Tourmaline as a late-magmatic or postmagmatic mineral in granites of the Czech part of the Krušné hory - Erzgebirge batholith and its contact zone

Turmalín - pozdně magmatický až postmagmatický minerál granitů české části krušnohorského batolitu a jeho kontaktní zóny (Czech summary)

(2 text-figs.)

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Tourmaline is an accessory mineral of the Late Palaeozoic granites of the Krušné hory - Erzgebirge batholith (290-330 Ma). Its occurrence is distinctly regionally dependent; it is common in the Western pluton of the batholith and extremely rare in granites of the Eastern pluton. Very low content of Mg and Fe in granites cause the rare occurrence of tourmaline in the pluton in spite of a high content of boron in granite melt, e.g., in Blatná granite body. The magmas themselves were incapable of conserving much boron as displayed by the occurrences of tourmalinized phyllites and tourmalinites at contact of this body. All the tourmalines examined correspond to schorl-dravite series with a low content of uvite component, especially in metasedimentary rocks. A higher concentration of fluorine in tourmaline is in greisenized granites, whereas the lowest contents were found in tourmalines occurring in wolframite - quartz veins at Rotava. Thus the chemistry of tourmalines indicates the conditions of their crystallization.

Key words: tourmaline, chemical composition, Late Palaeozoic granites, Krušné hory Mts., Czech Republic

Introduction

Tourmaline is a common accessory in more evolved granites, associated hydrothermal products and pegmatites. In particular, Fe-Mg tourmalines are characteristic of peraluminous leucocratic granites accompanied by Al-minerals like andalusite, biotite, muscovite, garnet, or cordierite. Elbaitic types are also found in greisen zones (Benard et al. 1985). Tourmaline of magmatic origin is usually homogeneous with high Fe/Mg ratio, high F and Al in the divalent cations (Y) sites. Tourmaline of hydrothermal origin in granites displays commonly fine compositional zonation with a general tendency towards more magnesian composition near the schorl-dravite solid solution (i.e. little or no Al in Y site). Tourmaline precipitated in the contact aureole of granites reflects the composition of the host rocks with a tendency towards higher Fe^{3+}/Fe^{2+} (London - Manning 1995). The peraluminious granites, the main carriers of tourmalines are widespread in the European Hercynian belt including granitic rocks of the Bohemian Massif. The bulk analyses of granites from the Krušné hory batholith contain generally a lower content of boron compared with e.g., Cornubian granites (Hall 1973), granites of Massif Central (Pichavant - Manning 1980) or Portugal (Neiva 1974).

Within late Palaeozoic granites of the Krušné hory batholith (290-330 Ma) occurrences of tourmaline are distinctly regionally dependent. They are common in the Western pluton of this batholith but extremely rare in the granites of the Eastern pluton where they were observed e.g. in the two-mica granites of the Fláje granite stocks.

Chemical data on tourmalines from the granites of the Krušné hory - Erzgebirge batholith were absent, with exception of two analyses in the study by Povondra (1981). The purpose of this paper is to characterize the types of tourmalines by routine electron microprobe analyses and to discuss significance of tourmaline in the studied granites also with regard to the possible influence of the boron content in the transport of tin (e.g., Charoy 1982).

Geological position

The Krušné hory - Erzgebirge granite batholith consists of three plutons (Štemprok 1994) differing in the depth of their emplacement and erosion level. The highest amount of tourmaline in the Western pluton is in the Nejdek - Eibenstock body (Fig. 1). Numerous tourmaline-quartz nodules, mostly of round shape and attaining a diameter of up to 50 cm, were described by Schust et al. (1970) in Eibenstock granite. These nodules are relatively frequent and reach up to ten nodules per m^3. Schust et al. (l.c.) suggested that these accumulation are the results of postgranitic metasomatic processes between pegmatites and greisens. Increased amount of tourmaline occurs in the contact aureole of the Blatná granite as quartz-tourmaline-topaz metasomatites in phyllite (firstly described by Dieroff 1909) accompanied by accessory cassiterite (Pácal - Pavlů 1967, Roos 1976) in the vicinity of Podlesí and Pískovec. Tourmaline is rare in the granites of the Nejdek subpluton (Škvor 1975) and also in the Karlovy Vary subpluton as well as in transitional Kfely granite (TG); subordinate amount occurs in most types of granites of the younger intrusive complex (YIC). Evaluated tourmaline content is found also in the granites of Slavkovský les region (e.g., Třídomí type - Fiala 1968) acccompanied by andalusite, apatite, garnet and dumortierite. Local accumulations of tourmaline about 1.1 vol.% were found by Neužil - Konta

