CORUNDUM-BEARING PEGMATITE FROM POKOJOVICE NEAR TŘEBÍČ, CZECH REPUBLIC

KORUNDOVÝ PEGMATIT Z POKOJOVIC U TŘEBÍČE, ČESKÁ REPUBLIKA

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Abstract

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The Pokojovice corundum-bearing pegmatite is found in the varied group of Moravian Moldanubicum. It forms a discordant dike, up to 2 m thick, penetrating amphibolite with thin layers of calcite marble, and skarn-like rocks. The pegmatite is composed of three different units:

1. Pyroxene pegmatite (K – feldspar + Fe – diopside + plagioclase + titanite ± quartz ± amphibole ± biotite).
2. Biotite pegmatite (K – feldspar + biotite + plagioclase).
3. Corundum pegmatite (K – feldspar + corundum + plagioclase + biotite ± muscovite ± tourmaline).

The geological position, as well as the mineral and chemical composition of pegmatite and the surrounding rocks are described. The paper also discusses conditions of the corundum formation.

Key words: corundum, pegmatite, amphibolite, mineralogy, Moldanubicum, western Moravia, Czech Republic.

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Introduction

The corundum-bearing pegmatite is situated near Pokojovice, about 10 km west of Třebíč.

It was reported and briefly described by Dvorský (1885, 1898), Barvíř (1893) and Sekanina (1928). Němec (1976) explains the origin of corundum by a desilication of the pegmatite on contact which amphibolite and its marble intercalations. He suggests partial removal of silicon and kalium, inertness of aluminium, low content of water and reduction conditions which enabled the stability of corundum with biotite.

Geological setting

The Pokojovice region is located within the varied group in the eastern part of the Moravian Moldanubicum, bordering on the western margin of the Třebíč massif. The area is formed by predominating biotite paragneisses (+ sillimanite, + cordierite), locally with intercalations of quartzite, amphibolite, calc – silicate rocks, graphite gneiss, and sporadically also of marbles. A remarkable alkali – feldspar gneiss with minor magnetite and microcline rocks with substantial

amounts of andradite, amphibole, monoclinic pyroxene and calcite (Houzar and Šrein 1990) also occur within this region. Němec (1992) regards these rocks to be a part of the Leptite formation. Metamorphic rocks are locally penetrated by small bodies of biotite or muscovite – tourmaline granites and by numerous dikes of primitive pegmatite, aplite and quartz.

The main strike of metamorphic foliation within the eastern part of the Moravian Moldanubicum is NNE-SSW to N-S. In the vicinity of Pokojovice, this strike changes to E-W. The geological situation of the Pokojovice region is shown in Figure 1.

