Field stop B.2.3 **Vlastějovice near Zruč nad Sázavou** **June 15, 2015**

Anatectic amphibole-bearing pegmatites and tourmaline-bearing granite-pegmatite system (LCT, barren to elbaite-subtype) contaminated from host Fe-skarn

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Introduction

Contamination from a host rock is a common feature of many granitic pegmatites. It is evident particularly in those pegmatites, which are enclosed in rocks with contrasting chemical composition (e.g., Martin-Izad *et al.* 1995; Novák *et al.* 1999c, 2012, 2013a; Ackerman *et al.* 2007; Novák and Dosbaba 2012); nevertheless, low degree of contamination of pegmatite melts is likely in majority of pegmatites (Novák 2007). Contamination may generally proceed in three distinct stages (Novák 2007): (i) Pre-emplacement stage (PRE) - contamination of pegmatite melts proceeded during their propagation from fertile granite to the place of pegmatite solidification (Novák *et al.* 2012); (ii) Post-emplacement stage (POE) - contamination of pegmatite melt from host rock in situ (Novák *et al.* 2013a); (iii) Hydrothermal (subsolidus) stage – high to low temperature alterations of a solid pegmatite by fluids infiltrating from host rocks largely after thermal and fluid re-equilibration of pegmatite and host rock (Dosbaba and Novák 2012). The pre-emplacement and post-emplacement contaminations may generally involve the following major mechanisms: assimilation (dissolution) of fragments of solid rocks in pegmatite melt followed by a more or less perfect homogenization of such contaminated melt (Novák *et al.* 2012), and infiltration (diffusion?) of fluids from host rocks into pegmatite melt.

Granitic pegmatites in the Moldanubian Zone are very illustrative to demonstrate contamination of granitic pegmatites because they quite commonly cut rocks with highly contrasting chemical compositions (Fig. B-15). Pegmatites cutting serpentinite with evident Mg- and minor Ca-contaminations are the most abundant as small bodies with thick reaction rims composed of anthophylite, actinolite, phlogopite, chlorite and/or vermiculite. Oligoclase is a dominant mineral in these pegmatites, whereas quartz and chiefly K-feldspar are minor, rare to absent. Quartz is commonly at least partly dissolved or replaced by clay minerals (e.g., Dosbaba and Novák 2012). Additional primary minerals biotite, cordierite, and tourmaline are typically Mg-rich. Widespread late hydrothermal alteration processes produced prehnite, scapolite, carbonates, clay minerals and zeolites. Typical localities of contaminated pegmatites include beryl-columbite pegmatites Věžná I and II, and barren pegmatites Drahonín, Nová Ves u Hrotovic and Utín near Havlíčkům Brod (Novák *et al.* 2003; Novák 2005; Dosbaba and Novák 2012; Prokop *et al.* 2013). Pegmatites cutting dolomite and calcite marbles with evident Ca- and Mg-contaminations are less common and degree of contamination is commonly lower relative to the pegmatites from serpentinites. Reaction rims between pegmatite and host marble, if present, are usually thin and include diopside, tremolite, grossularite, epidote, vesuvianite, and/or wollastonite. The most interesting locality contaminated by carbonate rocks is the elbaite pegmatite Bližná I near Černá v Pošumaví, southern Bohemia with Ca,Mg-rich elbaite, dravite, uvite, diopside, andesine, titanite, allanite-dissakisite and primary bastnaesite (Novák *et al.* 1997a, 1999c, 2012). Pegmatites cutting Fe-skarn with Ca-, Fe-, F- and REE-

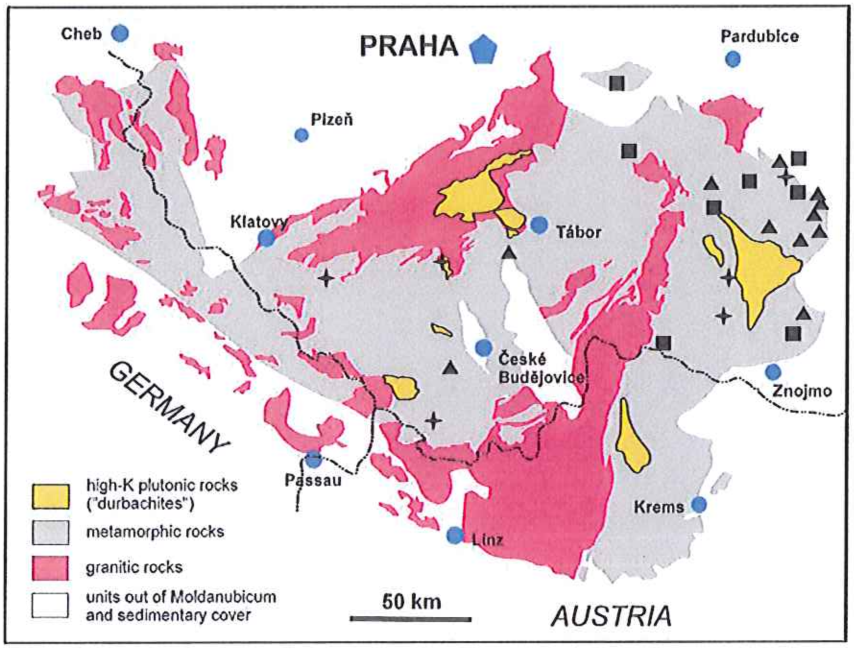

Fig. B-15. Schematic geological map of the Moldanubian Zone with major occurrences of contaminated pegmatites of groups IIc and IIIa, crosscutting skarns, serpentinites or marbles; (modified from Novák and Cempírek 2010).