(1965) in Karlovy Vary (Tři kříže Hill). This amount corresponds to the boron content about 400 ppm similarly to some Cornish granites, England (Exley - Stone 1982). For comparison, Tischendorf et al. (1989) mentioned the range of boron in granites of Westergebirge - Vogtland from 17 to 26 ppm in OIC (Older intrusive complex) granites and from 34 to 43 ppm in YIC granites. Present authors detected in Karlovy Vary vicinity from 25 to 30 ppm of boron in OIC, and from 9 to 86 ppm in YIC granites. The occurrences of tourmalines in pegmatites (e.g., Smolné Pece also with Nb, Ta-oxide minerals) and in greisens (Pácal - Pavlů 1967, Pavlů 1969) show a wide range of tourmaline origin. The wide range is also shown by small dykes of medium grained tourmaline-biotite granite protruding coarse biotite adamellite (OIC) of the Abertamy part of the Nejdek subpluton. According to Sattran - Škvor (1960) these dykes represent filling of fissures replacing their salbands. Dyke rocks of the YIC with accessory tourmaline (Schovánek et al. 1980) were found also in three boreholes in the region of Zlatý kopec (Goldenhöhe) - Potůčky. Tourmalines (dravites) in metamorphic rocks of the Arzberg series described from the wider region of the Erzgebirge batholith by Abraham et al. (1973) show a problematic genetic connection with this batholith.

Sampling and analytical methods

Tourmaline was sampled in the main rocks units of Western pluton and its contact aureole with regard to the variable mineral association of the host rocks. Tourmaline from 11 localities was analysed by electron microprobe JEOL JXA 50A equipped with EDAX 711 for major and minor elements. Representative major element composition for 10 of these samples are given in Table 1 as means and uncertainties (2) for analysis of at least three spots on each tourmaline, representing part of grain of the same colour. Minerals as jadeite, diopside, leucite, apatite and synthetic phases - SiO_2, TiO_2, Fe_2O_3, MgO were used as standards for Na, K, Ca, Mg, Fe, Mn, Ti, Al, and Si. F and Cl were determined by EDAX, whereas boron was treated as stoichiometric and was not determined. Analyses were normalised to 31(O,OH,F) atoms.

Chemistry of tourmaline

The general formula for tourmaline is $XY_3Z_6B_3Si_6O_{27}(OH,O)_3(OH,F)$ where X = Na, K, Ca and vacancy, Y = Fe^{2+}, Mg, Mn^{2+} and Z = Al, Fe^{3+} Mg (when coupled with Ca in X) or 1.33 Ti^{4+} (Burt 1989, London -

