. Low representations shows quartzite and graphitic quartzite. Alkali-feldspar in the quarries on the Markvartice Hill show locally massive structure and have been provisionally termed alkali-feldspar syenites (H o u z a r 1986). The prevailing rocks of this type is, however, banded leucocratic gneiss in which K-feldspar bands alternate with thin quartz or magnetite-quartz bands. In this alkali-feldspar gneiss bands and nests of andradite and calcite occur.

Magmatic rocks are represented predominately by small bodies of muscovite-biotite granites with preferred orientation (e. g. quarry WNW from Bílá hora) or by dikes turmaline-muscovite granites. Rare are dikes of alkali microsyenites (N ě m e c 1988) and diorite porphyrites. Smaller dikes of andradite pegmatites are encountered in alkali-feldspar gneisses, pyroxene pegmatites with titanite are encourtered in marbles and pegmatite with turmaline and andalusite in biotite gneisses.

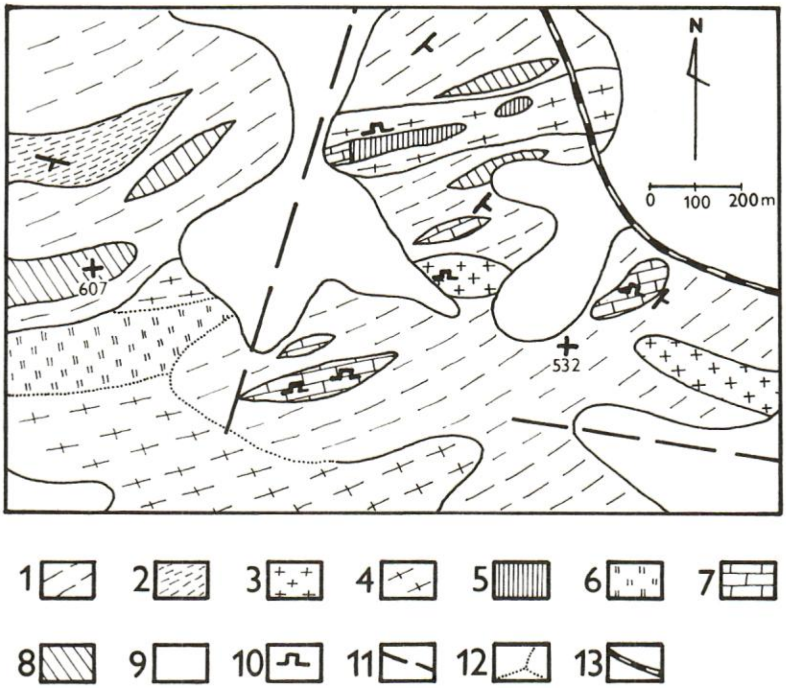

Fig. 1. Schematic map showing the area 0.5 km north of Markvartice
Obr. 1. Schematická mapa oblasti 0,5 km severně od Markvartic

1 – biotite to sillimanite-biotite gneiss, biotitická až sillimaniticko-biotitická rula, 2 – leucocratic garnet gneiss, leukokratní granátická rula, 3 – granite, granit, 4 – alkali-feldspar gneiss, alkalicko-živcová rula, 5 – calcite-andradite microclinite, kalcit-andraditový mikroklinit, 6 – alkali-feldspar syenite, alkalicko-živcový syenit, 7 – marble, mramor, 8 – pyroxene gneiss to amphibolite, pyroxenická rula až amfibolit, 9 – quaternary sediment, kvartérní sediment, 10 – quarry, lom, 11 – tectonic line, tektonická linie, 12 – rock border-approximately, předpokládaná hranice hornin, 13 – railroad, železnice.

The strike of foliation as well as of stretching of varied intercalations is mostly to the ENE-WSW with flat dip (up to 10°) to SSE. The strike in the eastern part of the territory turn even to NE and the dip is as much as 35° to SE. Among main tectonic lines predominates the NNE-SSW and E-W direction often with steep dip. The E-W direction is manifested also in geomorphology. It can represent a surface manifestation of the conspicuous tectonic line in the continuation of the Třebíč Fault which was active from the Paleozoic to the Tertiary (B l í ž k o v s k ý e t a l. 1988, B a t í k a n d D o r n i č 1984, V a c e k e t a l. 1983, W e i s s 1977).

Sedimentary rocks are predominately of the Quaternary age. Deluvial and deluviofluvial loamy and sandy sediments rarely with quartz pebbles predominate. Locally Tertiary ferrolites and residual clays with nontronite and opal occur as well.

Petrography and Mineralogy

The studied body of alkali-feldspar gneisses with calcite-andradite microclinites runs in the E-W direction between the railroad and smaller valley west of the Kopec Hill. The mineral association with calcite occurs in the western part of the body (fig. 1).

Rocks can be divided in four basic types:

1. Alkali-feldspar gneiss with magnetite.
2. Andradite pegmatite.
3. Andradite microclinite with calcite.
4. Calcite microclinite with andradite, pyroxene and amphibole.

