JAHRBUCH DER GEOLOGISCHEN BUNDESANSTALT
Jb. Geol. B.-A. | ISSN 0016–7800 | Band 141 | Heft 1 | S. 25–37 | Wien, September 1998

Latest Intrusions of the Eisgarn Pluton (South Bohemia – Northern Waldviertel)

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10 Text-Figures and 4 Tables

Tschechische Republik
Niederösterreich
Böhmische Masse
Eisgarner Granit
Petrographie
Österreichische Karte 1 : 50.000 *Geochemie*
Blätter 4, 5, 17, 18 *Geochronologie*

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Spätintrusionen des Eisgarner Plutons (Südböhmen – Nördliches Waldviertel)

Zusammenfassung

Im Gefolge des Eisgarner Granits treten Muscovit bzw. Muscovit und Biotit führende, kieselsäurereiche kleine Granitkörper auf, die einen unterschiedlichen Grad von Fraktionierung aufweisen. Sie sind peraluminös, mitunter mit Natriumvormacht, angereichert an seltenen Alkalien, an Zinn, Niob und Tantal. Charakteristisch ist der hohe Gehalt an Phosphor, der vornehmlich in den Alkalifeldspaten konzentriert ist.

Eine ältere Suite von rund 320 Millionen Jahren, repräsentiert durch die Intrusionen von Galthof und Homolka, ist typisch für die Entwicklung der Restschmelze im zentralen Teil des Eisgarner Plutons nördlich Gmünd. Die jüngere, etwa 314 Millionen Jahre alte Suite mit den Vorkommen Ober- und Unterlembach, Lagerberg und Pyhrabruck-Nakolice tritt im Eisgarner Granitkörper W Gmünd bzw. N Weitra auf. Kleine Intrusionen sind noch um ca. 6 Millionen Jahre jünger.

Die Schmelzen entwickelten sich lokal und intrudierten zu signifikant unterschiedlichen Zeiten. Die Abkühlalter von Muskoviten sind ähnlich den Intrusionsaltern.

Abstract

In the course of Eisgarn type granite intrusions highly differentiated muscovite or muscovite-biotite bearing granites crystallised from residual melts. They are rich in silica, peraluminous, enriched in rare alkalies, often sodium dominated, with high concentrations of tin, niobium and tantalum. Typical is the high content of phosphorus which is incorporated in the crystal lattice of alkalifeldspar.

These granites form two suites. One suite with the intrusions of Galthof and Homolka is bound to the central part of Eisgarn type granite N of Gmünd and is approximately 320 million years old. The other suite with the granites of Ober- and Unterlembach, Lagerberg und Pyhrabruck-Nakolice is approximately 314 million years old and occurs in the Eisgarn granite body W of Gmünd and N of Weitra. Small intrusions like the dykes of Šejby intruding paragneisses or a small stock of Galthof type granite are approximately six million years younger.