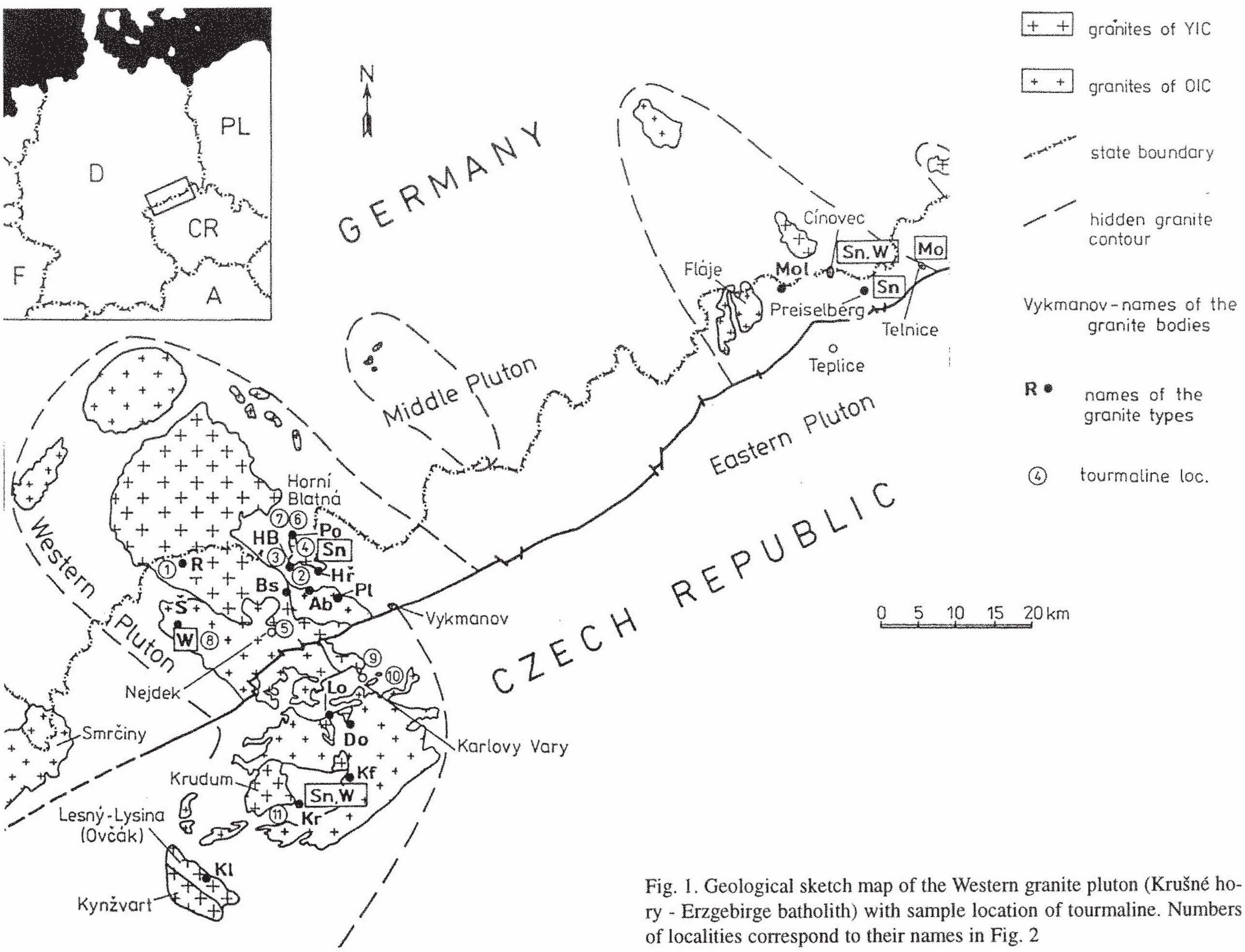

Fig. 1. Geological sketch map of the Western granite pluton (Krušné hory - Erzgebirge batholith) with sample location of tourmaline. Numbers of localities correspond to their names in Fig. 2

Manning 1995). The composition of tourmaline is represented in Al-Mg-Fe triangular diagrams (after Henry - Guidotti 1985 - Fig. 2). The amount of Al as atoms p.f.u. in Y position of tourmaline generally increases from 0.4 in lesser evolved granites to more evolved topaz-zinnwaldite granites and pegmatites (> 1). The concentric zonation given mainly by a different intensity of a brown or olive-green colour is remarkable mainly in the tourmalines from pegmatites. The changes to the blue colour occur mainly along cracs and inhomogeneities, probably as the result of change Fe^{3+} to Fe^{2+}. Fluorine content of tourmalines reflects the conditions and the environment of their crystallization. Tourmalines in greisenized granites have a higher fluorine content (up to 0.64 wt.% F), the lowest content is in tourmalines in quartz-wolframite veins from Rotava (0.22 to 0.37 wt.% F).

The intensity and colours of pleochroism in tourmaline varies considerably and the intensity does not always correlate with their chemical composition, similarly as it was described by London - Manning (1995) on the tourmaline samples from SW England.