Alkali-feldspar gneiss with magnetite

This rocks forms several structural varieties. The pinkish syenite with massive structure is found least of all. It occurs except the mentioned occurence on the Markvartice Hill only rarely. It is fine-grained to medium grained, composed of K-feldspar and small amount of quartz, biotite and magnetite (Houzar 1986). In fissures are found small needles of bluish green amphibole and grains of martitized magnetite. In one place, the enclave of biotite granite was found in syenite. The remaining structural varieties are marked by banded structure of alternating pinkish medium grained bands of the K-feldspar with low contents of biotite and magnetite and grey bands of quartz with magnetite. The content of magnetite in quartz bands is up to 30 %. Larger magnetite grains are encountered also in fissures. According to the spectral analyses, it is magnetite of common chemistry with low content of Zn, Mn, Ti, Cu. In comparison with magnetites of West Moravian skarns (Němec 1968) it is comparatively poorer especially in Sn. Distinct varieties of gneisses differ mainly in the ratio of bands with different mineral assemblage. On the whole, however, feldspar bands predominate.

K-feldspar forms isometric grains 1 to 2 mm in size, including zircon, apatite and biotite. It is perthitic microcline ($\Delta = 0.86$) and orthoclase and a part of grains shows microcline reticulation. It is exceptionally replaced from margins by muscovite. Quartz forms elongated to isometric grains with undulating extinction, concentrated usually in isolated elongated aggregates and bands with magnetite. Magnetite in this bands is opaque and sometimes transformed in hematite. Magnetite in K-feldspar parts forms isometric to lobate grains (see photo 1) from 0.3 to 2 mm in size and occurs together with quartz. It replaces rarely biotite and penetrates even in feldspar grains. Biotite forms sporadic oriented flakes with pleochroism X – light brown, Y = Z – yellowish brown. In rocks it is preserved only in insignificant relicts. Sporadic amphibole forms deformed greyish green needles or fills small fissures. Apatite grains are isometric or shortly columnar up to 1 mm in size, in the same way as rarer zircon, titanite and epidote.

Andradite pegmatite

Dikes of the quartz-feldspar pegmatite with garnet corresponding to grossular-andradite are exposed in the middle and in the eastern part of the body of alkali-feldspar gneisses. The thickness of dikes as well as of irregular nests reaches up to 1 m but usually they are decimetre-thick. Pegmatites show a simple zonal structure. The majority of dikes is formed by medium-grained to coarse-grained pegmatite consisting of K-feldspar and quartz. The margins are occupied graphic pegmatite. Andradite occurs predominately in the block zone where it forms centimetre-sized crystals (combination of 211 and 210). Fine grains are also in graphic pegmatite. Among other minerals were found only accessoric amounts of titanite and zircon. Epidote occurs in fissures.

Table 1. Microprobe analyses of garnets, epidote and titanite
Tabulka 1. Mikrosondové analýzy granátů, epidotu a titanitu

	Garnet 1	Garnet 2	Garnet 3	Epidote	Titanite
SiO_2	36.51	37.35	36.57	38.92	30.51
TiO_2	0.94	0.76	1.07	0.04	33.43
Al_2O_3	7.15	5.36	7.04	24.33	2.37
Fe_2O_3	21.04	23.64	20.95	12.69	1.97
FeO	0.67	0.00	0.59	–	–
MnO	0.17	0.03	0.93	0.00	0.00
MgO	0.17	0.17	0.17	0.00	0.00
CaO	33.09	33.76	32.12	23.48	28.27
Na_2O	0.00	0.01	0.01	0.01	0.02
K_2O	0.00	0.00	0.00	0.00	0.00
Σ	99.74	101.08	99.35	99.47	96.57
	12 O	12 O	12 O	12.5 O	5 O
Si	2.980	3.019	2.994	3.033	1.031
Ti	0.058	0.046	0.066	0.002	0.849
Al	0.687	0.511	0.679	2.235	0.094
Fe^{3+}	1.291	1.438	1.291	0.744	0.050
Fe^{2+}	0.046	0.000	0.040	–	–
Mn	0.012	0.002	0.064	0.000	0.000
Mg	0.021	0.020	0.008	0.000	0.000
Ca	2.891	2.924	2.818	1.960	1.023
Na	0.000	0.002	0.002	0.002	0.001
K	0.000	0.000	0.000	0.000	0.000

Fe calculated according to Fejdi (1982)
Fe rozpočítáno podle Fejdi (1982)

Microscopically, perthitic K-feldspar with microcline reticulation alongside of quartz prevails. The margins of grains use to be crushed and recrystallized because of tectonic influences. The texture varies from hypidiomorphic to mortar and graphic. In the graphic pegmatite, separate ichtyoglypts of quartz are composed of fine quartz grains with different optic orientation. Dark brown andradite is idiomorphic to hypidiomorphic, includes quartz grains and it is replaced by epidote. Some larger grains show dark centre and lighter margins. The chemical composition corresponds to andradite with 30 % of grossular and 2 % pyralspite (tab. 1). Crystals of titanite and short columns of zircon are accessoric. The andradite pegmatite resembles the corundum pegmatite from neighbouring Pokojovice, considering the simple mineral assemblage and especially the absence of plagioclase. The presence of Ca-garnet is unusual in the pegmatites of this type (cf. Černý 1971, Novák et al. 1985).

Andradite microclinite with calcite

This rocks forms a larger part of the body and its boundary against alkali-feldspar gneiss with magnetite is not sharp. At the margin, magnetite-quartz bands are substituted by andradite ones and the rock structure is preserved. Closer to the centre, calcite and andradite occurs and the structure changes up to massive one. Andradite microclinite is pinkish with brown aggregates of andradite and yellowish green epidote. The part rich in K-feldspar are fine grained, the andradite ones coarse-grained. A part of andradite forms also veins.