■ pegmatites in skarns ▲ pegmatites in serpentinites ✦ pegmatites in marbles

contaminations also are quite common and they are known from several localities such as Rešice and Líšná, western Moravia and chiefly from Vlastějovice nad Sázavou, central Bohemia (Vavřín 1962; Žáček *et al.* 2003; Ackerman *et al.* 2007; Kadlec 2007; Novák 2007; Novák *et al.* 2013a), where well-exposed, numerous pegmatite dikes with dominant oligoclase, amphibole, biotite, fluorite, and allanite, and less common tourmaline-bearing pegmatites occur at large quarry.

Geological setting

The locality Vlastějovice is situated in the Ledeč-Chýnov belt of Variegated Group (Drosendorf terrane), Moldanubian Zone (Fig. B-16). Dominant two-mica to locally migmatized biotite-sillimanite gneisses contain common intercalations of amphibolite, pyroxene gneiss, quartzite, marbles, and common two-mica tourmaline-bearing orthogneisses. Several lenticular bodies of Fe-skarns, up to several tens m thick and several hundreds m long, occur in the NE-SW trending synclinal structure at Vlastějovice. Small bodies of leucocratic granites and simple tourmaline-bearing pegmatites with garnet (e.g., Březina, Nosatá skála; Novák *et al.* 2013a) are common in this region as well. The Fe-skarn body is highly heterogeneous and consists of: skarn s.s. - monomineral massive garnetites and banded garnet-clinopyroxene (andradite-grossular + hedenbergite-diopside + magnetite ± allanite); clinopyroxene-garnet-epidote rock; lenses of massive magnetite, up to several m thick; and minor hybrid rock (hastingsite + almandine + biotite + quartz + K-feldspar + plagioclase) located between Fe-skarn and surrounding gneisses. These Fe-skarns were regionally metamorphosed at the conditions T ~ 590-680 °C and P ~ 0.45-0.65 GPa (Fig. B-1) corresponding to the main Variscan metamorphic event (Žáček 1997).

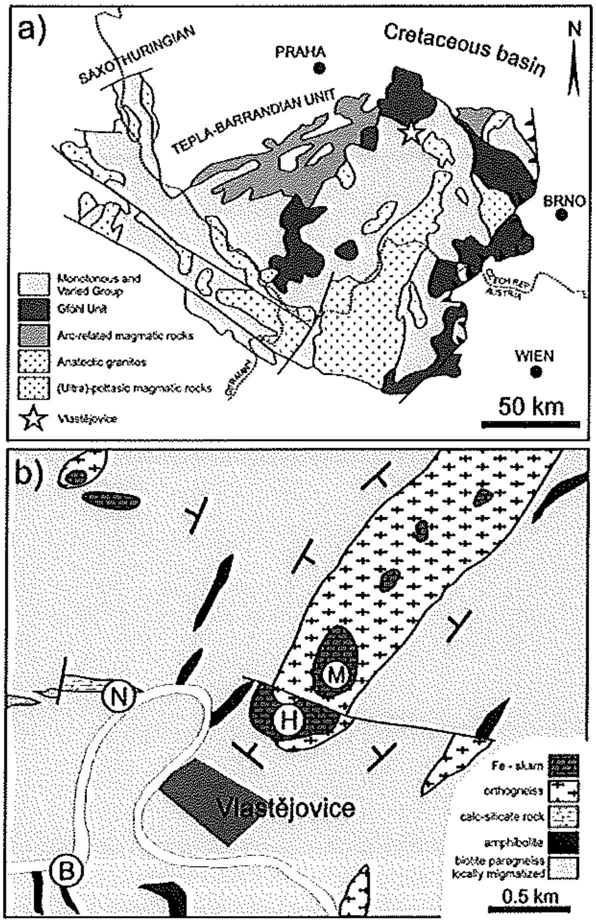

Fig. B-16. a) Schematic geological map of the Moldanubian Zone showing the major geological units and the position of Vlastějovice; b) Geological sketch of the Vlastějovice region. H – Holý vrch quarry, M – Magdalena quarry, N – Nosatá skála pegmatite, B – Březina pegmatite. Modified from Koutek (1950).

Granitic pegmatites

Three principally distinct types of pegmatites were distinguished at the Vlastějovice region (see Žáček *et al.* 2003; Ackerman *et al.* 2007; Kadlec 2007; Novák *et al.* 2013a).

Pre-Variscian tourmaline-bearing pegmatites from orthogneiss (Qz~Kfs~Pl) occur as elongated pods, up to about 0.5-1.5 m long and up to 0.5 m thick, in the Holý vrch quarry and show transitional contacts. Elongation of pods commonly follows foliation of the host orthogneiss; however, foliation of the orthogneiss does not continue into coarse-grained pegmatite. The pegmatites are simply zoned showing increasing grain size from the contact inwards and locally small quartz core. Biotite, common in outer part of pegmatite pods, mostly predominates over prismatic crystals of black tourmaline (dravite, schorl), up to 10 cm long, more common in centre. Large flakes of muscovite and small grains of green fluorapatite are common; other accessory minerals such as zircon are rare (Novák *et al.* 2013a).

Amphibole-bearing pegmatites ($Plg_{An0\text{-}35}$>Qtz>Kf) form numerous (up to about 100) dikes and complicated bodies (Fig. B-17), from 10 cm to 1 m thick, with homogeneous to subhomogeneous internal structure. They cut Fe-skarn and have not been found outside of the skarn body including hybrid rock on the contact with host orthogneiss. Coarse-grained pegmatites contain locally abundant amphibole, fluorite, biotite, hedenbergite, garnet, accessory allanite-(Ce), titanite and very rare ferroaxinite and schorl. Monomineralic grey quartz forms locally irregular masses and veins located along the contact with host skarn and enclosing its fragments and crystals of amphibole. Abundant reaction rims, up to 30 cm thick, consist of dominant amphibole and locally also fluorite, biotite, and Ca-rich $plagioclase_{An6\text{-}35}$ relative to Ca-poor $plagioclase_{An0\text{-}20}$ from the central portions of pegmatite (Ackerman *et al.*