Tourmaline in the main rock types

Rocks of the Nejdek subpluton and the Blatná granite body

Tourmaline occurs in biotite granites, two-mica granites and greisenized granites. It was studied in the localities of Blatná Hill, Rolava, Černá valley, Přebuz, Rotava abandoned Sn-mines and Podlesí. The tourmaline, according to classification plot (Fig. 2a), may be classified as schorl.

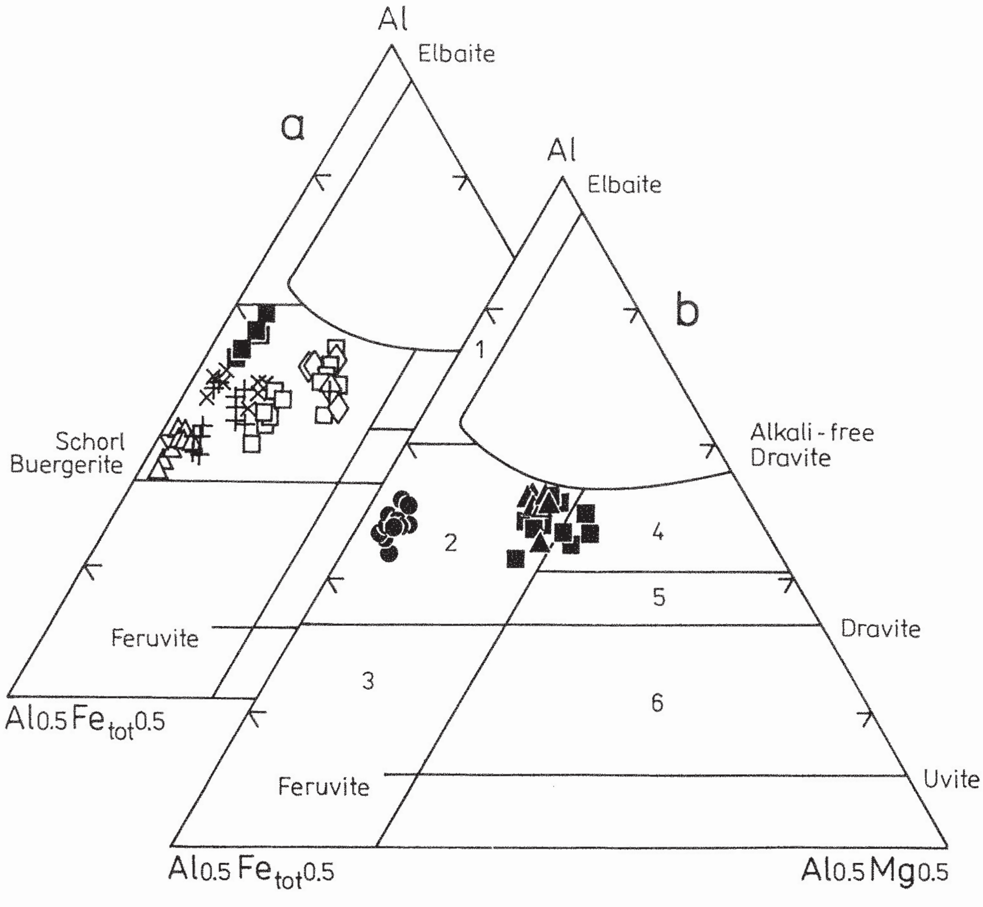

Fig. 2. Average composition of studied tourmalines plotted in triangular Al-Fe_{tot}-Mg diagram after Henry - Guidotti (1985)
Fields: 1 - Li-rich granitoids, pegmatites and aplites; 2 - Li-poor granitoids and their associated pegmatites and aplites; 3 - hydrotermally altered granites; 4 - metapelites and metapsammites coexisting with an Al-saturating phase; 5 - metapelites and metapsammites not coexisting with an Al-saturating phase; 6 - Fe^{3+}rich quartz tourmaline rocks, calc-silicate rocks, and metapelites.
a) Nejdek part of the Western pluton tourmaline from:
- biotite granite, *cross*, Rolava 1, Horní Blatná 2
- two-mica granite, x, Horní Blatná 3, Černá valley 4
- pegmatite, *full square*, Smolné Pece 5
- the contact, envelope of the Blatná granite body, *open square*, Podlesí 6
- greisenized granite, *open triangle*, Podlesí 7
- quartz - wolframite veins, *diamond*, Rotava 8
b) Karlovy Vary part of the Western pluton tourmaline from:
- two-mica granite, *full circle*, Karlovy Vary railway station 9, Tři kříže Hill 10
- pegmatite (zonal tourmaline), envelope of the Huber stock 11, i - rim *full triangle*, ii - core *full square*

The schorl from pegmatite at Smolné Pece is close to the tourmaline from Li-rich rocks and the tourmaline from greisenized granites (Podlesí) is very close to tourmalines from hydrothermally altered rocks. $Fe_{tot}/(Fe_{tot}+ Mg + Mn)$ ratio is highest in tourmalines from greisenized rocks at Podlesí and in granite Černá valley (0.91-0.95), but also tourmalines from all granite types are Fe-rich with high values (0.89-0.96). The deficiency of cations in position X is remarkable and the high values vary from 24 to 43 % in tourmalines from pegmatite in Smolné Pece, Blatná, Černá valley. Similarly the quantity of Al in tourmaline as atoms p.f.u. in Y position has an increasing tendency from lesser to more evolved rocks, i.e., from biotite granite (Černá valley) 0.40 to pegmatite (at Smolné Pece) 1.05. The fluorine content in tourmalines from Nejdek subpluton is higher in comparison with Karlovy Vary subpluton and varies from 0.23 (pegmatite Smolné Pece) to 0.60 (Podlesí greisenized granite).