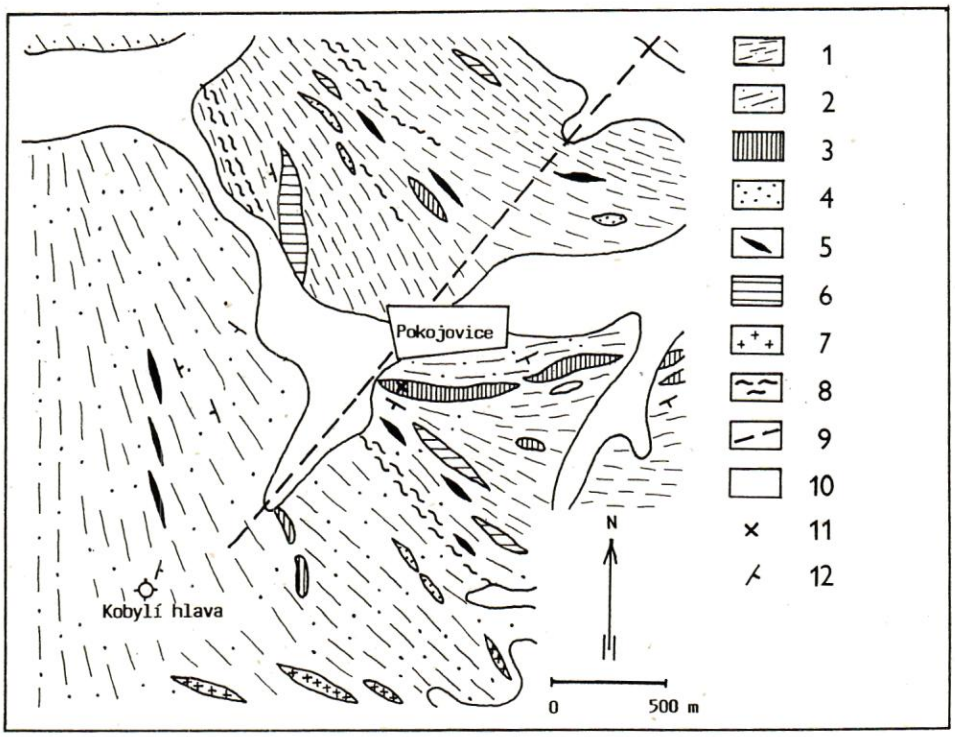

Fig. 1. Geological sketch of Pokojovice region.
1. sillimanite gneiss, 2. cordierite gneiss, 3. amphibolite, 4. pyroxene gneiss, 5. graphite gneiss, 6. quartzite, 7. aplite, 8. mylonite, 9. fault, 10. quaternary sediments, 11. corundum-bearing pegmatite, 12. foliation.

Obr. 1. Geologická situace okolí Pokojovic.
1. sillimanitická rula, 2. cordieritická rula, 3. amfibolit, 4. pyroxenická rula, 5. grafitická rula, 6. kvarcit, 7. aplit, 8. mylonit, 9. zlom, 10. kvartérní sedimenty, 11. korundový pegmatit, 12. foliace.

Amphibolite (host rock of corundum – bearing pegmatite)

The amphibolite body up to 40 m thick is situated in a cordierite – biotite gneiss. It contains rarely 2 cm to 20 cm thin layers formed by calcite marble (calcite + Fe – diopside + amphibole + magnetite) and a skarn-like rock (andradite + hedenbergite + amphibole + epidote + magnetite + scapolite + chalcopyrite).

In thin section, amphibolite is composed of monoclinic amphibole (pleochroism: pale greyish brown – dark khaki) plagioclase (An_{30-45}), and abundant K – feldspar. Accessory minerals include magnetite, apatite, zircon, chalcopyrite and sphalerite. The common presence of K – feldspar represents very an unusual feature – distinguishing it from similar metabasic rocks in the Moravian Moldanubicum as well as low MgO and K_2O and TiO_2 contents and the high proportion of Fe^{3+}/Fe^{2+} (Suk 1974, 1979).

On contact of pegmatite and amphibolite a rock similar to "pearl gneiss" is locally developed with the mineral assemblage biotite + plagioclase (An_{34}). Increased contents of pyroxene, amphibole, plagioclase, titanite and scapolite appear within the marble layers on contact with the pegmatite (Tab. 1).

Table 1. Chemical analyses of surrounding rocks (Pokojovice)
Tabulka 1. Chemické analýzy okolních hornin (Pokojovice)

SAMPLE	1 PO-5	2 PO-6	3 PO-7	4 PO-8	5 PO-9
SiO_2	53.28	49.78	47.20	46.56	7.04
TiO_2	0.22	2.17	2.56	2.44	0.03
Al_2O_3	22.91	15.23	16.87	16.35	1.74
Fe_2O_3	1.11	5.61	4.01	3.25	0.56
FeO	1.80	4.97	4.18	6.63	0.22
MnO	0.065	0.125	0.133	0.381	0.318
MgO	4.33	1.89	2.24	4.13	0.53
CaO	6.04	10.38	12.03	9.82	49.04
Na_2O	4.80	3.58	2.02	1.70	0.32
K_2O	2.70	2.80	4.50	5.66	0.94
Li_2O	0.016	0.002	0.009	0.014	0.001
P_2O_5	0.34	0.64	0.41	0.41	0.01
B_2O_3	0.005	0.003	0.008	0.005	0.003
SO_3	0.01	0.22	0.003	0.12	0.01
H_2O+	0.87	0.57	0.68	0.77	0.50
H_20-	0.50	0.17	0.24	0.23	0.12
TOTAL	98.996	98.140	97.093	98.47	60.882

1. biotitized amphibolite (in addition (ppm) Ba 164, Cr 1, Sr 234, Sn 12, Zr 10, Rb 160) 2–4. amphibolite, 5 – calcite marble.(Samples PO 1–8, see Figure 2).