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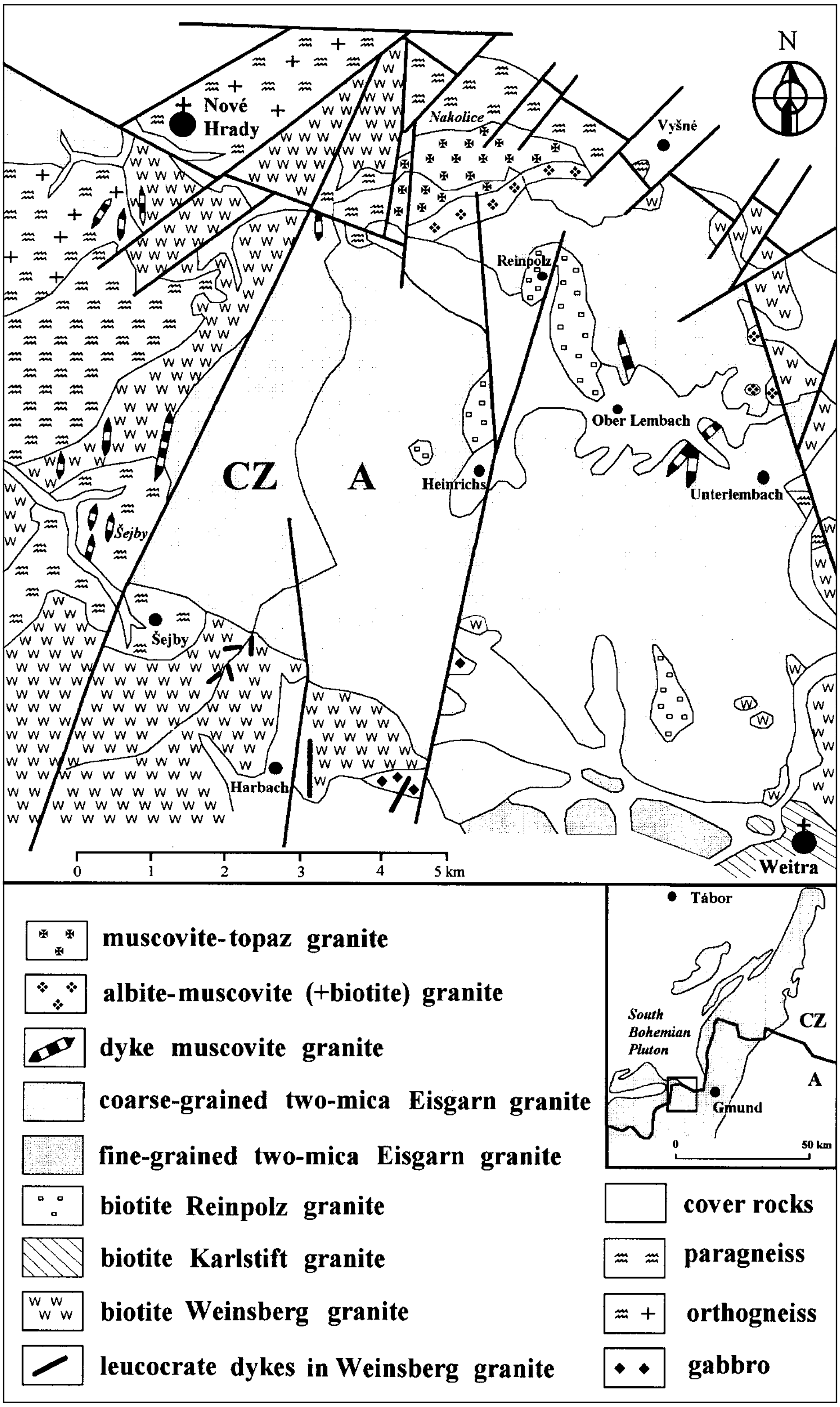
1. Introduction

We describe here highly differentiated granites from the northwestern Waldviertel and southern Bohemia. These are typically muscovite bearing granites mainly bound to Eisgarn type granite of the South Bohemian Pluton with special geochemical features.

In the past 10 years, several occurrences of late-Variscan leucocratic P-rich muscovite granites of different degree of fractionation were found throughout the whole Moldanubicum. Some of them are Sn-Nb-Ta specialized and show remarkable concentrations of cassiterite and columbite in recent sediments.

Characteristic features of these granites will be demonstrated on intrusions from two areas in the central part of the South Bohemian Pluton (SBP) near the Austrian-Czech border: an area between Weitra and Nové Hrady, the other between Litschau and Brand (Text-Figs. 1, 2a). Here several kinds of muscovite granites of slightly different age and chemistry were described.



Text-Fig. 1.
Geological map of the studied area Weitra – Nové Hrady according to ERICH & SCHWAIGHOFER (1977), FUCHS & SCHWAIGHOFER (1978), SKLABÝ, J. (1991), STANÍK, E. (1981), revised by the author KAREL BREITER.