Table 1. (contd.) Microprobe analyses of amphibole and pyroxenes
Tabulka 1. (pokračování) Mikrosondové analýzy amfibolu a pyroxenů

	Amphibole	Pyroxene	Pyroxene	Pyroxene	Pyroxene
SiO_2	43.01	50.70	49.58	50.37	50.29
TiO_2	0.58	0.10	0.06	0.09	0.07
Al_2O_3	9.46	0.95	1.93	1.12	0.97
FeO^{tot}	23.57	16.10	15.27	15.65	16.76
MnO	0.17	0.09	0.12	0.11	0.23
MgO	6.99	8.35	8.54	8.58	7.84
CaO	10.23	23.17	23.10	22.97	22.79
Na_2O	2.44	0.42	0.56	0.32	0.33
K_2O	1.81	0.07	0.02	–	0.02
Σ	98.26	99.95	99.18	99.21	99.30
	23 O	6 O	6 O	6 O	6 O
Si	6.667	1.97	1.937	1.966	1.972
Ti	0.068	0.003	0.002	0.003	0.002
Al	1.728	0.044	0.089	0.052	0.045
Fe^{2+}	3.053	0.520	0.499	0.511	0.549
Mn	0.022	0.033	0.004	0.004	0.008
Mg	1.615	0.484	0.497	0.499	0.458
Ca	1.669	0.965	0.967	0.960	0.957
Na	0.733	0.032	0.042	0.024	0.025
K	0.358	0.003	0.001	–	0.001

total FeO – všechno Fe jako FeO

Explanation of table 1.
Vysvětlivky k tabulce 1.

Garnet 1 and 2 are from andradite microclinite and garnet 3 from pegmatite. The other minerals are from calcite microclinite.

Granát 1 a 2 pochází z andraditového mikroklinitu, granát 3 z pegmatitu a ostatní minerály z kalcitického mikroklinitu.

X-ray microanalyser JEOL JXA – 50A, analyst O. Navrátil, A. Langrová, V. Šrein. Accelerating voltage 15 kV, sample current 20 nA, Standards: Al_2O_3 (Al), Fe_2O_3 (Fe), Mn_3O_4 (Mn), SiO_2 (Si), TiO_2 (Ti), MgO (Mg), diopside (Ca), jadeite (Na), leucite (K). Results were corrected using the ZAF program (O. Navrátil, unpublished).

Elektronová mikrosonda JEOL JXA – 50A, analyzovali O. Navrátil, A. Langrová, V. Šrein. Pracovní napětí 15 kV, proud na vzorku 20 nA, standardy: Al_2O_3 pro Al, Fe_2O_3 pro Fe, Mn_3O_4 pro Mn, SiO_2 pro Si, TiO_2 pro Ti, MgO pro Mg, diopsid pro Ca, jadeit pro Na, leucit pro K. Výsledky byly korigovány podle programu ZAF (O. Navrátil, nepublikováno).

Microscopically, the rocks consist of K-feldspar, andradite and titanite. Among secondary and accessoric minerals was found calcite, epidote, quartz, magnetite and amphibole. In the X-ray diffraction, K-feldspar was determined as microcline ($\Delta = 87$) and partly as orthoclase. It forms perthitic hypidiomorphic grains with medium size of 0.5 mm. Some feldspars are kaolinized. Andradite with higher grossular content (about 30 %) is of two types. The prevailing andradite with 33 % of grossular and 2.6 % of pyralspite forms grain aggregates of millimetre up to centimetre size arranged in distinctly folded bands. According to spectral analysis, andradite contains 0.X % of Zr. The second type of andradite is found in younger veinlets and is frequently accompanied by epidote. In thin sections both garnets are brown and greenish brown and evidently younger than feldspar, sometimes, however, the mutual relationship is not much clear. Frequently are garnets poikilitically inter-

Table 2. Chemical analyses of the rocks
Tabulka 2. Chemické analýzy hornin

	1	2	3	4	5
	wt %				
SiO_2	61.40	64.10	46.04	41.13	60.96
TiO_2	0.34	0.33	0.30	0.24	0.21
Al_2O_3	16.19	15.67	12.15	10.95	11.28
Fe_2O_3	1.66	3.23	3.70	3.17	4.22
FeO	0.40	0.06	0.72	0.69	0.44
MnO	0.02	0.01	0.04	0.04	0.15
CaO	2.55	0.58	16.28	19.95	10.83
MgO	0.69	0.30	0.51	0.54	0.36
K_2O	14.06	13.51	9.26	8.71	6.74
Na_2O	0.74	1.13	0.73	0.54	0.67
P_2O_5	0.08	0.03	0.07	0.05	0.03
H_2O^+	0.29	0.37	0.32	0.81	0.22
CO_2^*	1.49	0.71	9.77	13.44	3.39
H_2O^-	0.07	0.11	0.08	0.09	0.06
Σ	99.98	100.14	99.97	100.35	99.56
	ppm				
B	27	52	16	24	51
Ba	397	492	418	386	150
Cr	19	15	8	24	50
Cu	7	5	9	6	<5
Mo	<1	<1	<1	<1	<1
Sr	24	21	77	83	52
V	10	22	17	19	25
Zn	27	50	69	51	13
Zr	216	206	159	142	59

Explanation of table 2.
Vysvětlivky k tabulce 2.