1. biotitizovaný amfibolit (navíc (ppm) Ba 164, Cr 1, Sr 234, Sn 12, Zr 10, Rb 160), 2–4. amfibolit, 5. kalcitický mramor. (Vzorky PO 1–8, viz. obr. 2).

Geological position of corundum – bearing pegmatite

The pegmatite is located at the southern border of the village, in a wooded slope, about 300 m WSW from the 386 m elevation point. It forms nearly a vertical dike of NNW-SSE direction up to 2 m thick. There are many discordant up to 30 cm thick and concordant up to 5 cm thick apophyses. The dike is splitted into two separate ones at the bottom of the outcrop (Fig. 2).

The pegmatite dike penetrates amphibolite characterized by thin intercalations of calcite marble and skarn-like rock. The dike leaves the amphibolite and enters to cordierite – biotite gneiss. However, this portion of the pegmatite dike displays absence of corundum and pyroxene.

The contact between the dike and amphibolite is relatively sharp. No alteration, except of about the 5 cm thick zone of biotitized amphibolite occurring only in a small area, where the contact of pegmatite and amphibolite is concordant (Fig. 2). Rare biotite enclaves with distinct foliation identical with surrounding amphibolite are present also within the pegmatite body. However, some enclaves of amphibolite are not influenced or represent products of a resorption with varying contents of K – feldspar, pyroxene, amphibole and biotite.

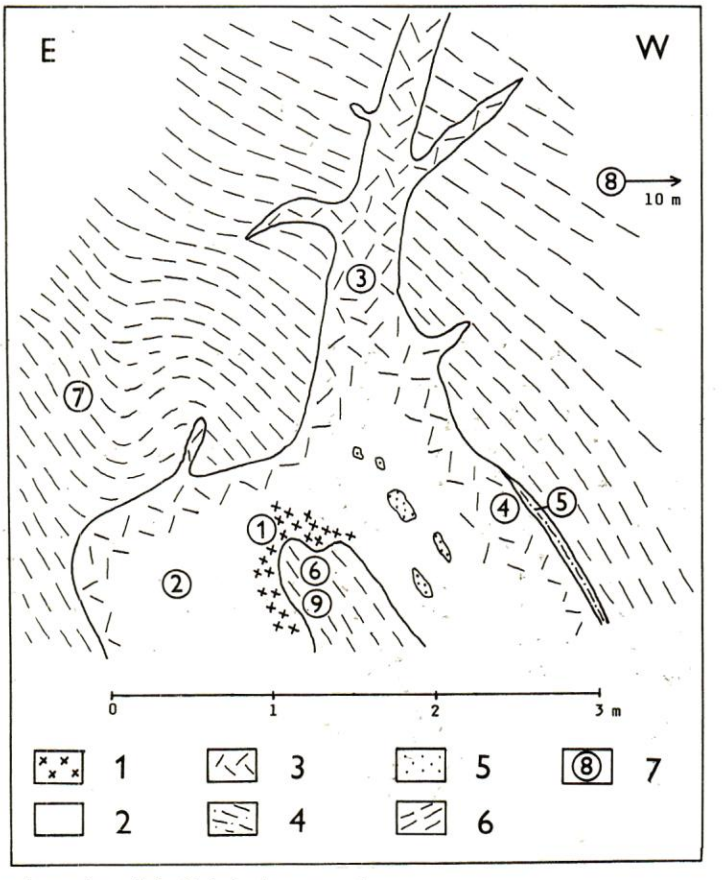

Fig. 2. Schematic section of the Pokojovice pegmatite.
1. corundum pegmatite, 2. biotite pegmatite, 3. pyroxene pegmatite, 4. biotitized pegmatite, 5. enclaves of a host rocks, 6. amphibolite, 7. analysed samples (PO 1–9).

Obr. 2. Schématický řez pokojovickým pegmatitem.
1. korundový pegmatit, 2. biotitový pegmatit, 3. pyroxenový pegmatit, 4. biotitizovaný amfibolit, 5. uzavřeniny okolních hornin, 6. amfibolit, 7. analyzované vzorky (PO 1–9).

