Blue dravite as an indicator of fluid composition during subsolidus replacement processes in Li-poor granitic pegmatites in the Moldanubicum, Czech Republic

Modrý dravit jako indikátor složení fluid během zatlačovacích procesů v subsolidu v lithiem chudých granitických pegmatitech moldanubika (Czech summary)

(4 text-figs.)

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Fibrous to needle-like blue dravite characterized by low and variable Fe/Mg ratios, low Ti, Mn, Li and F contents and locally elevated Ca contents was found at several localities of Li-poor granitic pegmatites in Moldanubicum, Czech Republic. These pegmatites commonly penetrate Ca, Mg-rich rocks such as dolomite-calcite marble and serpentinite. Blue dravite from Strážek and Věžná replaces cordierite in early stages of subsolidus crystallization at temperature above 450 to 500 °C, before relics of cordierite were completely replaced by a mixture of micaceous minerals. Simplified reaction may be expressed:
$3Na_{0.4}(Mg,Fe)_2Al_4Si_5O_{18}.\ nH_2O + 3B(OH)_3 + yH_2O + zCaO = 2(Na,Ca)_{0.7}(Mg,Fe)_3Al_6Si_6O_{18}(BO_3)_3(OH)_4 + 3SiO_2$. Blue dravite from Bližná formed in relatively late stage of subsolidus process and it is closely associated with Ca, Mg-rich elbaite. Pegmatite-derived fluids in Li-poor pegmatites are characterized by high activity of B and low activities of F and Li. It is in a contrast with highly evolved Li-rich complex granitic pegmatites, where high activities of B, F and alkalis (Li, K, Rb, Cs) in pegmatite-derived fluids were observed. Metamorphic fluids are Ca, Mg-enriched, but their participation in the reaction is negligible to moderate. Significant influx of metamorphic fluids is assumed particularly during a low temperature formation of blue dravite in Bližná, but it was small during replacement of cordierite at localities Věžná and particularly Strážek.

Key words: dravite, cordierite, electron microprobe, subsolidus replacement, fluid composition, granitic pegmatites, Moldanubicum, Czech Republic

Introduction

Mixing of pegmatite-derived fluids and metamorphic fluids from host rock and their reaction with solid rock represent a typical process in some Li-rich complex granitic pegmatites. It is commonly related to the transition from magmatic to hydrothermal phase (London et al. 1996). Mineral assemblages originated in the exocontact of pegmatite bodies are characterized by the presence of Rb, Cs, Li-enriched micas (phlogopite, biotite, zinnwaldite), tourmaline (schorl, dravite, uvite, elbaite, feruvite), holmquistite, calcite, garnet, epidote, Li, Be-bearing margarite and arsenopyrite (e.g., Shearer et al. 1986, Morgan - London 1987, Chakoumakos - Lumpkin 1990, Novák - Selway 1997a). Composition of pegmatite-derived fluids inferred from these mineral assemblages indicates high activities of B, F and alkalis (Li, K, Rb, Cs); metamorphic fluids reflect composition of the host rock and they are commonly Mg and Ca enriched (Morgan - London 1987, London et al. 1996).

The fluids may also react with some minerals inside of the pegmatite body, i.e. garnet replaced by zinnwaldite, Fe, Mn-rich lepidolite and/or tourmaline at complex granitic pegmatites (Němec 1983, unpubl. data of the author). Blue dravite originated during similar process occurs locally in Li-poor granitic pegmatites of the Moldanubicum. Consequently, it may serve as a potential indicator of chemical composition of internal pegmatite fluids derived from Li-poor granitic pegmatites as well as external metamorphic fluids infiltrating into pegmatite body.

The paper is focused at localities Strážek, Věžná and Bližná, distinct in their internal structure, overall paragenesis, mineral assemblage of blue dravite and host rock composition.

Occurrences and parageneses of blue dravite

Blue dravite was described from several pegmatites and quartz-feldspar rocks, mostly penetrating dolomite or dolomite-calcite marble or serpentinite: zoned beryl-columbite pegmatite with rare Li, Cs-bearing minerals penetrating serpentinite from Věžná near Rožná (Černý 1965, Černý - Novák 1992); Li-poor elbaite pegmatite in dolomite-calcite marble from Bližná near Český Krumlov (Novák et al. 1997, Novák - Selway 1997a); Li-poor complex pegmatite in dolomite marble near Vratěnín (Němec 1975); simple and texturally homogeneous pegmatite in serpentinite from Drahonín near Tišnov (Černý 1958); simple pegmatite in serpentinite from Stupná near Český Krumlov (Čech et al. 1965) and zoned barren pegmatite cutting biotite-sillimanite gneiss in Strážek (this work). The localities characterized below were selected to be examined in detail due to their distinct internal structure, mineral assemblages of blue dravite and host rock composition.