1 – alkali-feldspar gneiss with thin layers of andradite, alkalicko-živcová rula s tenkými proužky andraditu, 2 – medium-grained alkali-feldspar gneiss with magnetite, středně zrnitá alkalicko-živcová rula s magnetitem, 3 – coarse-grained calcite-andradite microclinite, hrubozrnný kalcit-andraditový mikroklinit, 4 – calcite microclinite with andradite, kalcitický mikroklinit s andraditem, 5 – coarse-grained andradite pegmatite, hrubozrnný andraditový pegmatit.

* loss of heating – ztráta žíháním

Analyst: Ing. Jílková's team, Unigeo, Brno
Analyzoval: skupina ing. Jílkové, Unigeo, Brno

grown with microcline and magnetite. Some lighter coloured garnets have anomalous birefrigence. Titanite forms fine isometric grains about 0.1 mm in size which are concentrated in elongated spindle-like millimetre sized aggregates (photo 3). The chemistry of titanite does not differ from titanite of pyroxene gneisses or diffusive Ca-skarns (cf. Novák et al., in press). Calcite occurs in fine-grained aggregates including microcline grains. It is macled without more pronounced plastic deformation and andradite grains use to be along the junction with magnetite and quartz. Epidote occurs in millimetre-sized grains with strong pleochroism (yellow to yellowish green). In fissures it forms up to centimetre crystals sometimes overgrowing on andradite. Quartz occurs in fine grains together with opaque grains of magnetite. Chemical analyses of minerals and rocks are presented in tab. 1 and 2.

Calcite microclinite with andradite, pyroxene and amphibole

This rocks originates by gradual increase of calcite content from andradite microclinite. In typical samples, it is composed of microcline and calcite. Their mutual ratio varies, calcite can reach up to 30 %. Coarse-grained andradite and fine grains of pyroxene and amphibole are always present. The rock is pinkish with greenish and brown streaks of Ca-silicates and grey and orange spots of calcite. The structure is plane-parallel up to massive and rock is strongly folded.

Microcline (Δ = 0.92) and orthoclase forms nearly idiomorphic grains about 1 mm in size. Calcite is macled and its grains are only weakly plastically deformed. They are up centimetre-size and include grains of microcline. According to the spectral analyses, it is pure calcite in which content of Mg, Fe and Mn varies in thousandth of percent. Calcite shows low content of Mg and Sr in comparison with marbles. Andradite differs neither in chemistry nor shape from andradite described in andradite microclinite. Its regularly shaped grains include calcite and microcline and veinlets of andradite penetrate along the boundaries of grains into the neighbouring microclinite. Epidote, which together with quartz fills fine fis-

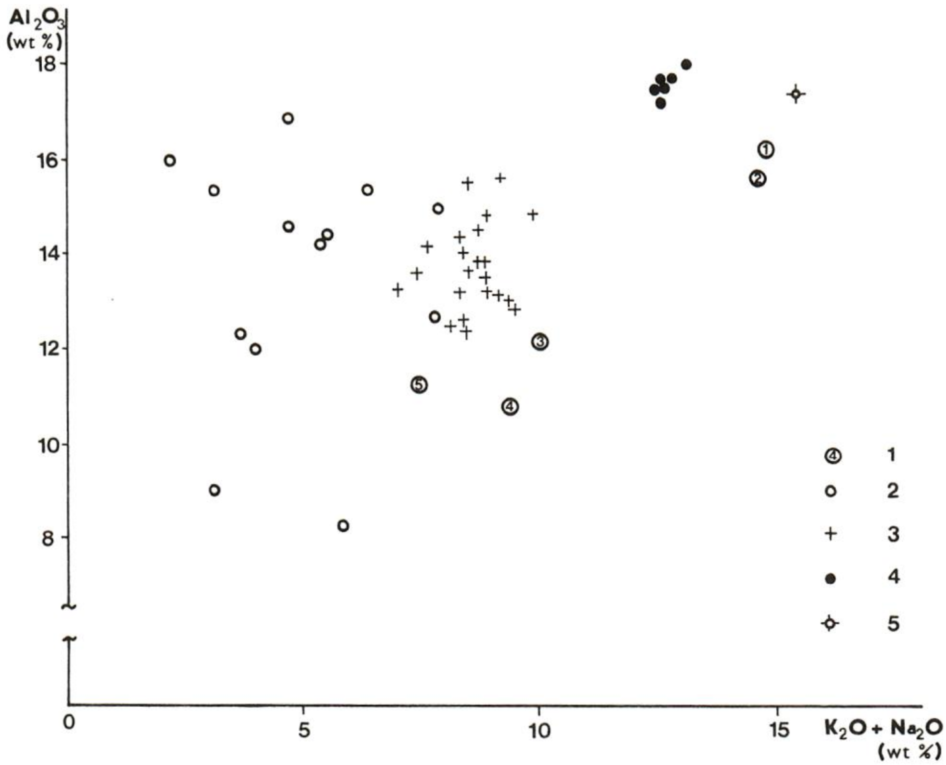

Fig. 2. Diagram showing Al_2O_3–K_2O+Na_2O ratio in the rocks of the western part of the Moravian Moldanubicum

Obr. 2. Diagram vztahu Al_2O_3–K_2O+Na_2O v horninách západní části moravského moldanubika

1 – Markvartice, Markvartice, 2 – metamorphites, metamorfity, 3 – granite and aplite, granity a aplity, 4 – alkali-syenite from Naloučany, alkalický syenit z Naloučan, 5 – alkali-feldspar syenite from Markvartice, alkalicko-živcový syenit z Markvartic

(with data of M. Novák, Hájek and Luna 1972, Weiss 1974, Houzar 1986. These symbols are used in figures 3 and 4.)