Mineralogical and petrographical characteristics of pegmatite

The pegmatite consists of the following coarse-grained to less abundant medium-grained textural – paragenetic units: (1) pyroxene pegmatite, (2) biotite pegmatite, and (3) corundum pegmatite. The dike displays irregularly developed

zonal structure. The pyroxene unit is situated along the contact with amphibolite and the thickness of this zone varies from 20 to 50 cm. The biotite unit forms the central part of the pegmatite body, whereas the corundum unit is represented by an irregular nest up to 30 cm large enclosed in the biotite unit, close but to a contact with amphibolite (or large amphibolite enclave ?).

Typical pegmatite textural units such as graphic pegmatite and blocky K – feldspar, or albitic units were not found in the Pokojovice pegmatite.

(1) Pyroxene pegmatite

It forms all apophyses and marginal parts of the dike, however, small nests occur also within the biotite pegmatite unit. Coarse-grained and medium-grained varieties are irregularly distributed within the pegmatite. The coarse-grained variety is composed of K – feldspar, plagioclase (An_{30-50}) and quartz (range from 1 to 10 vol. %), and relics of pyroxene mostly entirely replaced by actinolite amphibole and/or Fe – chlorite. Minor and accessory minerals are represented by titanite, apatite and magnetite. The medium-grained variety is characterized by increased amounts of pyroxene (Fe – diopside) and plagioclase (An_{20-30}), minor biotite and amphibole are present. Accessory minerals include titanite, scheelite, allanite and clinozoisite.

(2) Biotite pegmatite

It is generally medium-grained to coarse-grained and shows simple mineral composition, characterized by K – feldspar, minor plagioclase and chloritized biotite with sagenite. Perthitic K – feldspar is very similar to the one from corundum pegmatite (X – ray triclinity 0.90–1). Plagioclase ranges in composition from calcic albite to oligoclase. Biotite in flakes up to 2 cm long is strongly pleochroic (X – light brown, YZ – dark reddish brown). Quartz forms xenomorphic grains with undulatory extinction.

Accessories include zircon, titanite and allanite.

(3) Corundum pegmatite

This unit is represented by the isolated nest and its volumetrically unimportant in comparison with the other units. It is composed of coarse-grained K – feldspar, corundum, plagioclase and biotite. Minor muscovite, tourmaline and quartz as well as accessory minerals (apatite, zircon, chalcopyrite and scheelite) were found.

Perthitic K – feldspar (microcline with X – ray triclinity 0. 94–1. 00) was partly replaced by sericite and kaolinite and forms up to 75 vol. % of this unit. Corundum forms grey barrel-shaped crystals up to 10 cm long, occasionally distinctly zoned. Crystals are anomalously biaxial (Barvíř 1893) an contain rare ilmenite and rutile inclusion in center. They show distinct pressure deformations a replaced by sericite particularly along the planes of cleavage. Plagioclase (An_8–An_{20}) forms about 10 vol. % of the unit, whereas biotite intermediate between annite and siderophyllite only about 5 vol. % (Tab. 2.)

Minor muscovite and tourmaline represent later minerals. Flakes of muscovite up to 1 cm in size correspond in their composition to those of other barren pegmatites, the paragonite component is about 10 per cent (see Němec 1990). Tourmaline (schorl) forms xenomorphic grains in the vicinity of corundum.

Table 2. Representative microprobe analyses of some minerals
Tabulka 2. Reprezentativní mikrosondové analýzy některých minerálů

	muscovite	muscovite	biotite	biotite
SiO_2	43.94	43.50	33.41	33.60
TiO_2	0.57	1.01	2.94	2.97
Al_2O_3	32.35	32.42	17.60	17.34
FeO*	2.82	2.54	23.65	23.80
MnO	0.05	0.01	0.69	0.71
MgO	0.45	0.41	5.68	5.70
CaO	0.09	0.00	0.00	0.00
K_2O	10.58	11.32	10.57	10.58
Na_2O	0.73	0.79	0.15	0.13
H_2O**	4.27	4.27	3.76	3.77
TOTAL	95.85	96.27	98.45	98.60
		24 O		
Si^{4+}	6.175	6.113	5.323	5.349
Ti^{4+}	0.060	0.107	0.352	0.356
Al^{3+}	5.358	5.369	3.305	3.253
Fe^{2+}	0.331	0.298	3.151	3.169
Mn^{2+}	0.006	0.001	0.093	0.096
Mg^{2+}	0.094	0.086	1.349	1.353
Ca^{2+}	0.014	0.000	0.000	0.000
K^{+}	1.897	2.029	2.149	2.149
H^{+}	4.000	4.000	4.000	4.000
CATSUM	14.134	14.218	15.769	15.763

* total Fe as FeO – celkové Fe jako FeO
** determined by stoichiometry – určeno ze stechiometrie

Proportions of quartz, apatite and zircon are very low in comparison with other pegmatite units. Scheelite and chiefly chalcopyrite are concentrated particularly close to contact with amphibolite.