Strážek

Barren, symmetrically zoned pegmatite dike, about 3 m thick, penetrates biotite-sillimanite gneiss of the Strážek Moldanubicum, western Moravia. Rare, blue to greyish blue dravite forms fibrous aggregates, up to 12 mm long, in the graphic unit. They are developed in a close proximity to black foitite-schorl crystal and in the expence of elongated grain with a typical "cordierite"-like basal cleavage. Textural relationships suggest that dravite originated by a direct replacement of cordierite, before it was completely replaced by a mixture of micaceous minerals.

Věžná

Symmetrically zoned dike of the beryl-columbite subtype with rare Li, Cs-minerals, up to 2 m thick, penetrates serpentinite located on a border between Strážek Moldanubicum and Svratka Unit (Černý - Novák 1992). Greyish blue dravite forms needle-like to fine-grained aggregates, up to 1 cm in size, apparently replacing columnar grains with a typical "cordierite" - like basal cleavage in graphic unit or in blocky K-feldspar. Detailed paragenesis of the blue dravite sample analyzed by Povondra (1981) given in Table 1 is not known. Cordierite is completely replaced by a mixture of micaceous minerals, only a basal cleavage, shape of aggregates and presence of cordierite in the locality (Černý - Povondra 1967) indicate that prediction. Blue dravite is also locally associated with early crystallized dark brown schorl-dravite. Their textural relationship is quite ambiguous in some cases; however, blue dravite seems to be later.

Bližná

An elbaite subtype Li-poor pegmatite forms dike about 4 m thick cuttting dolomite-calcite marble in the graphite mine Bližná, Český Krumlov Unit, southern Bohemia (Novák et al. 1997). Pale blue to almost colourless dravite is commonly closely associated with olive green to greenish brown Ca, Mg-rich elbaite. Dravite overgrows elbaite grains as fine fibrous aggregates or locally cut elbaite in thin veinlets. A direct replacement of elbaite by dravite, however, is rather exceptional.

Experimental

Electron microprobe analysis was done in wavelength-dispersion (WDS) mode on a Cameca SX-50 instrument, with a beam diameter 4-5 μm, accelerating potential 15 kV. A beam current of 20 mA was used for Si, Al, Ti, Fe, Mn, Mg, Ca, Na and K, and a current of 40 mA for Zn, F and P; counting time for all elements was 20 seconds. Natural minerals were used as standards for Kα! X-ray lines. The data were reduced using the PAP routine (Pouchou - Pichoir 1985). Further details about the conditions of the electron micropope analyses are given by (Novák et al. 1998). The structural formulae were calculated on the basis of 31 anions, assuming stoichiometric amounts of H_2O as $(OH)^-$, i.e. OH + F = 4, and B_2O_3 as $(BO_3)^{3-}$, i.e. B = 3 atoms per formula units (apfu).

Chemical composition

Blue dravite was analyzed from locality Věžná using a wet method (Povondra 1981). Chemical characteristics display high Mg contents, low Ti, Mn and F concentrations, slight X-site deficiency and very low Li content. The latter was also found spectrographically in blue dravite (indicolite) from Drahonín and Stupná (Čech et al. 1965). Partial chemical analyses of blue dravite from Vratěnín show very low Mn, Ti and Li but elevated Ca contents (Němec 1975).

Table 1. Chemical characteristics of blue dravite from studied localities (in apfu)

	Strážek	Věžná			Bližná
sample		1	2	3	
n	11	4	2	2	13
Si	6.00-6.08	5.98-6.05	5.91-6.18	5.94-6.00	6.08-6.14
Al	6.49-6.65	6.38-6.59	6.12-6.78	5.98-6.52	6.28-6.46
Mg	1.29-1.48	1.64-1.70	1.40-1.82	1.85-2.51	2.00-2.24
Fe^{2+}	0.69-0.86	0.46-0.68	0.69-0.77	0.48-0.61	0.21-0.29
Na	0.58-0.76	0.72-0.74	0.68-0.82	0.60-0.62	0.50-0.62
Ca	< 0.03	< 0.04	< 0.01	0.04-0.26	0.04-0.13
Ti	< 0.01	< 0.01	0	0.02-0.06	< 0.01
Mn	< 0.04	< 0.03	< 0.05	< 0.02	< 0.02
F	< 0.04	0.04-0.09	0.12-0.28	0.01-0.22	< 0.02