Contact aureole of the Nejdek subpluton

Tourmalines occur in the contact zone of the Blatná body on several localities, the main concentration being in the vicinity of Podlesí. The amount of tourmaline locally increased and it replaced phyllites to tourmalinites. The contact metamorphosed metasediments within this area are impregnated by tourmaline, which is preferentially introduced along pelitic bands and foliation planes and also as younger small quartz-tourmaline-topaz veinlets perpendicular to foliation in size up to several cm.

Tourmaline is characteristically fine grained and, as expected, tourmaline chemistry reflects composition of the host rocks and contrasts with the chemistry of the granite hosted tourmaline in higher content of Mg and Ca and lower Fe (Table 1).

Projection points of the studied tourmalines in the plot (Fig. 2a) correspond mainly to schorl-dravite solid solution. The deficiency of cations in positions X is relatively higher in the range from 18.5 to 35 % and the quantity of Al as atoms p.f.u. in Y is higher (1.02). These tourmalines have relatively low $Fe_{tot}/(Fe_{tot}+ Mg + Mn)$ ratio from 0.74 to 0.85. Detected fluorine content is relatively high (0.30 to 0.55 wt.%).

The quartz-wolframite veins with tourmaline occur in the old abandoned wolframite mine near Rotava. The obtained chemical data on tourmaline are very similar to the data for tourmalinized phyllites (Fig. 2a); the difference is in the high content of dravite component, a lower uvite component, and a lower content of fluorine (0.13 to 0.22 wt.%). The amount of Al atoms in position Y is also high (> 0.57 atoms p.f.u).

Karlovy Vary subpluton

Occurrences of tourmaline were studied in the two-mica type YIC granites inclusive facies with topaz and zinnwalditized biotite from the vicinity of Karlovy Vary railway station and Tři kříže Hill. Besides disseminated grains of tourmaline in two-mica granite from Karlovy Vary (old quarry and road profile near the railway station) tourmaline forms aggregates occurring mainly in porphyritic facies. These quartz-tourmaline nodules are similar to those

Table 1. Representative electron microprobe tourmaline analyses (wt.%) of the Western pluton and its mantle (Krušné hory Mts.)