Chemical composition of pegmatite

Chemical compositions of individual units (Tab. 3) within the Pokojovice pegmatite are characterized by high K_2O, CaO and low MgO contents, subaluminious to peraluminious signature and relatively high K/Rb and low K/Ba relations. These characteristics do not correspond to granitic pegmatites. They are rather close to syenitic rock more or less influenced by host amphibolite.

Particularly medium-grained pyroxene pegmatite (Anal. 1, Tab. 3) displays a very high degree of contamination and its composition is close to those of enclaves of the partly resorbed amphibolite.

Discussion

The mineralogical and petrographical character and chemical compositions of individual units and the pegmatite dike as a whole are similar to some other primitive barren pegmatites from calc – silicate rocks, marbles and amphibolites occurring in the Moravian Moldanubicum (see Švábenský 1933, Houzar

Table 3. Chemical analyses of pegmatite units (Pokojovice)
Tabulka 3. Chemické analýzy typů pegmatitu (Pokojovice)

SAMPLE	1 PO-4	2 PO-3	3 PO-2	4 PO-1
		(wt %)		
SiO_2	56.67	62.98	62.99	62.21
TiO_2	0.32	0.21	0.10	0.11
Al_2O_3	20.42	18.52	20.36	20.73
Fe_2O_3	1.06	0.84	0.33	0.21
FeO	1.80	0.96	0.37	0.29
MnO	0.091	0.056	0.018	0.015
MgO	2.52	0.71	0.31	0.11
CaO	8.01	2.18	2.17	1.98
Na_2O	5.10	4.12	5.34	5.08
K_2O	2.06	7.64	6.08	7.04
Li_2O	0.003	0.001	0.003	0.003
P_2O_5	0.09	0.06	0.08	0.02
B_2O_3	0.009	0.015	0.010	0.004
SO_3	0.01	0.01	0.02	0.01
H_2O+	0.60	0.45	0.36	0.26
H_2O-	0.28	0.23	0.18	0.14
TOTAL	99.043	98.991	98.721	98.212
K/Rb		240	255	205
K/Ba		148	149	71
		ppm		
Ba		428	338	818
Cr		1	10	8
Sr		136	120	154
Sn		9	6	6
Zr		10	5	28
Rb		264	198	285
A/CNK	0.81	0.97	1.05	1.06
A/NK	1.92	1.23	1.33	1.30

1. pyroxene pegmatite (medium-grained), 2. pyroxene pegmatite (coarse-grained), 3. biotite pegmatite, 4. corundum pegmatite.
1. pyroxenový pegmatit (středně zrnitý), 2. pyroxenový pegmatit (hrubozrnný), 3. biotitový pegmatit, 4. korundový pegmatit.

1985). The typical features of these pegmatites are the simple mineral assemblage (K – feldspar + plagioclase + Fe – diopside or/and biotite + titanite) and homogeneous to indistinct zonal structure (Fig. 3, Tab. 4).

The typical feature of the Pokojovice pegmatite is the presence of corundum. This mineral occurs as a replacement product of andalusite at the Dolní Bory pegmatite (Staněk 1991), another occurrence is in a desilicated pegmatite penetrating ultrabasic rocks near Drahonín (Černý 1958). The origin of corundum in the Pokojovice pegmatite was explained by a desilication process (Němec 1976). Because this process perhaps occurs in the formation of this pegmatite only in a limited extent, it very likely did not influence the formation of corundum (see also Uspenskij 1968, Clarke 1981). This is supported by the following facts:

- the proportion of SiO_2 and Al_2O_3 is similar in the whole dike, except contaminated medium-grained pegmatite (K – feldspar + Fe – diopside + plagioclase + amphibole + biotite).
- there are thin and rare rims (biotitization), which indicate only unimportant removal of silicon and alkalies.

The stability of corundum was probably enabled by the following factors:

a) Low Mg and Fe contents within the corundum pegmatite, which prevented the formation of biotite and cordierite.