(s údaji M. Nováka, Hájka–Luny 1972, Weisse 1974, Houzara 1986. Tyto symboly jsou použity v obrázcích 3 a 4.)

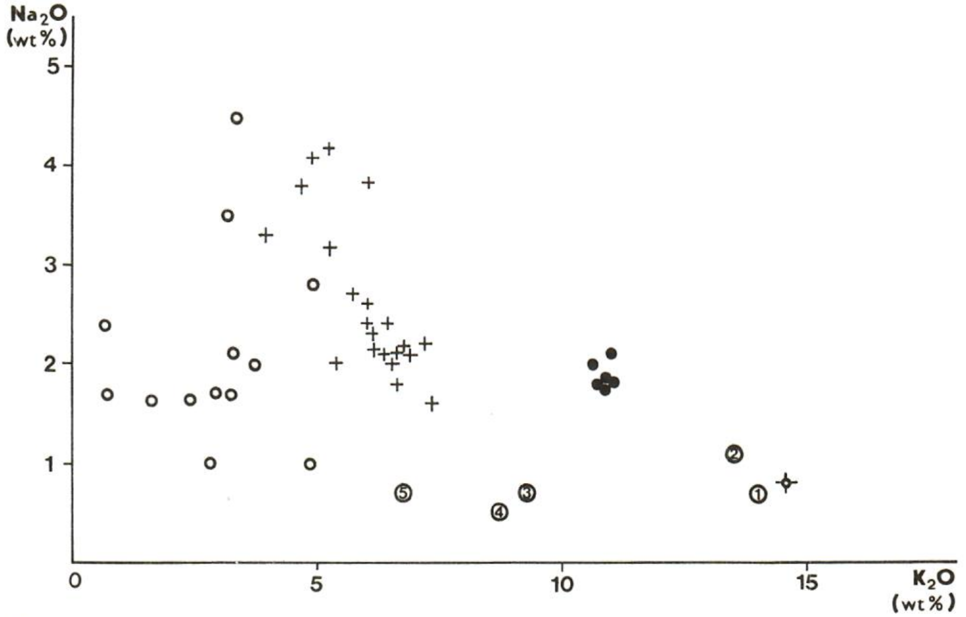

Fig. 3. Diagram showing Na_2O–K_2O ratio in the selected rocks of the western part of the Moravian Moldanubicum

Obr. 3. Diagram vztahu Na_2O–K_2O ve vybraných horninách západní části moravského moldanubika

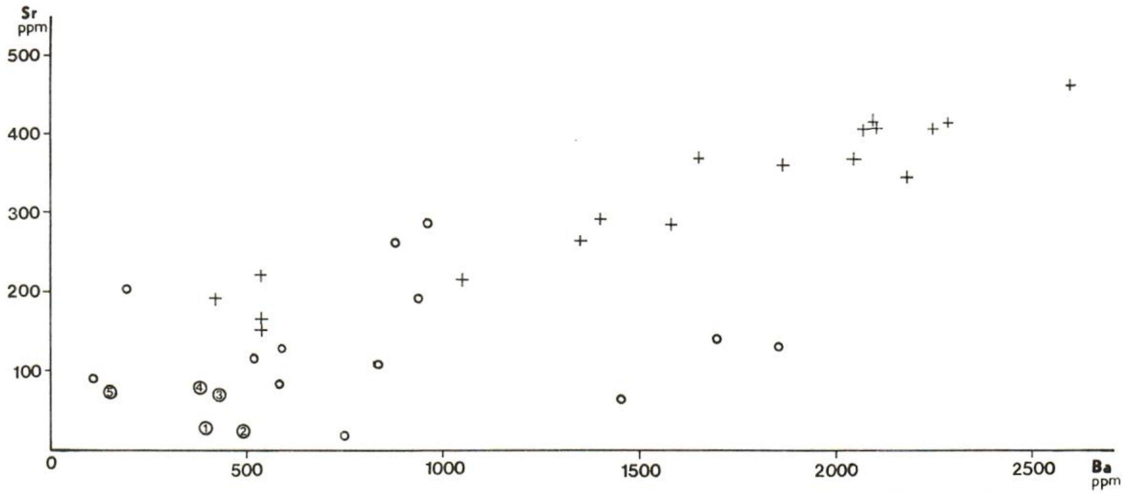

Fig. 4. Diagram showing Sr–Ba ratio in the selected rocks of the western part of the Moravian Moldanubicum

Obr. 4. Diagram vztahu Sr–Ba ve vybraných horninách západní části moravského moldanubika

sures, is the youngest mineral. Pyroxene (Di_{46-50}) is green and is only weakly pleochroic. It forms up to xenomorphic grains and together with amphibole rims magnetite along its contact with microcline (photo 2). Amphibole occurs in elongated hypidiomorphic grains. They are about 0.5 mm in size and are pleochroic (X – greenish, Y – yellow green, Z – bluish green). Accessoric titanite and magnetite are included in older minerals. The exposure of the contact of calcite microclinite with marble in the westernmost margin of the body is significant for genetical considerations. Marble is white, fine-grained and beside calcite it contains minor amount of amphibole, diopside and titanite, exceptionally wollastonite.