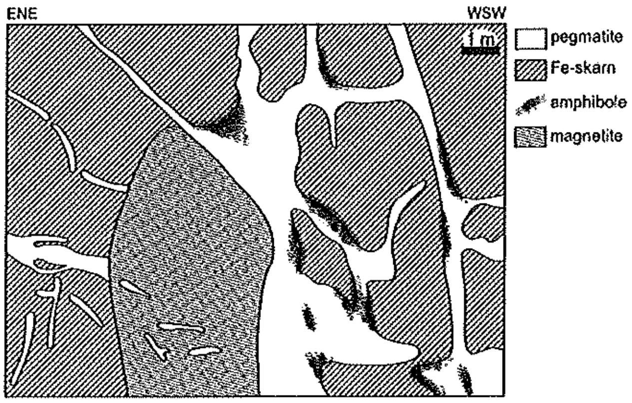

Fig. B-17. Amphioble-bearing pegmatites cutting Fe-skarn. Modified from Novák and Hyršl (1992)

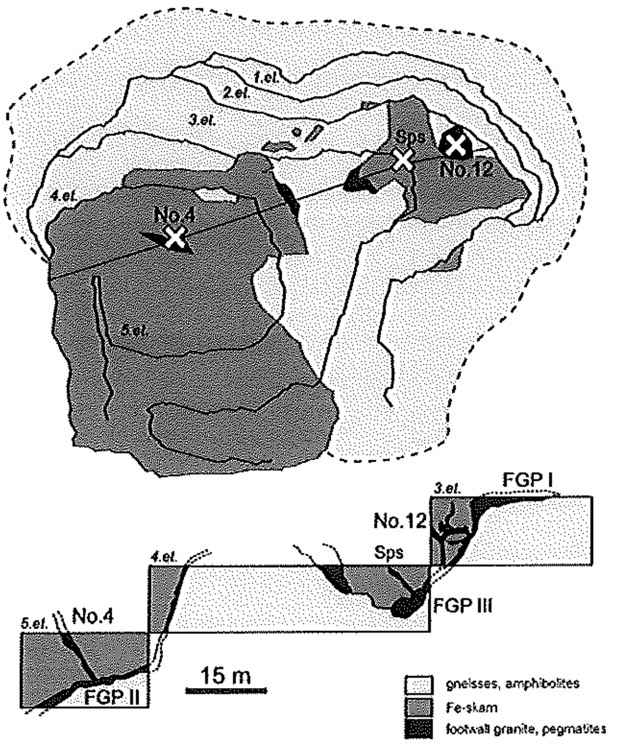

Fig. B-18. Above - schematic geological map of the Holý Vrch quarry; bellow – cross section through the Fe-skarn, orthogneiss, Footwall granite-pegmatite (FGP) and related tourmaline-bearing pegmatites (No.4, No.12, and Sps-Spessartine pegmatite). After Novák *et al.* (2013a)

2007; Novák *et al.* 2013a). Allanite, hedenbergite, garnet, epidote, calcite, wollastonite, magnetite, chlorite, prehnite, apophyllite and pyrite occur in minor amounts in marginal parts of pegmatite dikes or as products of late hydrothermal processes and/or contamination (Vavřín 1962; Žáček and Povondra 1991; Novák and Hyršl 1992; Žáček *et al.* 2003).

Tourmaline-bearing pegmatites form rare dikes, 20 cm to 4 m thick, with homogeneous to simply zoned internal structure, cutting Fe-skarn and also biotite and pyroxene gneisses (Březina and Nosatá skála) at the Vlastějovice region. They contain minor to accessory biotite, tourmaline, fluorapatite, whereas primary muscovite and garnet were found only in the pegmatite bodies hosted in gneisses except the Spessartine dike. The pegmatites enclosed in Fe-skarn locally have thin reaction rims, 1 mm to 1-3 cm thick, with amphibole and less commonly also with biotite, garnet, fluorite and allanite. They are members of granite-pegmatite system represented by ***footwall granite*** (Fig. B-18) and several tourmaline-bearing pegmatite dikes (about 15 dikes were observed during last 30 years). Granite body occurs along the footwall contact of the Fe-skarn body and underlying orthogneiss as tectonically broken dike, about 200 – 250 m long and up to ~ 6 m thick in current outcrops (Fig. B-19d). It texturally evolves from medium- to coarse-grained and locally porphyric granite to coarse-grained granite with large blocks of K-feldspar, locally up to 30 cm in size. Accessory tourmaline is locally present. Footwall granite evidently generated several pegmatite dikes (Fig. B-18) varying from texturally and mineralogically simple dikes ($Kf{\sim}Qtz{>}Plg_{An0\text{-}31}$) with rare tourmaline and locally amphibole, biotite and chlorite (**dikes No. 12 and 4**) to more evolved ***Spessartine pegmatite***. It forms a zoned dike, up to 0.5 m thick and ~ 20 m long (Fig. B-19d,f), mined out in 2008. It consists of dominant coarse-grained unit with locally developed graphic unit, blocks of K-feldspars, small quartz core and fine-grained albite locally with small masses of fluorite and several accessory minerals. The most evolved ***Elbaite pegmatite***, which occurred in the western part of the Fe-skarn body and was very likely derived from the Footwall granite, was completely mined out in mid 1980ies. This pegmatite dike, up to 2 m thick, exhibited simply zoned internal structure with fine- to medium-grained outer zone, coarse-grained inner zone with abundant graphic intergrowths (quartz + K-feldspar, quartz + tourmaline), blocky K-feldspar, albite and rare pockets with red elbaite, bavenite and datolite (Čech 1985; Povondra *et al.* 1985).