2. Geological Setting

The area under study is built up by different granitoid varieties, all of which are constituents of the Variscan South Bohemian Pluton (SBP). Occurrences of pre-Variscan rocks, mainly paragneisses, are limited to the surroundings of Weitra and Nové Hrady (Text-Fig. 1).

The main constituent of the SBP in the area described here is the t w o - m i c a b e a r i n g E i s g a r n t y p e g r a n i t e . The granite is medium- to coarse-grained and mostly porphyritic. It consists of quartz, alkalifeldspar, albite-oligoclase, biotite, and muscovite. The size of the microcline phenocrysts commonly reaches 3×1 cm, locally even 4×2 cm. Their quantity strongly fluctuates. Zircon and apatite are accessory.

A fine-grained variety of the same mineral composition occurs for example W of Litschau and in several places west of Weitra. Contacts with the common medium-grained variety have not been observed. Pegmatite veins or schlieren are rare.

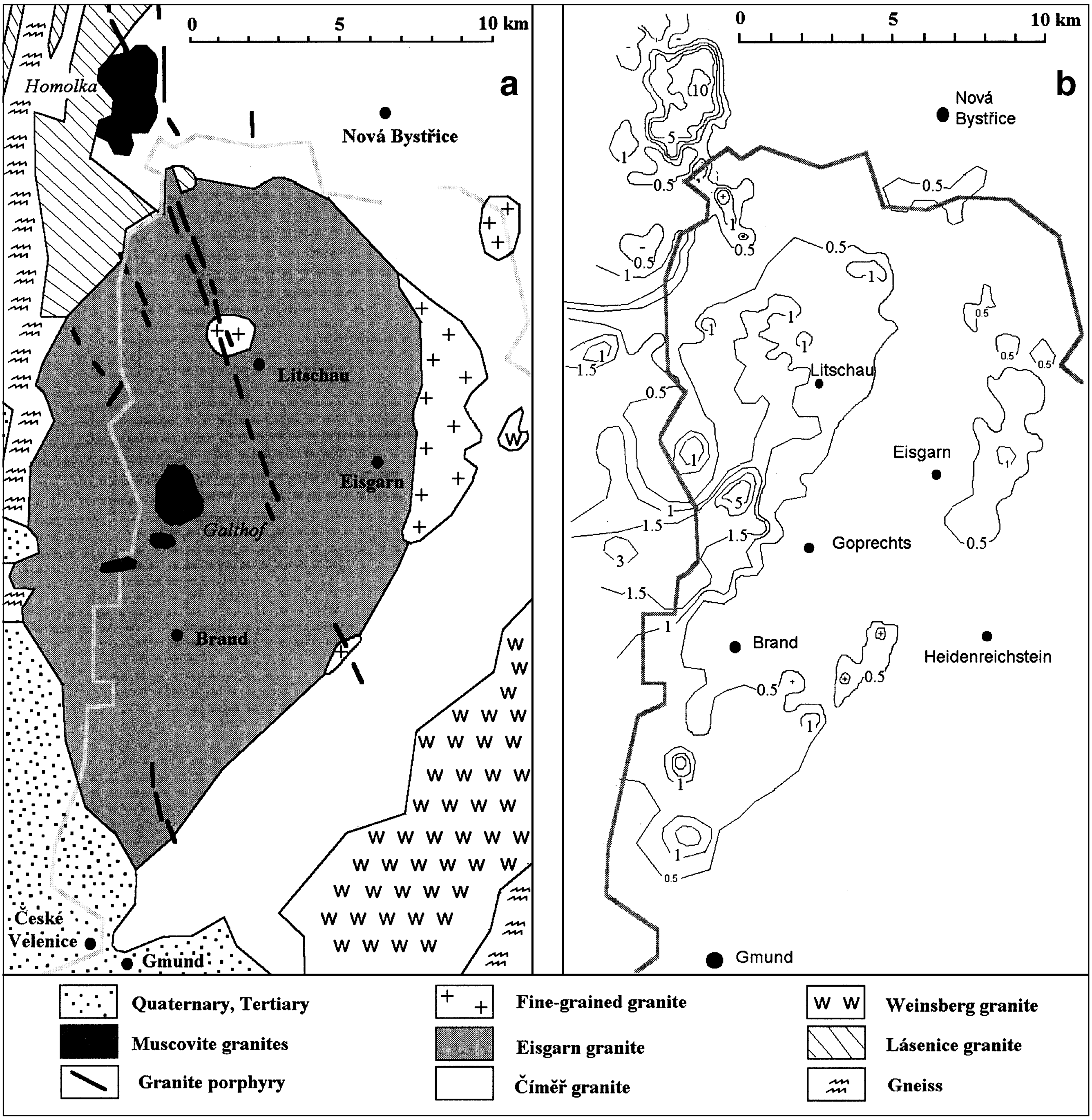
Recent gamma-spectrometric measurements and detailed geological mapping distinguished two varieties with different U/Th-ratio within the Austrian Eisgarn-type granite (GNOJEK et al., 1996). The U-poor subtype with U/Th ratios about 0.5 is prevailingly medium-grained and porphyritic, and roughly comparable to the Bohemian Čiměř type granite. The second type, relatively U-rich with U/Th ratios close to 1, is coarse-grained and well comparable to the Landstejn type granite in Bohemia (Text-Fig. 2b). The U-rich subtype is geologically younger.