	Karlovy Vary subpluton		Nejdek subpluton					
	two mica granite K. Vary	pegmatite Krásno (mantle)	biotite granite Rolava	two mica granite Černá valley	greisenized granite Podlesí	pegmatite Smolné Pece	quartz- W veins Rotava(mantle)	tourmalinites Podlesí (mantle)
SiO_2	34.48	35.90	34.82	34.42	33.98	34.72	35.38	34.81
TiO_2	0.42	1.06	0.76	0.52	0.52	0.75	0.24	0.73
Al_2O_3	34.00	34.03	32.54	31.10	29.10	35.78	33.08	31.41
FeO_1	14.05	9.03	13.55	16.54	19.11	12.61	15.08	13.83
MnO	0.16	0.13	0.08	0.11	0.18	0.17	0.05	0.13
MgO	0.90	3.70	1.73	0.88	0.43	0.89	0.45	2.39
CaO	0.22	0.41	0.28	0.17	0.20	0.22	0.12	0.68
Na_2O	1.80	1.87	2.30	2.10	2.22	1.53	1.94	1.71
K_2O	0.03	0.05	0.22	0.09	0.12	0.08	0.08	0.07
H_2O^+	3.55	3.68	3.58	3.45	3.26	3.62	3.60	3.57
F	0.45	0.32	0.42	0.55	0.64	0.38	0.40	0.43
Si	5.854	5.952	5.910	5.941	6.013	5.815	6.004	5.945
Al	6.803	6.650	6.510	6.327	6.069	7.063	6.621	6.322
Ti	0.054	0.132	0.097	0.067	0.069	0.065	0.031	0.094
Fe^{+2}	1.995	1.252	1.923	2.388	2.828	1.766	2.140	1.975
Mn	0.023	0.018	0.012	0.016	0.028	0.024	0.007	0.019
Mg	0.228	0.915	0.438	0.226	0.113	0.222	0.114	0.608
Ca	0.040	0.073	0.051	0.031	0.038	0.039	0.022	0.124
Na	0.592	0.601	0.757	0.703	0.762	0.497	0.638	0.566
K	0.006	0.011	0.048	0.020	0.027	0.015	0.017	0.015
F	0.242	0.168	0.225	0.300	0.358	0.201	0.215	0.232
sum. oct	2.957	2.929	2.890	2.965	3.106	2.955	2.906	2.963
sum. alk	0.639	0.685	0.855	0.754	0.827	0.706	0.677	0.695

1 - total iron reported as FeO. H_2O^+ calculated by the program MINCALC (OH+F+O)=4

described by Schust et al. (1970). Their sizes range between a centimetre and a decimetre. These tourmaline - and quartz- rich nodules are surrounded by a halo of bleached granite, essentially free of biotite and tourmaline. The chlorite remnants after biotite indicate that the bleached zone results from the alteration and migration of at least Fe and Mg towards the nodules. The tourmaline nodules result from metasomatic circulation of boron-rich fluids. The activity of fluids proceeding the low temperature postmagmatic stage is visible on pseudomorphs after K-feldspars formed by the dickite-kaolinite mixture in surrounding granite. Tourmaline is unzoned, remarkably uniform and close to schorl in composition according to Al-Mg-Fe plots after Henri - Guidotti (1985) (Fig. 2b). Tourmalines from Li-poor granite of Karlovy Vary subpluton have high $Fe_{tot}/(Fe_{tot}+ Mg + Mn)$ ratios from 0.89 to 0.93 and are comparable with tourmalines from northern Portugal (Neiva 1974) as wellas south-west England (Power 1968).

A deficiency of cations in position X is remarkable and corresponds to the range 26-36 % (n = 25). Tourmaline grains are anhedral, interstitial, roughly 0.5-2.0 mm in dimension. The quantity of Al, as atoms p.f.u. in Y generally increases from 0.4 in lesser to 0.8 in more evolved topaz-zinnwaldite granites. The fluorine content of these granites is uniformly higher and lies in the range of 0.24 to 0.50 atoms p.f.u.