Electron microprobe study of blue dravite from three Li-poor granitic pegmatites generally yielded rather similar results (Table 1, 2); high Mg, and commonly low Ti, Mn and F contents. A slight Si excess found in most analyses (Table 1) may be caused due to the formula normalization on (OH + F) = 4 (Taylor et al. 1995) which is likely less than 4. However, the chemical compositions from individual localities exhibit quite a different patterns. Slightly heterogeneous dravite from Strážek is characterized by moderate Mg and Al contents and very high X-site vacancy (Figs. 1a, 2a, 3a) but low Ca content (Fig. 4a). Two analysed samples of blue dravite from Věžná yielded quite a similar compositions: moderate and comparable Mg contents, variable Al contents, (Figs. 1b, 2b), moderate to low X-site vacancy (Fig. 3b), low Ti, Mn and Ca contents (Table 1, Fig. 4b), and a slight variation in F (Table 1). Blue dravite with density fraction > 3.1 analyzed by Povondra (1981) by a wet method yielded considerably elevated Mg content, total Al < 6 apfu and apparently increased Ca (Fig. 1b, 2b, 4b; Table 1). Homogeneous blue dravite from Bližná shows very high Mg contents (Figs. 1c, 2c), high vacancy in the X-site (Fig. 3c) and elevated Ca contents (Fig. 4c).

Relatively homogeneous compositions of blue dravite (Figs. 1-3; Table 1) make a prediction of reliable substitution mechanisms complicated. A weak homovalent subtitution Mg↔Fe was found in blue dravite from Strážek (Fig. 2a). A positive correlation Na-Ca (Fig. 4c), large vacancy in the X-site combined with only a weak variation in Al and R^{2+} (Figs. 2c, 3c) indicate participation of heterovalent substitution $\square^{Y}$OH↔(Na,Ca)O in blue dravite from Bližná. A positive correlation between X-site vacan-

Table 2. Representative microprobe analyses of blue dravite

sample	Strážek		Věžná 1	Věžná 1	Věžná 2	Bližná	
SiO_2	36.92	37.46	37.28	37.43	37.52	38.66	37.75
TiO_2	0.01	0.00	0.07	0.05	0.00	0.01	0.03
B_2O_3*	10.69	10.75	10.70	10.79	10.67	10.94	10.79
Al_2O_3	34.72	34.33	33.28	34.70	32.50	33.64	33.11
FeO**	6.08	4.89	4.91	3.45	5.68	1.66	1.63
MnO	0.18	0.32	0.21	0.14	0.30	0.03	0.01
MgO	5.55	6.15	7.04	6.95	7.27	9.05	9.34
ZnO	0.00	0.03	0.03	0.08	0.00	0.02	0.00
CaO	0.13	0.02	0.23	0.16	0.00	0.58	0.76
Na_2O	1.84	2.44	2.36	2.32	2.15	1.95	1.95
K_2O	0.02	0.02	0.03	0.03	0.02	0.03	0.04
F	0.10	0.12	0.13	0.08	0.23	0.09	0.12
H_2O*	3.64	3.65	3.62	3.68	3.57	3.73	3.66
O=F	-0.04	-0.05	-0.05	-0.03	-0.10	-0.04	-0.05
TOTAL	99.84	100.13	99.84	99.83	99.81	100.35	99.13
T-Si	6.00	6.06	6.06	6.03	6.11	6.14	6.08
Z-Al	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Y-Ti	0.00	0.00	0.01	0.01	0.00	0.00	0.00
Al	0.65	0.54	0.37	0.59	0.24	0.30	0.29
Fe^{2+}	0.83	0.66	0.67	0.47	0.77	0.22	0.22
Mn^{2+}	0.03	0.04	0.03	0.02	0.04	0.00	0.00
Mg	1.35	1.48	1.70	1.67	1.77	2.14	2.24
Zn	0.00	0.00	0.00	0.01	0.00	0.00	0.00
ΣY	2.86	2.72	2.78	2.77	2.82	2.66	2.75
Ca	0.02	0.00	0.04	0.03	0.00	0.10	0.13
Na	0.58	0.77	0.74	0.72	0.68	0.60	0.61
K	0.00	0.00	0.01	0.01	0.00	0.01	0.01
ΣX	0.60	0.77	0.79	0.76	0.68	0.71	0.75
F^-	0.05	0.06	0.07	0.05	0.12	0.05	0.06
OH^+	3.95	3.94	3.93	3.95	3.88	3.95	3.94

* calculated from stoichiometry; ** total Fe as FeO

cy and Al content (Fig. 3b) indicate a weak heterovalent substitutions $\square^{Y}Al \leftrightarrow NaR^{2+}$ in blue dravite from Věžná.

Chemical composition of cordierite and tourmaline replaced by or associated with blue dravite

Due to a complete replacement of cordierite by micaceous minerals during a late hydrothermal process following the dravite formation at studied samples, its chemical composition used in discussion at the Strážek and Věžná localities may be inferred only via the comparison with the cordierite analyses from the same locality in the case of Věžná or from similar Moldanubian pegmatites (Černý - Povondra 1967, Černý et al. 1997). They typically exhibit very low Ti, Ca and Mn contents, subordinate Na amounts but highly variable Fe/Mg ratios (Fe-bearing cordierite to Mg-poor sekaninaite).