Very rare crosscutting dikes of amphibole-bearing and tourmaline-bearing pegmatites found recently confirmed that highly contaminated amphibole-bearing pegmatites crystallized earlier. Ackerman *et al.* (2007) suggested based on the detailed study of fluid inclusions and geological constraints (geothermal gradient, haplogranite solidus with 4.5 wt.% B_2O_3, feldspars thermometry) the following conditions for formations of the amphibole – bearing and the Elbaite pegmatite: $H_2O - CO_2$ low salinity fluids ($H_2O\text{-}CO_2/N_2\text{-}H_3BO_3$ - NaCl fluids); P = 0.40-0.58 (0.31-0.43) GPa; T = 600-

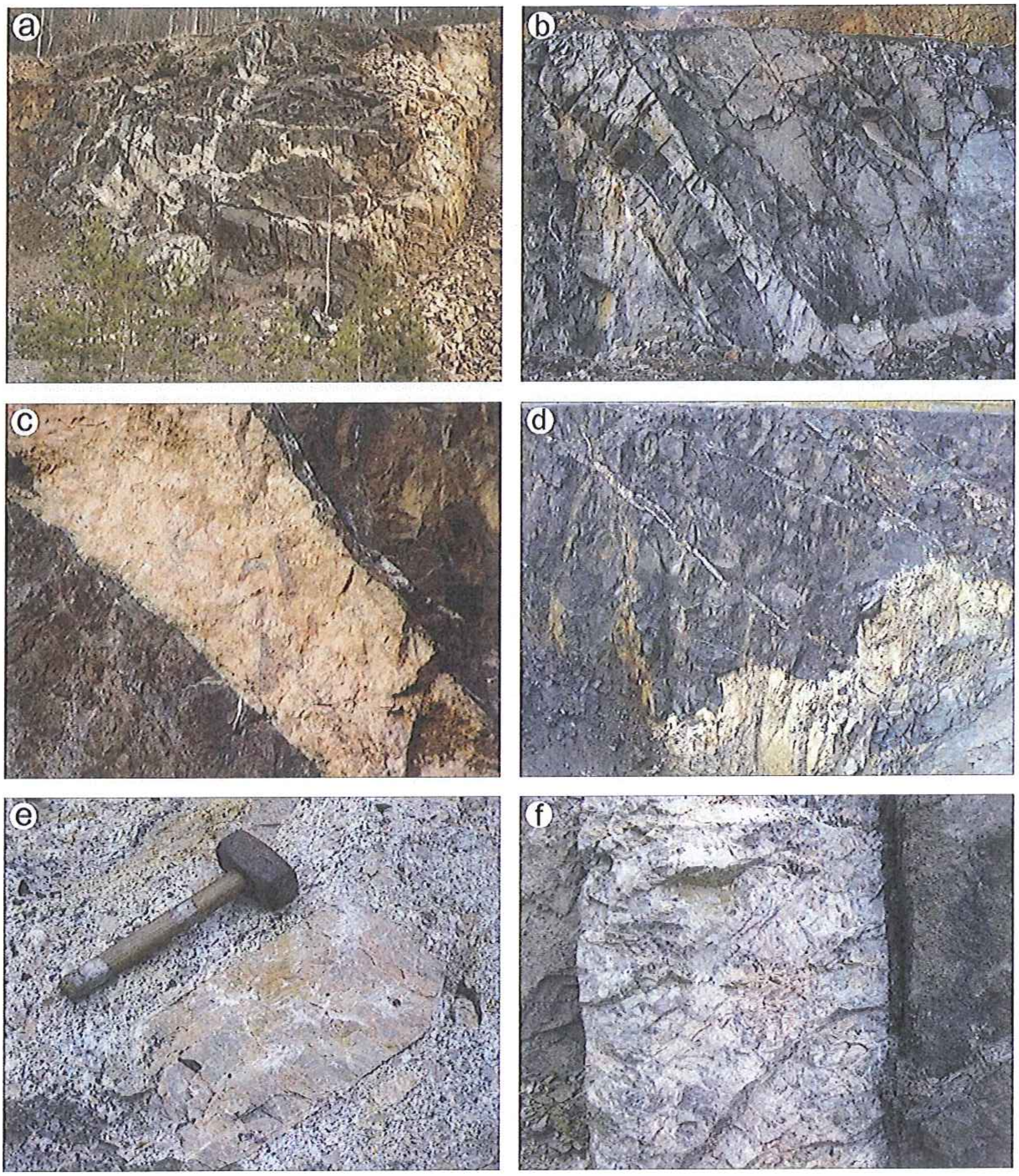

Fig. B-19. Tourmaline-bearing pegmatites cutting Fe-skarn. a) Footwall granite-pegmatite (granite I - right side) and Pegmatite No. 12 (left side); b) Footwall granite-pegmatite (granite II) and Pegmatite No. 4 up to 1 m thick; c) detail of the Pegmatite No. 4, about 30 cm thick, note thin reaction rim with amphibole in garnet skarn (left footwall); d) Footwall granite-pegmatite (granite III) and thin dike of the Spessartine pegmatite up to 50 cm thick; e) large crystal of K-feldspar with grains of black tourmaline in the Footwall granite-pegmatite (granite III); f) detail of the Spessartine pegmatite, note sharp contacts. Field situation on 28/3/2009 - a), 19/1/2007 - b), 10/12/2004 - c), 2/6/2009 - d), 6/7/2007 - e), 31/3/2007 - f); Modified from Novák *et al.* (2013).

640 (500-570) °C (Elbaite pegmatite in parenthesses). The host rock temperature during the Elbaite pegmatite emplacement was estimated at ~ 300 °C. The P estimated for the Elbaite pegmatite is slightly higher relative to the complex pegmatites in the Moldanubian Zone, where presence of primary petalite and locally abundant andalusite and sekaninaite suggests P < ~ 0.30 GPa (Novák 2005; Novák *et al.* 2013a).

Mineralogy

In order to demonstrate evident differences in contamination between amphibole-bearing pegmatites enclosed exclusively in Fe-skarn and and tourmaline-bearing pegmatites, cutting both Fe-skarn and gneisses, we focused on chemical composition of the individual minerals (amphibole, biotite, tourmaline and garnet) as well as overall mineral assemblages.