Contact aureole of the Karlovy Vary subpluton

In rocks of the contact aureole, i.e., gneisses of the Huber stock tourmaline was studied in a pegmatoid nest. This tourmaline is pen-case like and shows very expressive zoning given by the changing of khaki and olive green colours. The differences in chemical composition are not substantial, they are probably given by an undetermined variation in the Fe^{2+}/Fe^{3+} ratio. With regard to the projection points of chemical composition in Al-Fe-Mg plot, tourmaline may be classified as schorl containing a dravite component. Contents of Al atoms p.f.u. in Y decreases from the core to the margin while Mg has an opposite tendency. In comparison with tourmaline from granites these tourmalines have a lower $Fe_{tot}/(Fe_{tot}+ Mg + Mn)$ ratio from 0.57 to 0.88, and the deficiency of cations in position X varies from 17 to 46 %. In the marginal part the percentage of vacant positions increases. Al in Y position varies from 0.3 to 0.8. The fluorine content is relatively low (from 0.14 to 0.23 atoms of F in p.f.u.).

Discussion

The composition of tourmaline from the Western plutons plots mainly in the field in Li-poor granite rocks, pegmatites and aplites (Henry - Guidotti 1985) (Fig. 2a,b). In the Karlovy Vary subpluton the composition of tourmaline from a pegmatitic nest (in the contact aureole of the Huber stock) also plots partly in the field of metapelites and metapsamites with Al-saturating mineral phase. As shown in Fig. 2a, the composition of tourmaline from a pegmatite from two mica granite (Horní Blatná) and from a greisenized granite lies close to schorl-elbaite join whereby the composition of greisenized granite is closed the border of the field of hydrotermally altered granitic rocks. The composition of tourmaline in quartz-wolframite bearing veins from Rotava and the tourmalines from tourmalinites carrying tin mineralization in Podlesí are closer to the field 5 (Fig. 2a,b).

The studied granitic rocks in the Western pluton of the Krušné hory batholith are relatively B-rich, in addition to possessing elevated concentrations of F (Štemprok 1993) and P (Breiter - Frýda 1994, Štemprok et al. 1995). It is evident from the results of previous studies that granite magmas containing some initial amount of boron often evolved to more fractionated magmas, in which boron only partly was bonded as tourmaline. The extensive aureole of metasomatic tourmaline at the contact of the Blatná granite body in the vicinity of Podlesí, i.e., in the environment of metapelitic host rock representing a sufficient source of Mg and Fe (c.f. London - Manning 1995), indicates introduction of boron from the granite. Tourmalinization of host rocks along contact with boron-bearing leucogranites is a widespread phenomenon (Kretz 1968, Proctor - El-Etr 1968, Harris 1974).

The granitic rocks with tourmaline from the studied

Table 2. Occurrences of the studied tourmalines and their mineral assemblage

Host rock	Tourmaline assemblage		
	late-magmatic		postmagmatic
Biotite granite	quarz, albite, siderophyllite, topaz	tourmaline	chlorite, fluorite
Two-mica granite	quartz, albite, muscovite, Li-micas, tourmaline →		adularia, dickite, kaolinite, quartz, cassiterite, carbonate
Pegmatite	quartz, albite, K-feldspar ± Li-siderophyllite, tourmaline, Nb-Ta oxide, rutile		sericite
Albitized granite to greisenized granite	albite, quartz, Li-micas, muscovite, topaz	tourmaline	topaz II, quartz II, sericite, fluorite cassiterite, sulphide
Metapsamnite and metapelite (contact metamorphosed)			chlorite, muscovite, tourmaline, quartz, sericite, pyrite, cassiterite, topaz

area show a higher content of Sn (e.g., 20 ppm in YIC granites from Karlovy Vary profile, Štemprok et al. 1996) and the occurrences of cassiterite at Písky, Podlesí etc. (Pácal - Pavlů 1964, Roos 1976) are tied to tourmalinized rocks. Granites, especially YIC granites of Western pluton, are markedly rich in phosphorus, which also, like fluorine, decreases the solidus temperature of hydrous melt and causes expansion of the liquidus field (London et al. 1993) from magmatic to hydrothermal regimes (Henderson - Martin 1985, London et al. 1989). London et al. (1993) suggested and proved by experimental study that increased concentrations of boron, phosphorus and fluorine drive the path of melt evolution. This melt fractionation promotes increasing concentration of normally insoluble metals, especially high-field-strength elements in melt.