Cordierite was commonly associated with a primary tourmaline within the same textural-paragenetic unit at all localities. Chemical composition of foitite-schorl from graphic unit at Strážek is similar to that of associated blue dravite. Moderately elevated Fe/Mg ratio and slightly increased Ca and Ti contents relative to the blue dravite were found (Table 3, Figs. 1a, 2a, 4a). Primary black to brown schorl-dravite from Věžná is commonly Fe enriched relative to the blue dravite (Fig. 2b). It also displays elevated

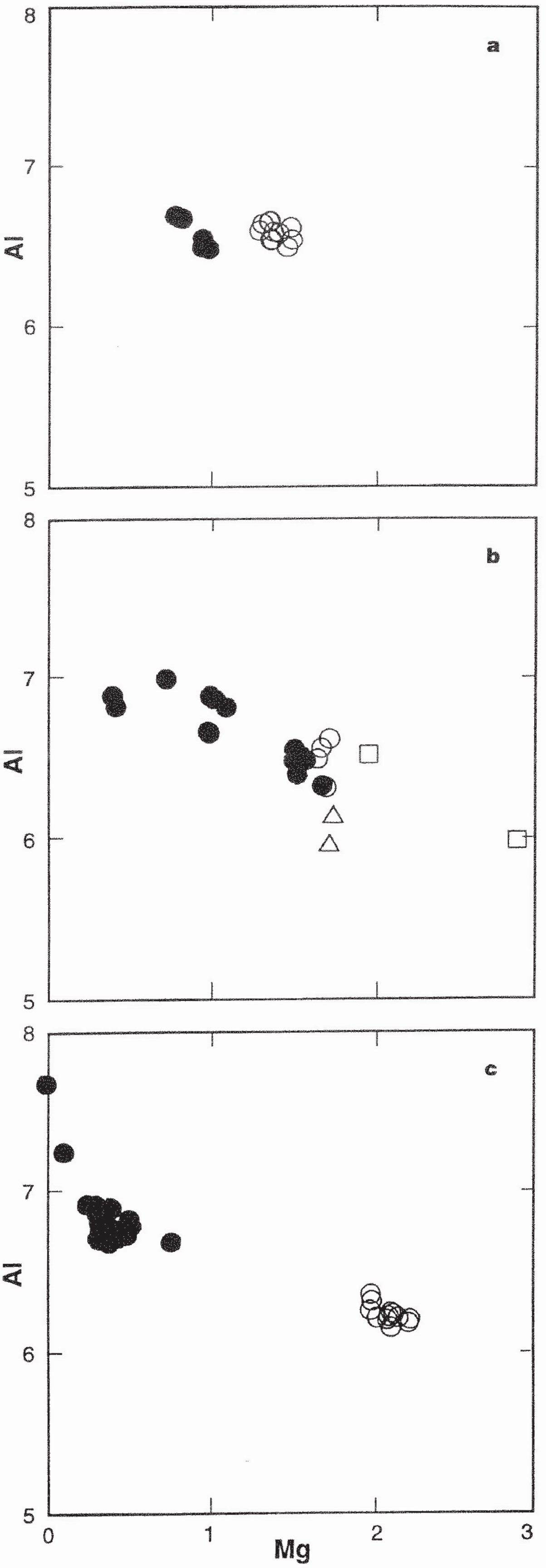

Fig. 1. Al-Mg diagram for blue dravite and associated tourmaline
a - Strážek, b - Věžná, c - Bližná. *Open symbols* - blue dravite; *solid symbol* - associated tourmaline Věžná; sample 1 - *circle;* sample 2 - *triangle;* sample 3 - *squire* (Povondra 1981)