Chemistry of rocks

The chemistry of all types of rocks is given in table 2. Some results of the comparison of microclinites from Markvartice with metamorphites and magmatites of the western part of the Moravian Moldanubicum analysed for the geochemical map 1 : 50 000 Třebíč (written communication of M. Novák) are presented in fig. 2 to 4.

From the data follows that the microclinites from Markvartice, in contrast to these rocks, show the higher content of K_2O and lower of MgO comparable e. g. with the alkali syenites from Naloučany near Náměšť nad Oslavou described by Hájek and Luna (1972) and Weiss (1974). They differ, however, from these rocks in the significantly lower content of Zr which content in alkali syenite at Naloučany can reach up to X000 ppm (oral communication of L. Rejl). When comparing microclinites with neighbouring rocks, the high Fe^{3+}/Fe^{2+} ratio and higher content of B is particularly conspicuous. Similar alkali gneisses described in some world localities (e. g. Floor 1974) differ again in the higher Na_2/K_2O ratio.

From the genetic point of view, the origin of microclinites required apparently only K_2O addition. The content of Fe can be primary, only the oxidation degree increased. Calcium has an independent position which generally does not show a positive correlation with other elementes with exception of Sr. The low number of analyses allows neither the more detailed discussion of chemistry nor of the primary rock. The chemistry together with further kvowledge is, however, in agreement with assumption that the primary rock (protolite) could be a leucocratic biotite gneiss or a specific sediment rich in Fe with variable content of carbonates. In the first case, it is necessary to accout mainly for the Mg removal, in the second case, for the addition of K_2O, B and partly Al_2O_3. The content of MgO is namely an order lower than in gneisses as well as in neighbouring granitoids the content of B is lower.

Discussion

In the discussion of the genesis of calcite-andradite microclinites we can proceed from following data:

a) Microclinites occur within the area by common marble bodies.
b) They are found to a narrow area in the western continuation of the Třebíč Fault.
c) Microclinites form unconformably lying nests and bands in alkali-feldspar gneisses with magnetite.
d) In microclinites, dikes of andradite pegmatite appear.
e) The wider vicinity of microclinites is characterized by rocks which are not known from other localities of the Moravian Moldanubicum – corundum pegmatite, K-rich amphibolites (Pokojovice), fine-grained pink marbles with epidote and andradite (Pokojovice, Hvězdoňovice, Chlístov).
f) The mineral assemblages of microclinites as well as of alkali-feldspar gneisses consists of minerals stable in an environment of higher fugacity of O_2.
g) The chemistry of microclinites differs from neighbouring rocks in the higher content of K_2O, in the predominance of Fe_2O_3 over FeO and in the lower content of MgO and Na_2O.
h) The content of trace elements corresponds to the neighbouring metamorphites.

The microclinites as well as alkali-feldspar gneiss with magnetite are significant by simple mineral assemblages. Based on the thin section studies as well as on the field survey, the following succession of associations is apparent: 1. quartz + microcline + magnetite + biotite, 2. quartz + microcline + calcite + magnetite, 3. microcline + magnetite + pyroxene

+ titanite, 4. microcline + calcite + andradite, 5. calcite + epidote + amphibole + hematite.

The mentioned mineral assemblages are characteristic for the environment of increased alkalinity and high 0_2 fugacity (Bea 1980, Koržinskij 1945, 1955, 1962, Rutherford 1969, 1973, Wones and Eugster 1965). In such environment the reaction: biotite + O_2 = K-feldspar + MgFe-silicates (or oxides) occurs. Titanite and pyroxene are counted among older minerals and they do not require so high fugacity as younger andradite (Burton et al. 1982). Andradite garnet is typical of contact skarns with higher fugacity O_2 and P_{total} lower than 300 MPa. Even though the increasing proportion of grossular component widens the field of its stability towards reducing conditions and lower X_{CO_2} (Gordon and Greenwood 1971, Gustafson 1974, Liou 1974, Mueller 1973, Taylor and Liou 1978) it is usually absent in metamorphosed Fe-rich sedimentes. The higher O_2 fugacity is also suitable for the origin of epidote (Holdaway 1972).

The origin of calcite-andradite microclinites can be explained in two ways which require metasomatic changes.

1. In the first case, they can represent oxidic metaferrolites affected by metamorphic differentation and microclinization. The starting educt then should be quartz-magnetite-hematite banded rocks with smaller bodies of pure carbonates. Also Fe-carbonates could be present. Such rocks have been described from the Moravian Moldanubicum by Koutek (1925) from Jakubov and by Veselá et al. (1988) from Brtnice. This kind of genesis would require the import of K_2O and perhaps Al_2O_3 and obviously the removal of MnO and P_2O_5. This view is contradicted by the fact that calcite-andradite microclinites and perhaps also alkali-feldspar gneisses does not concordant with neighbouring metamorphites. This data, however, should be tested by drilling survey.

2. The hitherto researches suggest rather a second possibility of origin. The biotite gneiss or leucocratic gneiss with small intercalations of calcite marble was the initial rock. The widespread migration of fluids and the transformation of gneiss into microclinite could take place along the E-W tectonic line. The activity of these lines in the Moravian Moldanubicum is proved by Late Paleozoic intrusions of alkali-feldspar dike granites with turmaline as well as by dikes alkali microsyenites (Kalášek 1954, Němec 1988). These rocks are cropping out mainly south and west of the Třebíč Fault and occur in the southern and eastern neighbourhood of the microclinites at Markvartice as well.