Tourmalines represent products of the high temperature magmatic crystallization to postmagmatic alteration of rocks by the volatile-rich fluids associated with cooling of the most evolved granitic intrusives (Tab. 2). Cassiterite is the main ore mineral of Sn commonly associated with fluorite and/or tourmaline. This association is not a real proof of the role of boron in tin transport but the presumption are in favour of this. The relationship tourmaline - Sn mineralization is not so expressive in the Krušné hory - Erzgebirge region owing to low content of ferromagnesian minerals in more evolved S-types of granites associated with Sn deposits. However, this relationship is very conspicuous from many localities in SAR (Rozendaal et al. 1986), Namibia (Pirajno - Jacob et al. 1987), Tasmania (Wright - Kwak 1989), Cornwal (Moor 1982), and Russia (Kuzmin et al. 1979).

Conclusion

The studied late-magmatic to post-magmatic tourmalines from the late-Variscan western Pluton of the Krušné hory - Erzgebirge batholith were found in biotite granites, muscovite-biotite leucogranites, pegmatites, quartz-wolframite hydrothermal veins and in the metamorphic rocks at the contact of granite bodies. Most of these tourmalines correspond to schorl tourmaline in their chemical composition. In the classification diagram of Henry and Guidotti (1985) they fall within the field of Li-poor granitoids and their associated pegmatites and aplites. The projection points of tourmalines from the same locality within this field are very closely accumulated. Only slightly different chemical compositions were observed, e.g., between the core and rims in tourmaline from pegmatite in gneisses of the contact aureole around Huber stock (Horní Slavkov). The chemical composition of tourmaline is strongly influenced by the chemical composition of the host rock. A good example of this relation represents the locality Podlesí where ferrous tourmalines from greisenised granite substantially differ from the tourmaline in neighbouring contact phyllites with the highest contents of Mg and Ca (dravite and uvite components) among the studied tourmalines. The boron specialization of the Western pluton is manifested also in the increased boron in the bulk analyses of rocks accompanied by increased phosphorus and fluorine.

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Turmalín - pozdně magmatický až postmagmatický minerál granitů české části krušnohorského batolitu a jeho kontaktní zóny

Turmalín se vyskytuje v granitech krušnohorského batolitu jako celku akcesoricky, jeho množství však lokálně vzrůstá až do několika obj.%. Výskyt turmalínu je regionálně podmíněn a vázán na granity mladšího intruzivního komplexu. Zatímco v YIC granitech západní části batolitu je výskyt turmalínu běžný, ve východní části se objevuje ojediněle. Velmi nízké obsahy Mg a Fe v granitech YIC jsou důvodem řidšího výskytu turmalínu, navzdory tomu, že množství bóru v granitické tavenině bylo vysoké. Důkazem tohoto tvrzení je např. blatenský granitový masivek, jehož horniny obsahují turmalín v množství řádově kolem 1 %, zatímco na kontaktu granitu s okolními metasedimenty v nich došlo ke vzniku turmalínovců.

Všechny studované turmalíny odpovídají schorl-dravitové sérii s nízkým obsahem dravitové popř. uvitové komponenty. Obě tyto složky vzrůstají zejména při výskytu turmalínů v plášťových horninách granitů. Variace chemického složení v rámci jednotlivých lokalit jsou poměrně malé. Nejvyšší koncentrace fluoru v turmalínech byly zjištěny v greisenizovaných granitech, zatímco nejnižší se vyskytují v turmalínech wolframit-křemenných žil na lokalitě Rotava. Pouze malá část turmalínů, zejména v pegmatitech, vykazuje výraznou zonálnost, projevující se barevně. Běžné jsou také změny barvy v turmalínech, vázané na okolí trhlin, které byly vyvolány hydrotermálními fluidy již v pevném stavu. Výzkum potvrdil vliv hostitelských hornin na chemické složení turmalínů, tj. závislost na podmínkách a prostředí jejich krystalizace.