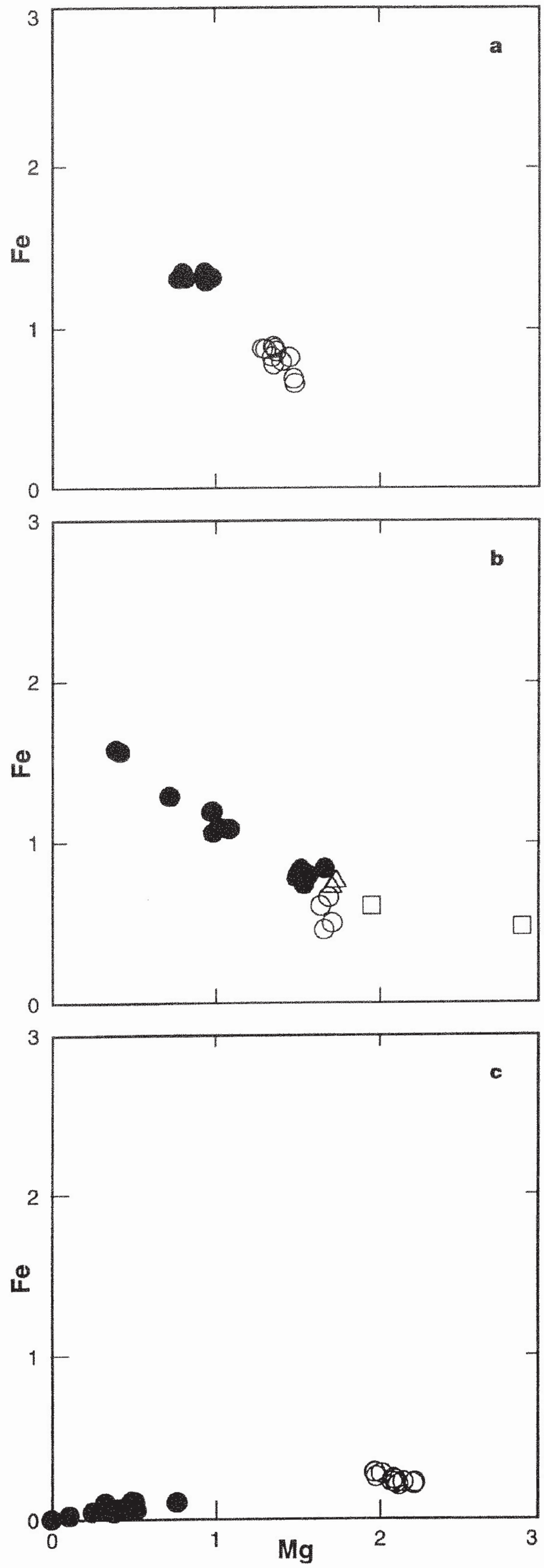

Fig. 2. Fe-Mg diagram for blue dravite and associated tourmaline
a - Strážek, b - Věžná, c - Bližná
Same symbols as in Fig. 1

Table 3. Representative microprobe analyses of primary tourmaline associated with blue dravite

	Strážek		Věžná				Bližná
SiO_2	36.57	35.91	36.15	36.29	36.92	36.68	38.49
TiO_2	0.17	0.55	0.44	0.49	0.41	0.41	1.05
$B_2O_3^*$	10.57	10.42	10.52	10.64	10.68	10.64	10.95
Al_2O_3	34.44	32.96	34.02	35.29	33.82	32.79	36.91
FeO^{**}	9.77	9.42	8.57	7.67	5.75	6.14	0.41
MnO	0.10	0.16	0.11	0.08	0.04	0.04	0.51
MgO	3.27	3.94	3.94	4.01	6.16	6.82	1.41
ZnO	0.03	0.00	0.02	0.00	0.00	0.01	0.01
Li_2O	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.76
CaO	0.18	0.24	0.09	0.11	0.21	0.35	2.36
Na_2O	1.36	1.86	1.94	1.81	2.09	2.40	1.59
K_2O	0.04	0.05	0.01	0.01	0.01	0.00	0.02
F	0.03	0.14	0.33	0.12	0.15	0.13	1.00
H_2O^*	3.63	3.53	3.46	3.60	3.61	3.61	3.30
O=F	-0.01	-0.06	-0.14	-0.05	-0.06	-0.05	-0.42
TOTAL	100.15	99.12	99.49	100.12	99.80	99.97	99.35
T-Si	6.01	5.99	5.97	5.93	6.01	5.99	6.11
Al	-	0.01	0.03	0.07	-	0.01	-
Z-Al	6.00	6.00	6.00	6.00	6.00	6.00	6.00
Y-Ti	0.02	0.07	0.06	0.06	0.05	0.05	0.13
Al	0.68	0.47	0.60	0.72	0.49	0.30	0.91
Fe^{2+}	1.34	1.31	1.18	1.05	0.78	0.84	0.05
Mn^{2+}	0.01	0.02	0.02	0.01	0.01	0.01	0.07
Mg	0.80	0.98	0.97	0.98	1.50	1.66	0.33
Zn	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Li	-	-	-	-	-	-	1.12
ΣY	2.85	2.85	2.83	2.82	2.84	2.86	2.62
X-Ca	0.03	0.04	0.02	0.02	0.04	0.06	0.40
Na	0.43	0.60	0.62	0.57	0.66	0.76	0.49
K	0.01	0.01	0.01	0.01	0.01	0.00	0.00
ΣX	0.47	0.65	0.65	0.60	0.71	0.82	0.89
F^-	0.02	0.07	0.17	0.06	0.08	0.07	0.50
OH^+	3.98	3.93	3.83	3.94	3.92	3.93	3.50

*calculated from stoichiometry; **total Fe as FeO

Al and Ti contents and relatively high X-site vacancy (Figs. 1b, 3b; Tables 2, 3). Olive green Ca, Mg-rich elbaite associated with pale blue dravite in Bližná exhibits significantly different composition; apparently increased Ca, Mn, Ti and F concentrations (Tables 2, 3; Fig. 4c), high Li (up to 1.76 wt.% Li_2O) and depressed Fe and Mg contents (Fig. 2c).