Other magmatites of the SBP are only little represented within the studied area:

Gabbro builds two small isometric bodies east and southeast of Harbach (Text-Fig. 1). According to KOLLER & NIEDERMAYR (1981), the gabbro contains clino- and orthopyroxene together with basic plagioclase (An_{60-70}).

The Weinsberg granite is more coarse-grained than Eisgarn types, conspicuously porphyritic, relatively dark and locally shows parallel texture. It crops out in the surroundings of Nové Hrady and Weitra. It is often accompanied by dykes, several meters to tens of meters thick, of a leucocratic granite.

The "Reinpolz" granite is a fine-grained biotite granite that forms small bodies in the surroundings of Reinpolz and Heinrichs NW of Weitra. The contacts with the Eisgarn granite is sharp. The granite is fine-grained (up to 1 mm), rarely porphyritic, and consists of quartz, orthoclase, albite, biotite, and of minor muscovite and common



Text-Fig. 2
The area of Brand – Litschau.
a) Geological map of the studied area according to WALDMANN (1950), MALECHA et al. (1977) and unpublished maps of PŘICHYSTAL & K. BREITER.
b) U/Th ratio in the Brand – Litschau area (according to GNOJEK et al., 1996).

accessories. The number of potassium feldspar phenocrysts increases towards the contact with the Eisgarn granite and they reach 5×1 cm in size.

Among the granite types known to occur in the Austrian Moldanubicum, it is closest to the Freistadt type which occurs further to the SW.

The Karlstift granite crops out in the western part of the town of Weitra. It is well exposed in a roadcut to Harbach. Macroscopically, it resembles the Eisgarn granite, but has a higher content of biotite and lower content of muscovite. Schlieren with a higher mica content and both flat and steeply dipping aplite and pegmatite veins are frequent. The Karlstift granite occupies a large area further south of Weitra, where it was studied by PŘYCHYSTAL (in HEINZ, 1993).

The muscovite granites are the most varied and interesting rock group from the point of geochemistry. They form either N–S trending dykes (Ober-Lembach, Šejby; ÖK 50 sheet 18 and 17), stocks (Unterlembach; ÖK 50 sheet 5), or larger irregular bodies (Pyhrabruck, Galthof; ÖK 50 sheet 4 and 5).