Amphibole-bearing pegmatites

Their mineral assemblages involve along with major oligoclase to andesine, quartz and locally K-feldspar and the following minor to major primary minerals - **amphibole** > **fluorite** > **biotite** > **hedenbergite** > **andradite-grossularite** ~ **allanite** ~ **epidote** ~ **titanite** ~ **calcite** ~ **magnetite**. Subhedral to euhedral crystals of yellowish-brown **titanite**, ≤ 10 mm in size, occur in black amphibole and fluorite chiefly from reaction zones between pegmatite and skarn. Titanite is Al-rich (≤ 0.31 *apfu*) and contains also elevated Fe ≤1.71 wt.% of FeO = 0.05 apfu; 1.59 wt.% F (0.16 *apfu*) and 0.74 wt.% H_2O (0.16 *apfu* OH) (Mrázek and Vrána 1985). Abundant dark violet, purple to rare colorless **fluorite** forms coarse-grained aggregates in pegmatite or in exocontact zone, up to several dm in size. Fluorite locally predominates over quartz and feldspars. It is closely associated with allanite with deep violet to black rims around allanite grains. Ackerman (2005) presented REE-geochemistry and fluid inclusions study and suggested that fluorite crystallized under magmatic-hydrothermal transition conditions. **Biotite** is close to annite (Fig. B-20a). Quite common **REE-epidote** to **allanite-(Ce)** present in amphibole-bearing pegmatites and host skarn is often replaced by secondary fluorcarbonates (e.g., **bastnäsite**).

Amphibole

Black to green-black amphibole as euhedral to subhedral phenocrysts, up to ~10 cm in size, and massive, coarse-grained aggregates occur namely in amphibole-bearing pegmatites, it is rather rare in tourmaline-bearing pegmatites. They belong to **hastingsite** (potassic to potassian) to **ferro-edenite** with Fe^{3+} > ^{VI}Al (Fe^{3+} 0.70-1.07 *apfu*, ^{VI}Al = 0.18-0.30 *apfu*), high X_{Fe} (0.84- 0.72), and highly variable ^{A}K (0.23-0.66 *apfu*) and ^{A}Na (0.22-0.41 *apfu*). Moderate F (0.69-0.72 wt.%; 0.35-0.37 *apfu*) and 1.61-1.72 wt.% H_2O (1.74-1.85 *apfu* OH; Žáček and Povondra 1991; Novák *et al.* 2013a) are typical. Chemical compositions of amphibole from both pegmatite types are similar (Fig. B-20b), but in the tourmaline-bearing pegmatites ferroedenite predominates.

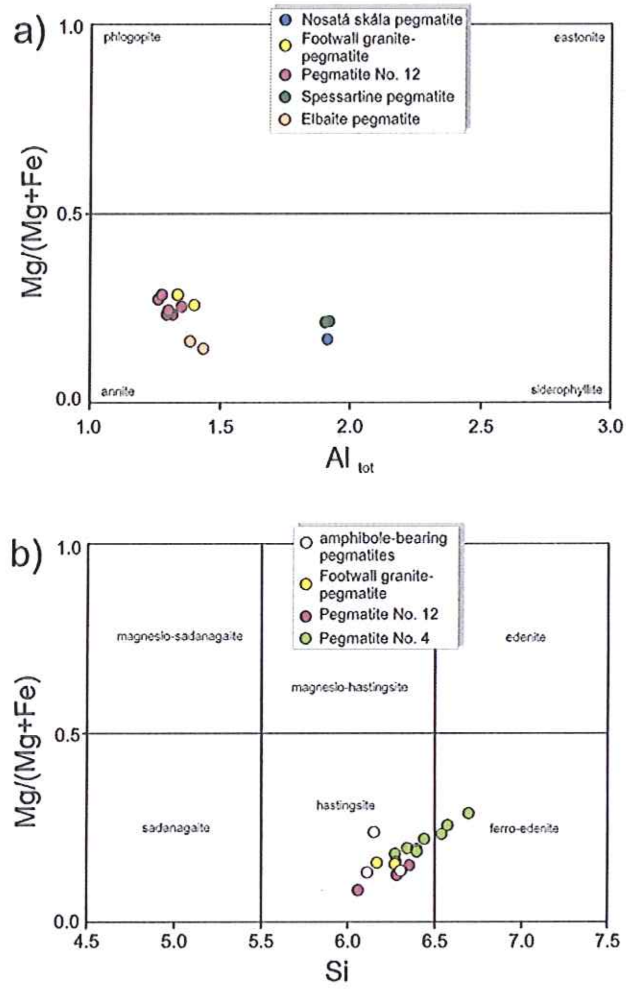

Fig. B-20. Compositional diagrams of biotite (a), and amphibole (b) (Leake *et al.* 1997) from granitic pegmatites in the Vlastějovice region. Amphibole analyses from ampfibole-bearing pegmatites taken from Žáček and Povondra (1991), Žáček (2007) and Novák *et al.* (2013a).

Tourmaline-bearing pegmatites

Mineral assemblages of tourmaline-bearing pegmatites are very different from the amphibole-bearing pegmatites except for presence of quartz, plagioclase, K-feldspar, and biotite. Also several very rare accessory minerals (fluorite, titanite, amphibole, allanite), occurring in minor to major amounts in amphibole-bearing pegmatites, are alike. Along with tourmaline, biotite and locally minor amphibole (Fig. B-20b) simple pegmatites contain accessory **fluorapatite**, **zircon**, **rutile**, **titanite**, **monazite-(Ce)**, **xenotime-(Y)**, **allanite-(Ce)**, **arsenopyrite** and **pyrite**, whereas **uraninite** (Fig.