Formation of fibrous blue dravite

Based on textural relations and chemical analyses, formation of blue dravite by a direct replacement of cordierite at early stages of the subsolidus crystallization at localities Strážek and Věžná is very likely. It may be generally expressed using the simplified mineral reaction: $3Na_{0.4}(Mg,Fe)_2Al_4Si_5O_{18}.\ nH_2O + 3B(OH)_3 + yH_2O + zCaO = 2(Na,Ca)_{0.7}(Mg,Fe)_3Al_6Si_6O_{18}(BO_3)_3(OH)_4 + 3SiO_2$ constant sum Al and R^{2+} is assumed; n, y, z - variable in different samples; $n < 1$, $y < 1$, $z < 0.5$ (approximately)

Natrium content in cordierite seems to be sufficient and its influx in fluids is not necessary. However, it is not excluded, particularly in Věžná, where all samples of dravite display relatively high Na contents and low X-site vacancy (Fig. 4b). An influx of Ca is apparent in the locality Bližná and in the Ca, Mg-rich dravite from Věžná (Table 1). The Fe/Mg ratio in cordierite and dravite may vary depending on the composition of metamorphic fluids and their participation in the reaction. Subsequent complete replacement of cordierite by a mixture of micaceous minerals at all localities, however, does not allow a more detailed discussion. Tourmaline is stabilized at pH < ~ 6.0 (Morgan - London 1989), acidic fluids contain > 0.3 wt.% B_2O_3 at T = 500 °C and P = 1 kbar (Weisbrod et al. 1986). Some H_2O (F, Mn) seems to be introduced, but lack of chemical data about replaced cordierite limits such discussion.

A direct replacement of the early crystallized Ca, Mg-rich elbaite by fibrous blue dravite in the Bližná pegmatite is quite negligible, consequently, derivation of the mineral reaction is not possible.

Discussion

Pegmatite-derived fluids indicate high activity of B but mostly low F and particularly Li activities. As all studied pegmatites are rich in tourmaline, high activity of B in fluids seems to be highly probable. Low activity of F found in all studied localities, except one sample from Věžná is interesting, because of F is a typical compound in residual fluids (Morgan - London 1987). However, all studied pegmatites are relatively poor in F, as can be seen from the absence or scarcity of lepidolite (Černý - Novák 1992, Novák et al. 1997). This fact very likely explains low F and Li contents in most blue dravites and in residual pegmatite-derived fluids as well. Increased activity of F in some samples from Věžná (Table 2) seems to be related to rare occurrence of lepidolite at the locality (Černý - Novák 1992).

Composition of blue dravite seems to be also a suitable indicator of composition of metamorphic fluids, where increased activities of Mg and Ca are commonly assumed (London et al. 1996). However, at the Strážek and Věžná localities, cordierite may be a sufficient source of Mg as is seen from mineral reaction given above. The metamorphic fluids perhaps did not supply any Mg into the replacement reaction or their control of the composition of blue dravite was negligible, particularly in the Strážek pegmatite located in gneiss. However, high Mg content in one sample from Věžná indicates an Mg influx from host serpentinite. Late blue dravite from Bližná commonly does not directly replace early Ca, Mg-rich elbaite, but it commonly forms overgrowths and small veinlets in elbaite locally associated with calcite. Hence, an influx of Mg via metamorphic fluids is significant.

Dolomite-calcite marble is a source for Ca in Ca-enriched blue dravite in Bližná. Calcium contents in blue dravite are increased relative to the other blue dravites, but lower then those found in early Ca, Mg-rich elbaite (Novák et al. 1997). An infiltration of Ca and CO_2 into pegmatite