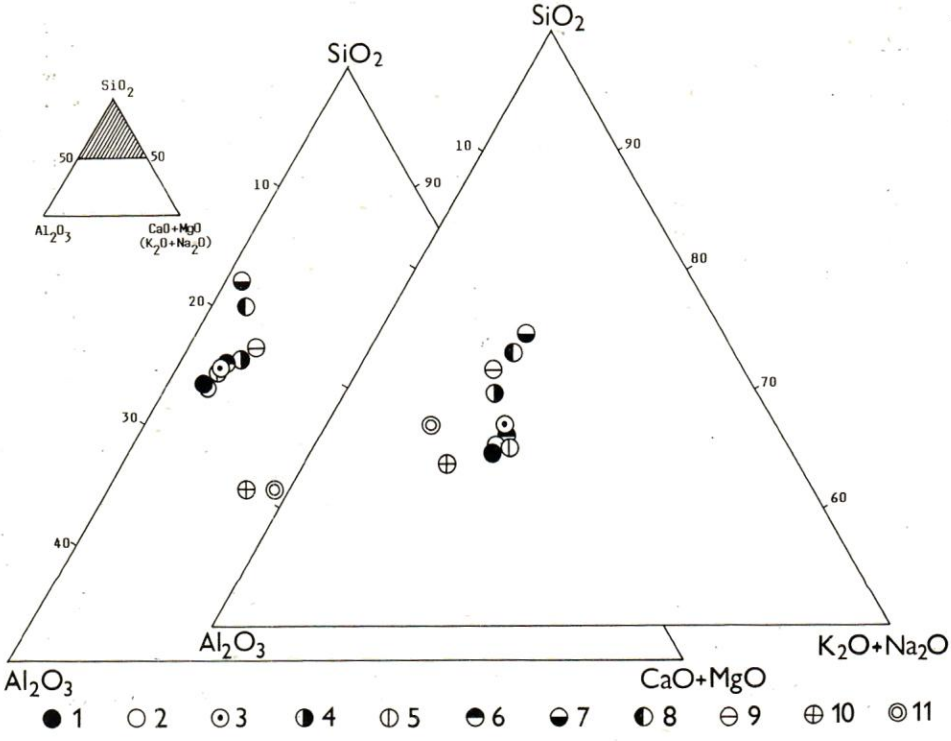

Fig. 3. The SiO_2 – Al_2O_3 – K_2O+Na_2O (CaO+MgO) diagrams of primitive barren pegmatites of the varied group of the Moravian Moldanubicum.

1. corundum pegmatite (Pokojovice), 2. biotite pegmatite (Pokojovice), 3. pyroxene pegmatite, coarse-grained (Pokojovice), 4. pegmatite from calcite marble (Čechočovice), 5. pegmatite from dolomite – calcite marble (Krahulov), 6. pegmatite from pyroxene gneiss (Lukov), 7. pegmatite from gneiss near contact with marble (Sokolí), 8. pegmatite from calcite marble (Markvartice), 9. diopside pegmatite from dolomite marble (Nová Ves), 10. biotite pegmatite from skarn (Županovice, Němec 1963), 11. pyroxene pegmatite, medium-grained (Pokojovice).

Obr. 3. Diagramy SiO_2 – Al_2O_3 – K_2O+Na_2O (CaO+MgO) primitivních pegmatitů pestré skupiny moravského moldanubika.

1. korundový pegmatit (Pokojovice), 2. biotitový pegmatit (Pokojovice), 3. pyroxenový pegmatit, hrubozrnný (Pokojovice), 4. pegmatit z kalcitového mramoru (Čechočovice), 5. pegmatit z dolomit – kalcitového mramoru (Krahulov), 6. pegmatit z pyroxenové ruly (Lukov), 7. pegmatit z ruly blízko kontaktu s mramorem (Sokolí), 8. pegmatit z kalcitového mramoru (Markvartice), 9. diopsidový pegmatit z dolomitového mramoru (Nová Ves), 10. biotitový pegmatit ze skarnu (Županovice, Němec 1963), 11. pyroxenový pegmatit, středně zrnitý (Pokojovice).