B-21), **cassiterite, niobian rutile, Sn-rich titanite,** gadolinite-hingannite related mineral close to **minasgeraisite** and **Y-rich milarite** are known only from the Spessartine pegmatite. Tourmaline (**schorl** to **elbaite**) is a typical minor mineral along with rare primary **danburite, annite** (Fig. B-20a) and accessory **magnetite, fluorite, zircon, pyrochlore-group minerals** and **columbite-(Mn)** in the elbaite pegmatite. Late **datolite** and **bavenite** were found in pockets associated with red elbaite, albite, K-feldspar and quartz.

Tourmaline

Tourmalines (schorl, dravite, foitite, elbaite, fluor-elbaite) from the individual types of pegmatites enclosed in the orthogneiss, the amphibole-bearing pegmatites

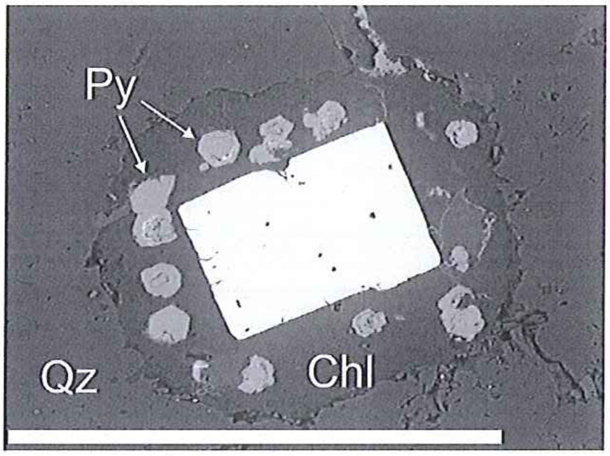

Fig. B-21. BSE image of an euhedral crystal of uraninite (bright in the center) in quartz, see pyrite (Py) in chlorite (Chl) rim, Spessartine pegmatite. Scale bars = 250 μm.

hosted by the Fe-skarn, and mainly the tourmaline-bearing pegmatites cutting the paragneisses and Fe-skarn, differ significantly in their chemical compositions. Because tourmaline forms fine-grained intergrowths with secondary Fe-rich chlorite in all tourmaline-bearing pegmatites cutting the Fe-skarn except for the Elbaite pegmatite and scarcely the Pegmatite No. 12, determination of Fe^{2+}/Fe^{3+} by Mössbauer spectroscopy (see e.g., Novák *et al.* 2011; Filip *et al.* 2012) was not possible.

Two groups of tourmalines are evident in Fig. B-22, Ca-poor (Ca < 0.15 apfu, moderate to high proportion of vacancy in the X-site) (Březina and Nosatá skála pegmatites cutting paragneisses, pegmatite in orthogneiss) and Ca-rich (Ca = 0.15–0.47 apfu, low to moderate X-site vacancy, $^{X}\square \leq 0.25$ pfu) (all pegmatites enclosed in the Fe-skarn, including rare fibrous tourmaline from amphibole-bearing pegmatite).

Extremely high variability in Al contents of the individual tourmalines (Al_{tot} = 4.81–8.29 apfu) is the most typical feature. Pegmatites enclosed in the para- (Březina, Nosatá skála) and orthogneisses, Footwall granite–pegmatite and part of tourmaline (with high elbaite component) from the Elbaite pegmatite (Fig. B-22b) have Al_{tot} greater than 6 apfu and they correspond to ordinary tourmalines from granitic pegmatites (Selway *et al.* 1999; Novák *et al.* 2004). Tourmalines from all tourmaline-bearing pegmatites cutting the Fe-skarn are Al-poor, including the Spessartine pegmatite (5.20–5.59 apfu Al) and black schorl from the Elbaite pegmatite (4.81–6.26 apfu Al) (Fig. B-22b). Tourmalines from pegmatites cutting the Fe-skarn mostly having Al_{tot} < 6 indicate the presence of Fe^{3+} (Povondra *et al.* 1985) Tourmalines from pegmatites in paragneisses and orthogneisses have evidently higher contents of Mg

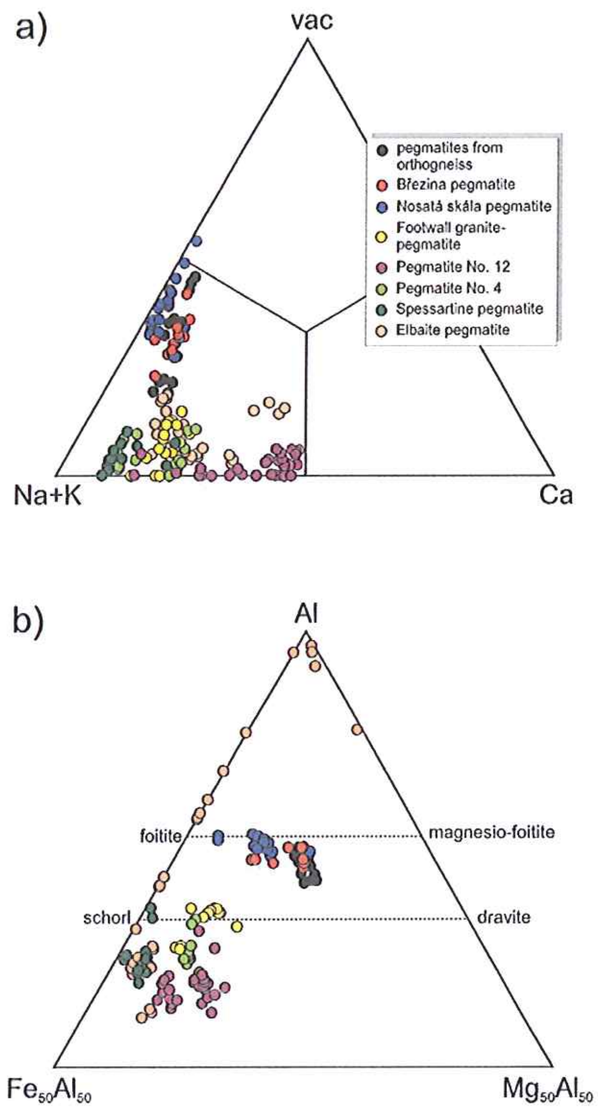

Fig. B-22. Compositional diagrams of tourmaline from granitic pegmatites in the Vlastějovice region; a) Na+K - vacancy - Ca in the X-site; b) Fe - Mg - Al in the Y+Z-sites; after Novák *et al.* (2013a).