According to this view, a migration of fluids rich in K_2O into gneisses occured under conditions of increasing oxygen fugacity. Locally, the mobilization of $CaCO_3$ from neighbouring marbles can be considered. The influence of marbles could be reflected in the increase of the O_2 fugacity as some authors consider CO_2 from marbles as oxidation agent in reactions with H_2O (Nockleberg 1973, Gustafson 1974). The presence of CO_2 could influence also instability of plagioclases, absence of which in the calcite microclinite is remarkable (cf. Rock 1976). Some authors already has drawn the attention to the microclinization and migration of alkali in the neighbourhood of marbles (cf. Koržinskij 1955, Šabynin 1973) and there exist the same evidence even from the Moravian and Strážek Moldanubicum (Houzar 1985, Novák 1988). The direct relations between formation of Ca-skarn and microclinization of calc-silicate rocks in Brno Massif was proved by Novák (1979).

The rocks at Markvartice are in their mineral assemblages as well as in their genetic appearance significantly similar to the so-called metasomatites of the quartz-feldspar formation which was described by Rudnik et al. (1970). These metasomatites are limited to tectonic lines and they originate from gneisses under conditions of the amphibolite facies. Beside feldspars (orthoclase, microcline, plagioclase) and quartz, they contain sometimes calcite, andradite garnet, alkali amphiboles, sillimanite and further minerals. The temperature under which these metasomatites originated ranges from 400 °C to 550 °C.

Beside further geochemical and petrological researches the finds of comparable rocks in other parts of the Moldanubicum are necessary for a more thorough knowledge of the genesis of microclinites from Markvartice.

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SOUHRN

V severním okolí Markvartic u Třebíče se vyskytují v pararulách pestré skupiny moldanubika leukokratní ruly s kalcit-andraditovými mikroklinity. Petrograficky byly vyčleněny alkalicko-živcové ruly s magnetitem, andraditové pegmatity, andraditové mikroklinity s kalcitem a kalcitické mikroklinity s andraditem, pyroxenem a amfibolem. Nejrozšířenější horninou je rula tvořená draselným živcem (mikroklin i ortoklas), křemenem a malým množstvím biotitu, obsahující pásky křemene s magnetitem. Vzácněji přechází v drobnozrnnou horninu s všesměrnou texturou, odpovídající alkalicko-živcovému syenitu. V rule jsou nekonformně uloženy kalcit-andraditové mikroklinity. Jsou tvořeny mikroklinem, andraditem a kalcitem. V malém množství je obsažen pyroxen (železnatý diopsid až hořečnatý hedenbergit), amfibol, titanit a epidot. Mikroklinity jsou doprovázeny žílami a hnízdy pegmatitů s andraditem. Geologická pozice mikroklinitů nasvědčuje jejich metasomatickému vzniku z rul vlivem přínosu K_2O v tektonicky exponované zóně v západním pokračování třebíčského zlomu. Tato přeměna probíhala v prostředí s vyšší fugacitou kyslíku a lokálně došlo i k mobilizaci $CaCO_3$ z blízkých mramorů. Přestože nelze zcela vyloučit možnost vzniku těchto hornin metamorfózou specifických Fe bohatých sedimentů, dosavadní poznatky ukazují na neobyčejnou podobnost mikroklinitů od Markvartic s metasomatity křemen-živcové formace, které popsali Rudnik et al. (1970) z tektonických zón v metamorfitech amfibolitové facie.

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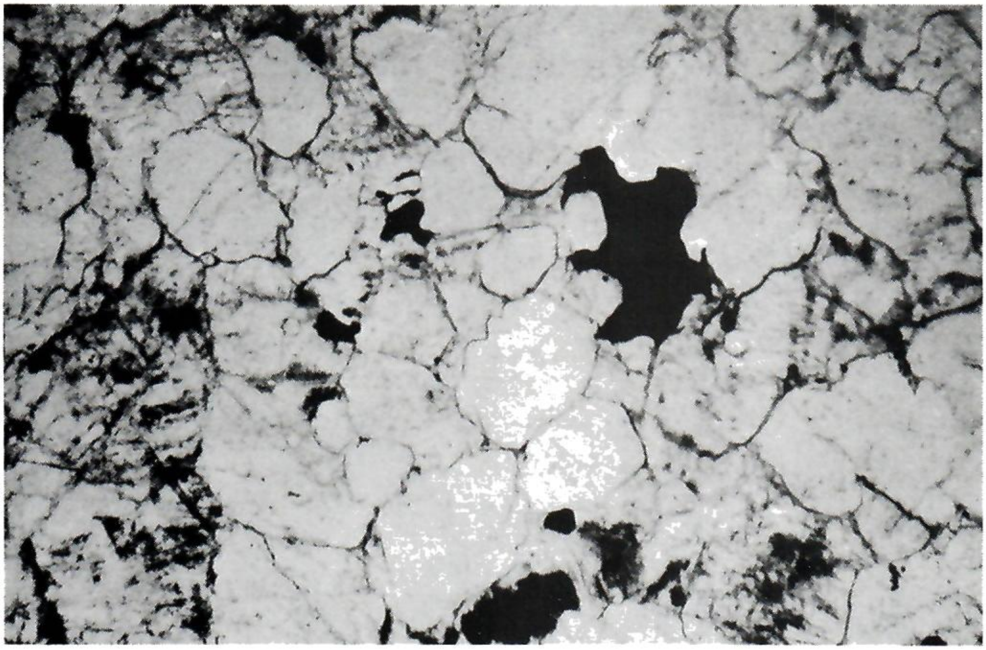