Table 4. Chemical analyses of primitive barren pegmatites of the varied group of the Moravian Moldanubicum

Tabulka 4. Chemické analýzy primitivních pegmatitů pestré skupiny moravského moldanubika

	Sokolí	Markvartice	Nová Ves	Čechočovice	Lukov	Krahulov
			(wt %)			
SiO_2	72.32	70.69	67.02	65.29	64.15	62.70
TiO_2	0.05	0.06	0.20	0.05	0.05	0.11
Al_2O_3	14.40	15.71	16.71	17.77	18.58	19.44
Fe_2O_3	0.16	0.19	0.30	0.14	0.09	0.02
FeO	0.14	0.28	0.57	0.27	0.07	0.36
MnO	0.02	0.02	0.02	0.03	0.04	0.02
MgO	0.05	0.39	1.28	1.15	0.10	0.43
CaO	1.44	1.43	2.97	3.68	2.90	1.65
Na_2O	2.49	3.76	4.08	1.90	1.78	1.74
K_2O	7.78	6.48	4.62	9.19	10.81	11.80
P_2O_5	0.15	0.06	0.45	0.03	0.02	0.23
H_2O+	0.21	0.48	0.46	0.36	0.38	0.23
H_2O-	0.10	0.05	0.20	0.29	0.16	0.12
TOTAL	99.31	99.60	98.88	99.15	99.13	98.85
K/Ba	227	62	50	94	94	38
			ppm			
Ba	285	870	765	810	957	2598
Cr	15	16	24	15	21	10
Sr	59	185	310	188	204	218
Zr	17	17	226	9	5	45
Be	3	8	6	14	14	2
A/CNK	0.95	0.99	0.98	0.90	0.93	1.04
A/NK	1.16	1.19	1.43	1.36	1.27	1.24

b) Relatively high content of K and low activity of water, which prevented the formation of andalusite and/or muscovite (Ivanov – Fonarev 1970).

c) Relative low SiO_2 / Al_2O_3 ratio.

Conclusion

1. The corundum-bearing pegmatite is located in amphibolite with thin layers of calcite marble and skarn-like rock. Its chemical composition displays high K and Ti and low Mg contents.
2. Corundum crystallized in early stages of pegmatite formation.
3. The geochemical conditions of the corundum formation were the low content of MgO, FeO and H_2O and high K_2O in the pegmatite.
4. The presence of corundum is a distinct mineralogical feature in which the Pokojovice pegmatite differs from similar primitive pegmatites penetrating calc – silicate rocks, marbles and amphibolites in the Moravian Moldanubicum (compare Staněk 1981).

SOUHRN

Pokojovický korundový pegmatit se vyskytuje v pestré skupině moravského moldanubika západně od třebíčského masívu. Tvoří příkře uloženou žílu v amfibolitu s tenkými vložkami kalcitických mramorů a skarnoidních hornin. Pegmatit je složen ze tří subtypů:

(1) pyroxenový pegmatit (K – živec + Fe – diopsid + plagioklas + titanit ± křemen ± amfibol ± biotit)
(2) biotitový pegmatit (K – živec + biotit + plagioklas)
(3) korundový pegmatit (K – živec + korund + plagioklas + biotit ± muskovit ± turmalín)

Korund tvoří až 10 cm velké soudečkovité krystaly a vyskytuje se pouze v místě, kde se žíla rozmršťuje. Podle deformačního postižení a srůstů s dalšími minerály patří korund spolu s draselným živcem (triklinita 0,94–1,00) k nejstarším minerálům pegmatitu. Postavení biotitu není jasné, muskovit a turmalín (skoryl) je zřetelně mladší.

Chemické složení pegmatitu odpovídá syenitu. Okolní amfibolit je nápadný vysokým obsahem K_2O a TiO_2 a nízkým obsahem MgO.

Geologickou pozicí, mineralogickým a částečně i chemickým složením jednotlivých jednotek se pokojovický pegmatit podobá dalším primitivním pegmatitům z erlanů, mramorů a amfibolitů moravského moldanubika. Hlavním mineralogickým rozdílem je výskyt korundu. Desilikace, která by vedla k jeho vzniku, nebyla prokázána a krystalizaci korundu lze pravděpodobně nejlépe vysvětlit výjimečnými podmínkami vzniku pegmatitu (nízký poměr SiO_2/Al_2O_3, nízký obsah H_2O, MgO, CaO, FeO a vysoký obsah K_2O v korundovém subtypu), které nebyly splněny u dalších podobných pegmatitů v okolí.

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