(Mg/(Fe + Mg) = 0.22–0.52, = 0.42–0.53, respectively; Fig. B-22b) than from the Footwall granite–pegmatite and primitive pegmatites cutting the Fe-skarn (Pegmatites No. 12 and No. 4; Mg/(Fe + Mg) = 0.20–0.24). Evidently the most fractionated are the Spessartine pegmatite and the Elbaite pegmatite ((Mg/(Fe + Mg) = 0.07–0.10 and 0.00–0.16, respectively). Tourmaline from the Elbaite pegmatite (elbaite, fluor-elbaite) is also significantly enriched in Mn (up to 0.31 apfu - Povondra *et al.* 1985, or 0.93 apfu Mn, electron microprobe data of the authors) as is common in elbaite-subtype pegmatites (Novák and Povondra 1995; Novák 2000; Novák *et al.* 1999a, 2013a).

Concentrations of F vary from low in tourmalines from the pegmatites enclosed in para- and orthogneisses (0.01–0.21 apfu) to moderate in tourmaline-bearing pegmatites cutting the Fe-skarn (0.24–0.37); the highest concentrations of F (0.31–0.46 apfu) were found in the Footwall granite–pegmatite dike and mainly in the Elbaite pegmatite (0.22 apfu - 0.56 apfu).

Tourmalines from pegmatites cutting gneisses suggest participation of the following dominant substitutions: $FeMg_{-1}$ and $\square OH\ (NaO)_{-1}$. However, tourmalines from other geochemically primitive pegmatites in the Moldanubicum show quite different exchange vectors (cf. Povondra 1981; Novák *et al.* 2004). Tourmalines from pegmatites cutting Fe-skarn are evidently distinct in high contents of Ca and Fe and participation of the general substitutions: $CaR^{2+}\ (NaAl)_{-1}$, $R^{2+}OH\ (AlO)_{-1}$ is suggested. However, due to fine-grained intergrowths of tourmaline with Fe-chlorite found in all tourmaline-bearing pegmatites cutting Fe-skarn except for the Elbaite pegmatite, determination of Fe^{2+}/Fe^{3+} by Mössbauer spectroscopy was not possible. Consequently, the above-elucidated substitutions are only approximate (Novák *et al.* 2013a).

Garnet

Subhedral grains and their aggregates of brownish red andradite-grossular, up to 2 cm in size, are typical of some amphibole-bearing pegmatites. They are slightly heterogeneous in composition (Fig. B-23). Almandine-dominant garnets from both tourmaline-bearing pegmatites in the paragneisses (Březina and Nosatá skála) are only slightly heterogeneous in the BSE images; garnet from the Březina pegmatite is slightly enriched in Mg and Ca (Fig. B-23). By comparison, spessartine-dominant garnet from the Spessartine pegmatite is evidently enriched in Ca, Mn and Fe^{3+} (Fig. B-23). Both the higher degree of fractionation expressed by higher Mn/(Mn + Fe) and strong Ca,Fe-contamination are recorded in this garnet. It is also enriched in Y (up to 0.02 apfu, i.e. up to 0.41 wt. % Y_2O_3). Elevated contents of Y were found only exceptionally in Czech pegmatites (Hönig *et al.* 2010; Novák *et al.* 2013a).

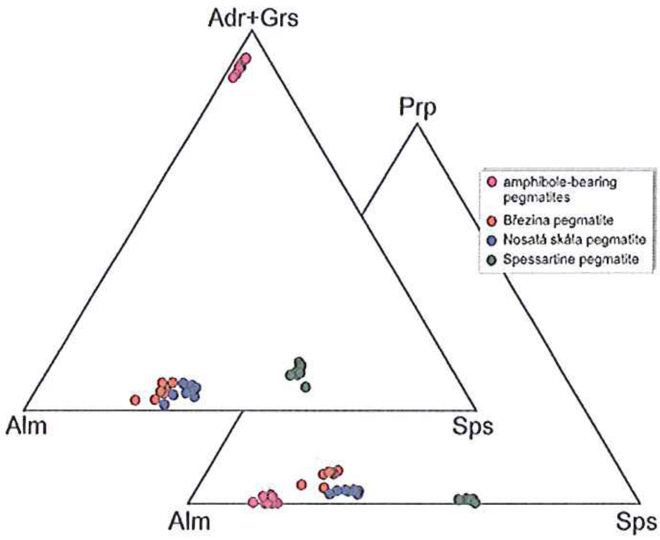

Fig. B-23. Compositional diagrams of garnet from granitic pegmatites in the Vlastějovice region; after Novák *et al.* (2013a).

Chemical composition of the selected associated minerals

Tourmaline-bearing pegmatites contain several accessory minerals and most of them apparently indicate elevated degree of fractionation of the parental granite. The Spessartine pegmatite contains several less common to very rare accessory phases with unusual compositions:

Sn-rich titanite:
$Ca_{1.02}(Ti_{0.61}Sn_{0.28}Al_{0.09}Fe_{0.04}Nb_{0.01})_{1.03}\ Si_{1.00}O_{4.93}F_{0.07}$

Agakhanovite-(Y):
$Ca_{2.24}K_{2.08}Na_{0.04}\ Y_{1.70}Fe_{0.20}Mn_{0.05}Be_{4.00}Si_{24.85}O_{59.84}F_{0.16}{\cdot}H_2O$

and mineral close to minasgeraisite-(Y) from inclusions in spessartine:
$(Y_{0.66}Yb_{0.09}Er_{0.05})\ Ca_{0.84}Fe_{0.35}Be_{2.0}Si_{2.04}O_8(OH)_{0.89}F_{0.11}$.