The sequence of emplacement of the intrusive rocks according to field relations can be outlined as follows:

- ❑ gabbro
- ❑ Weinsberg granite with its dyke suite
- ❑ Karlstift granite – ? – Reinpolz granite
- ❑ two subtypes of Eisgarn granite
- ❑ muscovite granites

3. Muscovite Granites

3.1. Rock Description

Muscovite granites form dykes, stocks and larger bodies and can be classified according to the following types:

- – muscovite (+biotite) granites without ore-mineral enrichment (Lagerberg, Ober-Lembach and Unterlembach types)
- – muscovite granites with topaz, highly chemically differentiated, with accessory ore mineral content (Pyhrabruck and Galthof types),
- – muscovite (+garnet) dyke granites with irregular fabric (aplitic to pegmatitic) and content of ore minerals (Šejby).

All these rocks are geologically younger than the Eisgarn type granite.

The Ober-Lembach granite forms two systems of steeply inclined dykes cutting the Eisgarn granite. The thickness of the dykes is 5 to 20 m. The granite is best exposed in a pit quarry southeast of the village. The intrusive contact to the Eisgarn granite is sharp. Two textural varieties can be distinguished: the most widespread is a fine-grained variety and contains schlieren and xenoliths of the medium- to coarse-grained one. The fine-grained granite shows structural features of a "two-phase rock": an older generation of coarser-grained minerals is enclaved by a fine-grained, mineralogically identical "cement". It is composed of quartz, albite (3–6 % An), orthoclase, Mg-Fe muscovite, and apatite. The coarse-grained variety contains much more muscovite and perthite (5–10 % Ab) in place of orthoclase.

About 5 cm thick veinlets of muscovite pegmatites are frequent.

The Unterlembach granite forms three stocks north of the village Unterlembach. In the stock 1 km N of the village, an important occurrence of U-micas, still abundant on joints of the rock, has been described. The contact with the Weinsberg and Eisgarn granites is intrusive and locally accompanied by marginal pegmatite occurrence (Dr. KOLLER, pers. com.). Therefore it is not a muscovitization product of the Eisgarn granite, as was argued by GÖD (in BREITER et al., 1994) but is a distinct type of muscovite granite emplaced in Eisgarn type.

The granite is medium-grained, equigranular to slightly porphyritic. It consists of quartz, P-rich orthoclase (3–6 % Ab, 0.5–1 % P_2O_5), albite (3–6 % An, 0.3–0.5 % P_2O_5), Na-rich muscovite, and biotite. Along the contact, a 5–10 m thick zone with a fine-grained variety can be observed, distinct by the absence of biotite and higher phosphorus content in the feldspars (around 1 %), but free of U-minerals.

The Pyhrabruck-Nakolice granite forms a body, ca. 2 km^2 in size on both sides of the state border. It is a leucocratic, medium-grained, equigranular rock, consisting of quartz, pure albite (up to 0.4 % P_2O_5), orthoclase (2–5 % Ab, 0.5–0.9 % P_2O_5), and Li-muscovite. Topaz, Mn-apatite, ilmenite, monazite, cassiterite, and columbite occur as accessories. Rarely, fragments of a fine-grained variety, which probably forms dykes in the southern part of the body, have been found.

The Lagerberg granite forms a rim along the SE margin of the Pyhrabruck granite. It is a medium-grained, non-porphyritic granite, texturally identical to the Pyhrabruck granite. It contains, however, biotite beside Na-rich muscovite. Other main constituents are quartz, albite (<2 % An), and orthoclase (<5 % Ab). Apatite is a characteristic accessory.

The Šejby dyke-granite forms several N–S trending dykes cutting paragneisses and the Weinsberg granite NW of the village Šejby. The maximum thickness is about five metres. The texture is very irregular, from aplitic to pegmatitic. The rock is hololeucocratic, consists of quartz, orthoclase (up to 5 % Ab and 0.5 % P_2O_5), albite (up to 0.5 % P_2O_5), and Na-muscovite. The geochemical specialization here is lower than in the Pyhrabruck granite, the content of ore minerals and topaz is only accessory, though in the surroundings of these dykes the highest concentrations of columbite in stream sediments were found.