Photo 1. Magnetite (black) in alkali-feldspar gneiss, nicols parallel, magn. 25×
Foto 1. Magnetit (černý) v alkalicko-živcové rule, rovnoběžné nikoly, zvětšení 25×

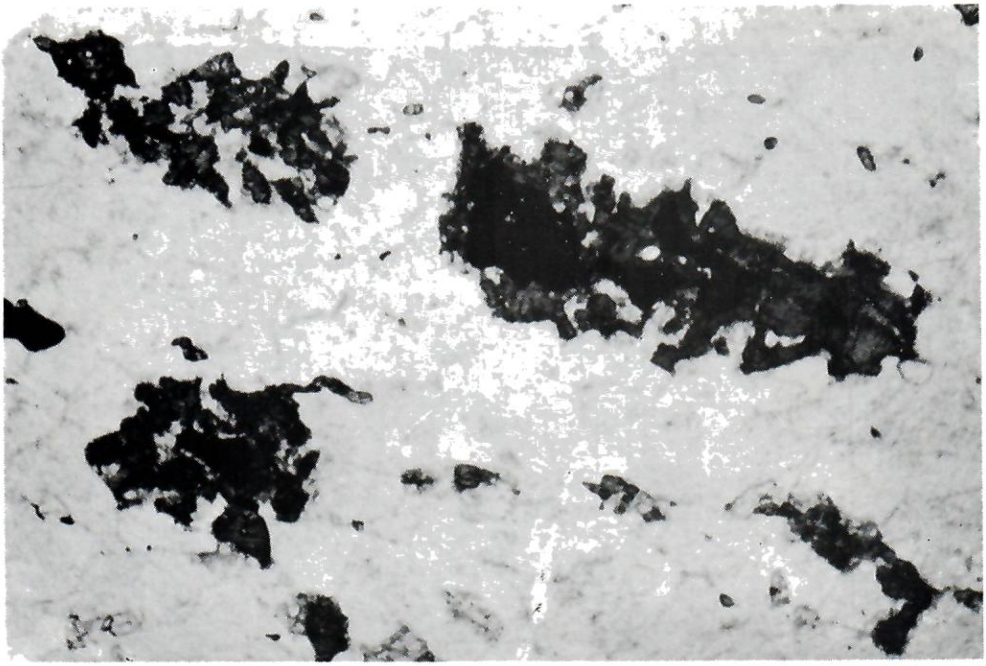

Photo 2. Magnetite (black) rimmed by pyroxene and amphibole (dark) in microclinite, nicols parallel, magn. 15×
Foto 2. Magnetit (černý) lemovaný pyroxenem a amfibolem (tmavé) v mikroklinitu, rovnoběžné nikoly, zvětšení 15×

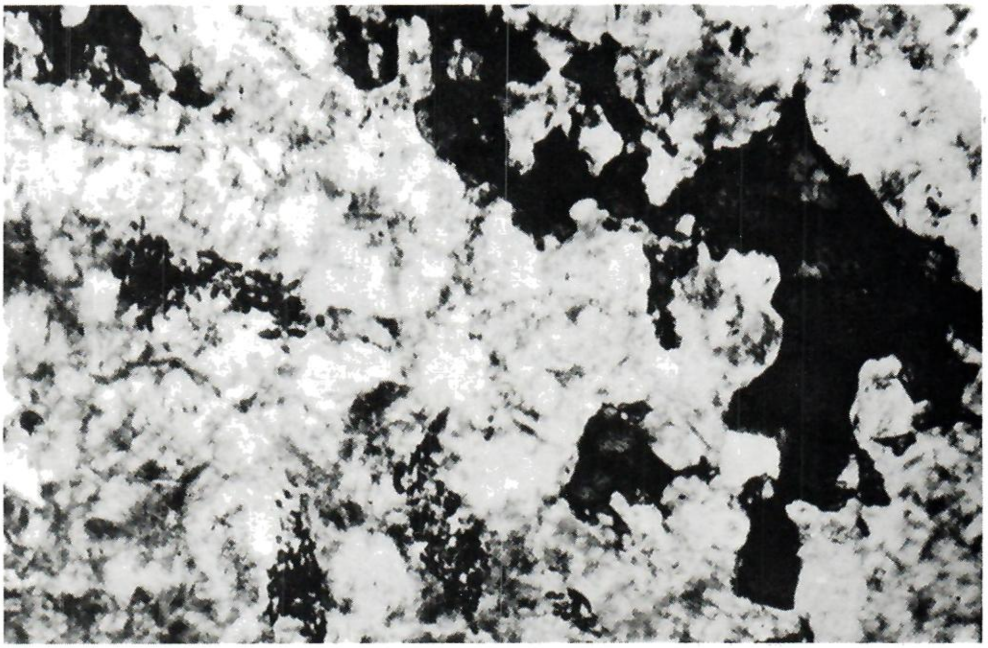

Photo 3. Lobate grain of andradite with fine-grained aggregates of titanite in microclinite, nicols parallel, magn. 25×
Foto 3. Laločnaté zrno andraditu s jemnozrnnými agregáty titanitu v mikroklinitu, rovnoběžné nikoly, zvětšení 25×

Photo 4. Microcline (grey) replaced by andradite (dark), nicols parallel, magn. 15×
Foto 4. Mikroklin (šedý) zatlačovaný andraditem (tmavý), rovnoběžné nikoly, zvětšení 15×