In the Elbaite pegmatite, fluorcalciopyrochlore:
$(Ca_{1.14}Na_{0.77}Sb_{0.01}U_{0.01})_{1.93}(Nb_{1.40}Ta_{0.52}Sn_{0.07}Ti_{0.01})_{2.00}\ O_6\ F_{1.17}$

and secondary Bi-rich pyrochlore:
$(Bi_{0.78}Ca_{0.36}Fe_{0.33}Pb_{0.28}Mn_{0.15}Sb_{0.06}U_{0.02})_{1.64}$
$(Nb_{1.64}Ta_{0.21}Sn_{0.13}Ti_{0.02}W_{0.01})_{2.00}\ O_6\ (OH)$

were found among other accessory minerals.

Final remarks

Amphibole-bearing pegmatites frequently with accessory allanite and fluorite cutting Fe-skarn bodies are quite common in the Moldanubian Zone (e.g., Rešice near Hrotovice, Líšná near Svratka, Domanínek near Bystřice nad Pernštejnem, Malešov near Kutná Hora; Němec 1963; Novák 2005; Novák *et al.* 2013a and references therein). They exhibit simple internal structure with dominant coarse-grained texture and locally with masses of quartz. At Vlastějovice, these masses are randomly distributed in the pegmatites and they apparently do not resemble quartz core developed in many granitic pegmatites. Also further textural-paragenetic units typical for granitic pegmatites such as graphic intergrowths quartz+feldspar or blocky K-feldspar are absent. Their Ca,Fe,(F)-rich mineral assemblages, concentrated particularly along contacts of the pegmatite bodies (amphiboles, fluorite, allanite) and in pockets (prehnite, apophyllite) suggest strong but variable post-emplacement in situ contamination from host Fe-skarn. In the studied pegmatites from Vlastějovice, Ca and Fe obviously come from host Fe-skarn; common allanite-(Ce) also suggests income of REE from host skarn.

The amphibole-bearing pegmatites with overall Ca,Fe,F-rich mineral assemblage concentrated especially along contacts of the pegmatite bodies suggest strong post-emplacement contamination in situ relative to the tourmaline-bearing pegmatites. Calcium and Fe obviously come from host Fe-skarn, and F was very likely derived from early F-rich garnet ($Grs_{79-87}And_{12-18}$; F = 0.82-1.18 wt.% F; Žáček 1997; Žáček *et al.* 2003). It was almost completely replaced by F-poor garnet (And>>Grs) during early stage of regional metamorphism (Žáček 1997) and this metamorphic event very likely produced also the primitive pegmatite melt in host metapelitic rocks. Ackerman *et al.* (2007) suggested, based on the fluid inclusions study and feldspars thermometry, the conditions of pegmatite crystallization at P = 0.42-0.58 GPa and T = 600-640 °C. These conditions are slightly lower than the conditions of regional metamorphism at P = 0.45-0.65 GPa and T = 590-680 °C estimated by Žáček (1997).

Granite and pegmatite bodies closely related to Fe-skarn (footwall granite, pegmatite No. 12, pegmatite No. 4, spessartine pegmatite, elbaite pegmatite) (Fig. B-18,19) represent a unique example of granite-pegmatite system, where the individual small pegmatite dikes show unambiguous relationship to well-defined parts of the texturally heterogeneous parental granite body with the exception of the Elbaite pegmatite mined out in about 1985. Both pegmatites from gneisses (Březina and Nosatá skála) are very likely related to the same magmatic event as granite-pegmatite system cutting Fe-skarn. Such a parental granite, however, is very small relative to the size of potential granitic plutons fertile to granitic pegmatites as was modeled by Baker (1998) and as is commonly expected (Černý 1991a,b; London 2008). Hence, granite-pegmatite system in Vlastějovice is very unusual and raises the question how granites fertile to granitic pegmatites appear including their size, textures, compositions etc. (see Martin and De Vito 2005; London 2008).

Tourmaline (schorl) from pegmatites cutting Fe-skarn is apparently Ca,Fe,F-enriched, relative to tourmaline (schorl to dravite) from pegmatites enclosed in gneisses. The chemical composition of the tourmaline suggests moderate contamination in situ of pegmatites cutting Fe-skarn, which is evidently higher in less fractionated and differentiated pegmatite bodies (dike No. 12) relatively the more evolved to the Spessartine pegmatite and chiefly to the Elbaite pegmatite. High degree of fractionation is indicated also by elevated Li, Mn and F concentrations. Garnet from the Spessartine pegmatite is evidently Ca-,Mn-,Fe^{3+}-enriched relative to garnets from pegmatites enclosed in gneisses, hence, both higher degree of fractionation and Ca,Fe-contamination are evident in this pegmatite. Elevated Y and REE contents relative to garnet from the pegmatites in gneisses support also introduction of Y and REE from Fe-skarn (with common accessory allanite). Contamination demonstrated by chemical composition of minerals and mineral assemblages is evident in pegmatites cutting Fe-skarn including the Elbaite pegmatite. It is in contrast with fluid inclusion study (see Ackerman *et al.* 2007), where no contamination was indicated in evolution of fluid inclusions from the Elbaite pegmatite relative to amphibole-bearing (barren) pegmatites.

Tourmaline-bearing granite-pegmatite system at Vlastějovice represents a unique example, where pegmatites are derived directly from their fertile granite and moderately contaminated from host Fe-skarn. However, pre-emplacement and post-emplacement stage of external Ca,Fe-contamination are uneasy to be distinguished. Short transport from fertile granite (Fig. B-18,19d) suggests that the latter is dominant. Amphibole-bearing pegmatites of anatectic origin, abundant in Fe-skarn, demonstrate evidently higher degree of contamination, which was enhanced by higher T during melt emplacement (Fig. B-1) and longer time suitable for mass exchange with Fe-skarn.