A muscovite-garnet granite occurs together with the foregoing type NW of Šejby. The main difference is the content of a certain amount of Mn-rich garnet (30–35 % of spessartine component) and lower contents of rare alkalies.

The Galthof granite builds up an irregular body (1.5 km^2) and two small outcrops (<0.1 km^2) SW of the town Litschau. The granite consists of quartz, orthoclase (up to 5 % of Ab and 0.5 % P_2O_5), albite (up to 0.5 % P_2O_5), muscovite, and rare biotite. Topaz and apatite are accessories. The large body consists of three textural varieties: a medium-grained porphyritic, a medium-grained equigranular, and a fine-grained one. One of the small outcrops shows the medium-grained, the other the fine-grained type.

3.2. Geochemistry

Results of the analyses are summarized in Tables 1 and 2. Some relations between the major elements are illustrated in Text-Fig. 3, between trace elements in Text-Figs. 4 and 5 and the distribution of REE in Text-Fig. 6.

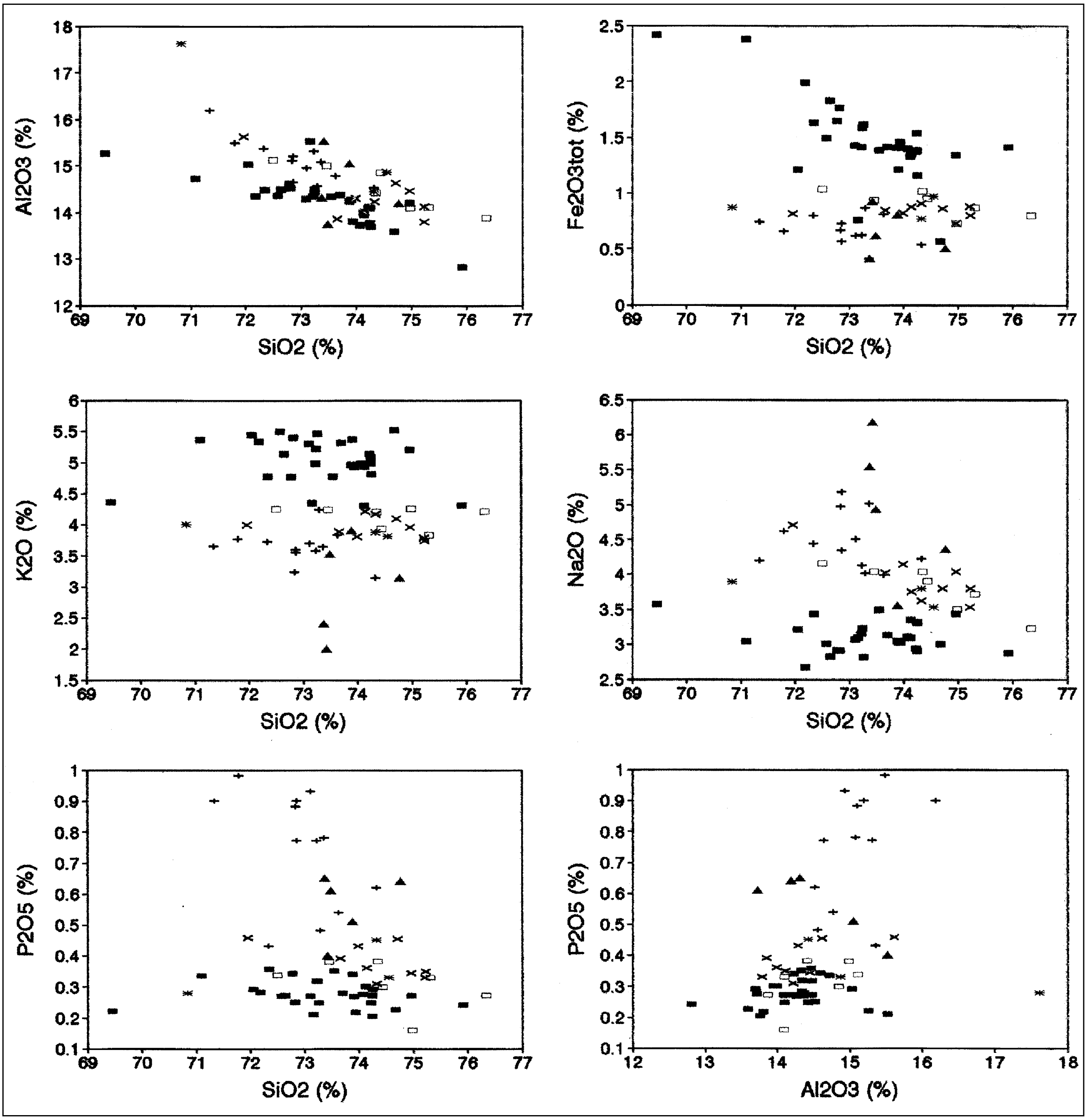
Table 1.
Major elements in granites [wt.-%].
Analysed by wet chemistry in the laboratory of CGS Praha.