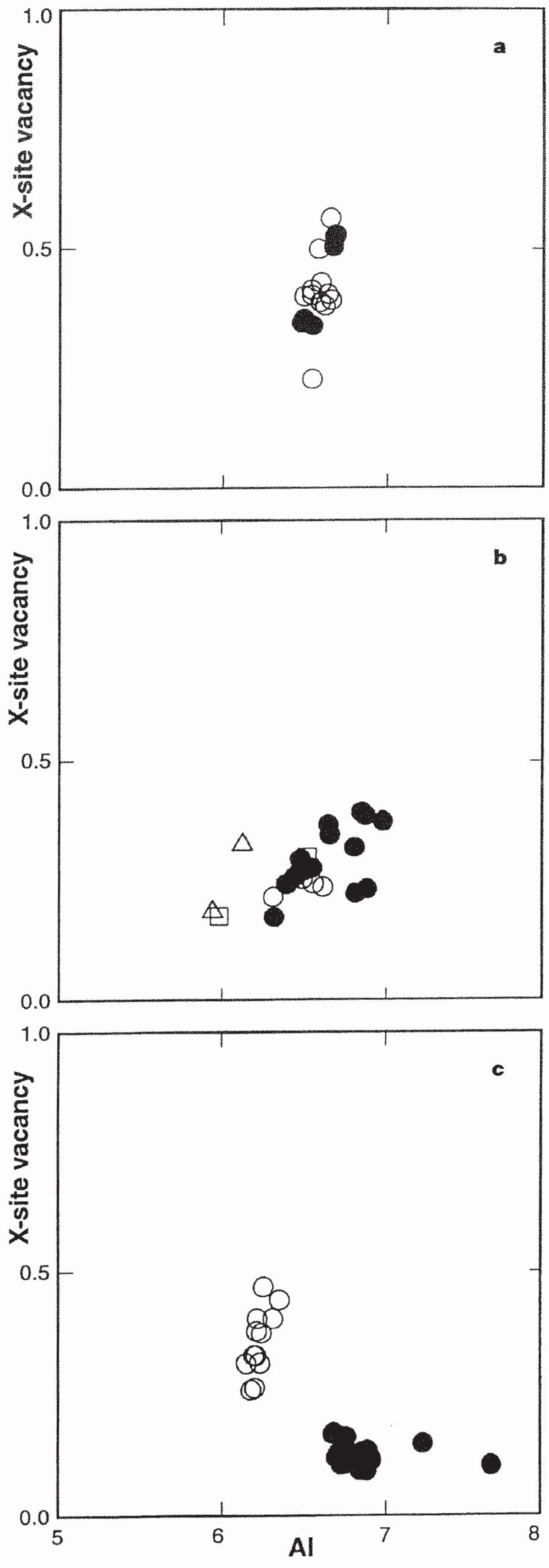

Fig. 3. X-site vacancy-Al diagram for blue dravite and associated tourmaline.
a - Strážek, b - Věžná, c - Bližná.
Same symbols as in Fig. 1

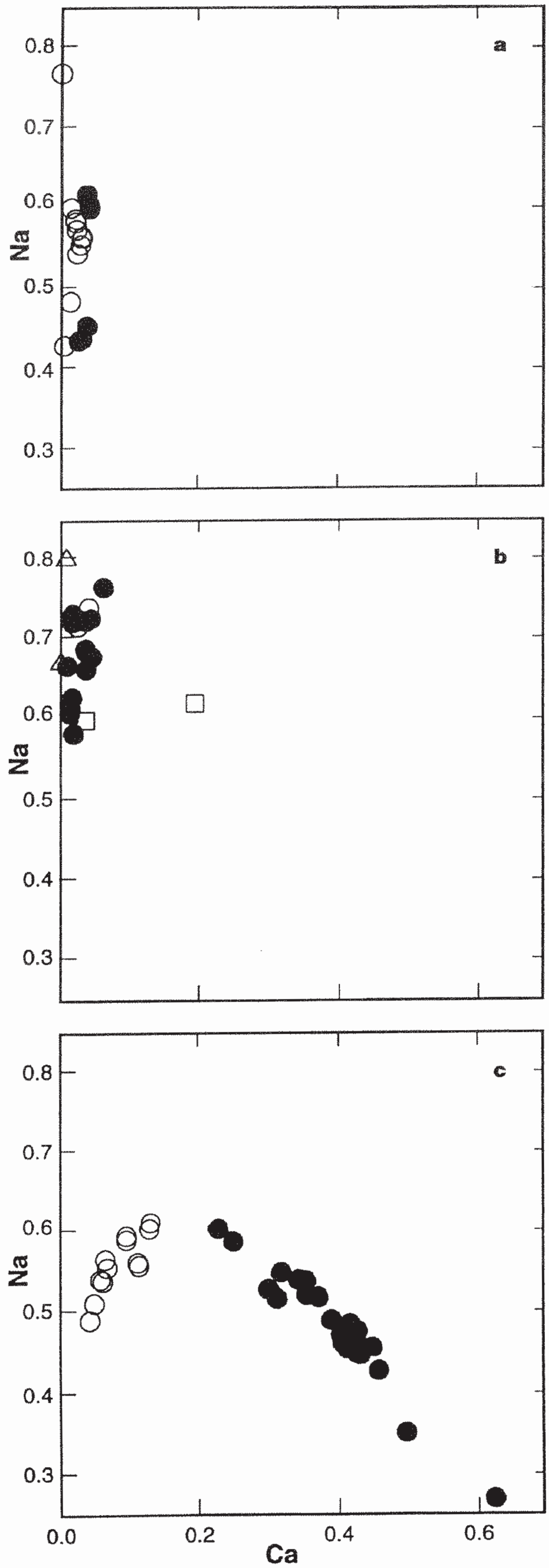

Fig. 4. Na-Ca diagram for blue dravite and associated tourmaline.
a - Strážek, b - Věžná, c - Bližná.
Same symbols as in Fig. 1.

through metamorphic fluids is very likely (Novák - Selway 1997b). As cordierite is typically Ca-poor (Černý - Povondra 1967, Černý et al. 1997), an influx of Ca indicated from Ca, Mg-rich dravite in Věžná is apparent (Table 2).