rock type	Eisgarn	Ober Lembach		Unter Lembach		Lagerberg	Pyhrabruck		Sejby			Galthof	
No.		2487	2488	2482	2483	2491	2477	2478	2476	2494	2613	2630	2628
SiO2	72.3	76.01	75.63	75.31	76.35	73.46	74.33	74.55	73.38	73.89	73.42	71.96	74.72
TiO2	0.27	0.06	0.07	0.03	0.04	0.05	0.03	0.04	0.03	0.02	0.04	0.07	0.07
Al2O3	14.5	13.78	14.23	14.1	13.87	14.99	14.43	14.87	14.31	15.05	15.52	15.62	14.62
Fe2O3	1.3	0.2	0.22	0.23	0.25	0.32	0.77	0.31	0.41	0.21	-0.01	0.32	0.42
FeO	0.8	0.26	0.2	0.58	0.5	0.56		0.6		0.54	0.85	0.45	0.4
MnO	0.02	0.02	0.012	0.02	0.017	0.02	0.03	0.02	0.042	0.041	0.254	0.034	0.025
MgO	0.37	0.08	0.1	0.05	0.04	0.07	0.04	0.04	0.01	0.06	0.05	0.06	0.1
CaO	0.87	0.42	0.41	0.3	0.31	0.36	0.43	0.3	0.54	0.5	0.4	0.46	0.51
Li2O	0.024	0.014	0.009	0.04	0.014	0.032	0.037	0.045	0.011	0.04	0.013	0.062	0.055
Na2O	3.2	3.58	3.99	3.72	3.23	4.03	3.79	3.53	5.54	3.55	6.17	4.7	3.8
K2O	5.4	4.37	3.75	3.83	4.21	4.23	3.87	3.81	2.39	3.89	1.99	3.99	4.09
P2O5	0.26	0.16	0.13	0.33	0.27	0.38	0.45	0.33	0.65	0.51	0.4	0.456	0.453
LOI		0.82	0.88	0.98	0.98	1.05	0.99	1.36	0.74	1.28	0.85	1.15	1.03
F	0.1	0.107	0.093	0.282	0.145	0.204	0.29	0.361	0.202	0.344	0.163	0.303	0.23
H2O-		0.12	0.15	0.07	0.08	0.16	0.12	0.13	0.12	0.09	0.1	0.08	0.06
TOTAL		99.96	99.84	99.75	100.3	99.83	99.49	100.2	98.3	99.87	100.1	99.59	100.5