Regarding known pegmatite dikes containing fibrous blue dravite in the Moldanubicum, except the pegmatite from Strážek, they are hosted in Mg-rich rocks (dolomite-calcite marble, serpentinite). They also exhibit relatively small thickness (up to 4 m) and most of them homogeneous to subhomogeneous internal structure (Bližná, Vratěnín, Stupná, Drahonín). On the other hand, blue dravite is not known from symmetrically zoned dikes penetrating serpentinite or dolomite marble disregarding their small thickness in some cases (e.g., Nová Ves near Český Krumlov, Sušice I and III, Radkovice, Biskupice, Dolní Rožínka; Novák et al. 1992, Čech et al. 1981, unpubl. data of the author). These zoned pegmatites seem to be sealed from the host rock not only through most of magmatic stage but at least in early stages of subsolidus crystallization, and infiltration of metamorphic fluids into the pegmatite body is negligible or pronounced to relatively low temperatures. Homogeneous (subhomogeneous) dikes very likely exhibit fluid exchange between pegmatite and host rock (Novák - Selway 1997b), which promotes formation of fibrous blue dravite during subsolidus crystallization if the host rock and/or the replaced mineral are a sufficient source of Mg and Ca.

Conclusions

Blue dravite was found at several localities of Li-poor barren and complex granitic pegmatites, mostly penetrating Ca, Mg-rich rocks such as dolomite-calcite marble and serpentinite. Chemical composition is characterized by low but variable Fe/Mg ratio, low Ti, Mn, Li and F contents, and increased Ca amounts particularly in pegmatites from Ca-rich rocks. Blue dravite replaces cordierite during its reaction with pegmatite-derived acidic B-rich fluids in early stages of subsolidus crystallization at pH < ~ 6 and temperature above 450 to 500 °C.

Participation of Ca, Mg-rich metamorphic fluids in the replacement reaction is negligible in high temperature replacement of cordierite (Strážek, Věžná), but significant during low temperature formation of blue dravite + calcite in veinlets from Bližná and of Ca, Mg-rich dravite from Věžná.

Pegmatite-derived fluids in Li-poor granitic pegmatites studied are characterized by high activity of B but mostly low activities of F and Li. It is in a contrast with highly evolved Li-rich complex granitic pegmatites, where high activities of B, F and alkalis (Li, K, Rb, Cs) were documented (Morgan - London 1987, London 1992). However, abundance of B in pegmatite derived fluids is typical in both Li-poor and Li-rich complex granitic pegmatites.

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Modrý dravit jako indikátor složení fluid během zatlačovacích procesů v subsolidu v lithiem chudých granitických pegmatitech moldanubika

Modrý dravit s nízkým ale kolísavým poměrem Fe/Mg, nízkými obsahy Ti, Mn, Li a F, a místy se zvýšeným obsahem Ca byl nalezen na několika lokalitách lithiem chudých granitických pegmatitů v moldanubiku. Tyto pegmatity většinou pronikají horninami bohatými Ca a Mg, jako jsou dolomit-kalcitické mramory a serpentinity. Modrý dravit ze Strážku a Věžné přímo zatlačuje cordierit v počátečních stadiích krystalizace v subsolidu za teplot vyšších než 450 až 500 °C, podle zjednodušené reakce:

$3Na_{0.4}(Mg,Fe)_2Al_4Si_5O_{18}.\ nH_2O + 3B(OH)_3 + yH_2O + zCaO = 2(Na,Ca)_{0.7}(Mg,Fe)_3Al_6Si_6O_{18}(BO_3)_3(OH)_4 + 3SiO_2$

dříve, než byly relikty cordieritu úplně zatlačeny směsí slídových minerálů. Modrý dravit z Bližné vznikl v relativně pozdním stadiu krystalizace v subsolidu a vyskytuje se spolu s elbaitem s vysokým obsahem Ca a Mg. Fluida uvolněná z těchto pegmatitů vykazují vysokou aktivitu B, ale nízké aktivity F a Li. To je v rozporu se složením těchto fluid ve vysoce frakciovaných, lithiem bohatých komplexních pegmatitech, kde byly zjištěny vysoké aktivity B, F a alkálií (Li, K, Rb, Cs). Metamorfní fluida jsou bohatá Ca a Mg, ale jejich účast v reakcích produkujících modrý dravit je různá. Významný přínos metamorfních fluid je předpokládán při nízkoteplotním vzniku modrého dravitu v Bližné, ale jen malý během relativně vysokoteplotního zatlačování cordieritu ve Věžné a zvláště ve Strážku.