We try to prove that the muscovite granites are the latest product of differentiation of the Eisgarn granite suite. To recognise the relationship between the muscovite granites and their suggested parental melts, typical analyses of the Eisgarn granites from various places of the pluton were plotted in Text-Figs. 3 to 5 (for data source see

Table 2.
Trace elements in granites [ppm].
Ba, Cs, Hf, Th, U and REE were analysed by Dr. R. SELTMANN by means of ICP-MS at GFZ Potsdam.

rock type	Eisgarn	Ober Lembach		Unter Lembach		Lagerberg	Pyhrabruck		Šejby			Galthof	
No.		2487	2488	2482	2483	2491	2472	2478	2476	2494	2613	2628	2630
Rb	320	351	271	559	482	575	811	726	567	714	313	583	654
Cs	22	18.1	8.53	19	7.34	16.7	18.1	12.7	16.8	45.9	6.2	47.5	33.4
Ba	200	43.9	53.6	10	18.6	7.23	6.8	4.73	7.53	10.5	10.3	33	11
Sr	70	25.9	21.8	<7	5.5	4.25	15.3	6.68	85.4	19.6	10	11	<7
Zr	74	22.3	20.4	<7	19.5	26.6	24.3	38.9	8.06	3	27.7	33	32
Hf	2.5	1.12	1.02		1.05	1.37	1.35	2.1	0.81	0.19	2.08	1.4	1.6
Sn	5	<7	16	16	8	12	27	24	20	25	16	29	22
Nb	13	17	28	44	33	18	340	39	59	50	25	29	31
Zn	82	16	27	62	43	70	57	72	32	53	18	78	7
Pb	23	21	16.6	<7	14.1	9.96	5.92	7.42	7.88	5.55	6.84	10.2	8.5
Th	15	3.19	2.34		1.94	1.88	1.88	3.1	0.57	0.32	1.2	3.04	2.2
U	10	8.36	4.95		20.4	3.42	6.48	4.65	1.57	0.87	1.49	2.53	2.6
Y	17	9.82	15.2	9	6.71	8.04	5.9	8.7	1.61	1.8	4.19	5.2	6.58
La	20	3.62	3.68		2.11	2.29	1.63	2.61	0.72	0.56	1	4.59	2.75
Ce	46	8.13	7.61		4.7	5.41	3.95	6.56	1.19	0.83	2.32	10.1	6.46
Pr		1.03	1.09		0.584	0.674	0.515	0.829	0.19	0.12	0.28	1.26	0.832
Nd		3.9	4.02		2.11	2.45	1.9	3.03	0.58	0.42	0.91	4.33	2.94
Sm	4.55	1.25	1.36		0.778	0.948	0.82	1.23	0.24	0.17	0.35	1.15	1.03
Eu	0.43	0.103	0.131		0.014	0.011	0.0092	0.005	0.02	0.04	0.04	0.08	0.02
Gd		1.234	1.67		0.909	1.13	0.89	1.39	0.23	0.19	0.33	1.07	1.07
Tb		0.239	0.377		0.2	0.259	0.19	0.305	0.06	0.05	0.09	0.2	0.223
Dy		1.52	2.49		1.15	1.49	1.08	1.68	0.3	0.3	0.65	1	1.23
Ho		0.29	0.478		0.187	0.243	0.17	0.265	0.04	0.05	0.12	0.16	0.195
Er		0.896	1.43		0.501	0.658	0.454	0.725	0.1	0.13	0.39	0.39	0.498
Tm		0.153	0.245		0.075	0.093	0.072	0.108	0.02	0.02	0.07	0.06	0.08
Yb	0.6	1.2	1.8		0.512	0.636	0.503	0.76	0.13	0.17	0.57	0.35	0.489
Lu	0.1	0.173	0.247		0.061	0.08	0.0614	0.096	0.02	0.02	0.07	0.05	0.066

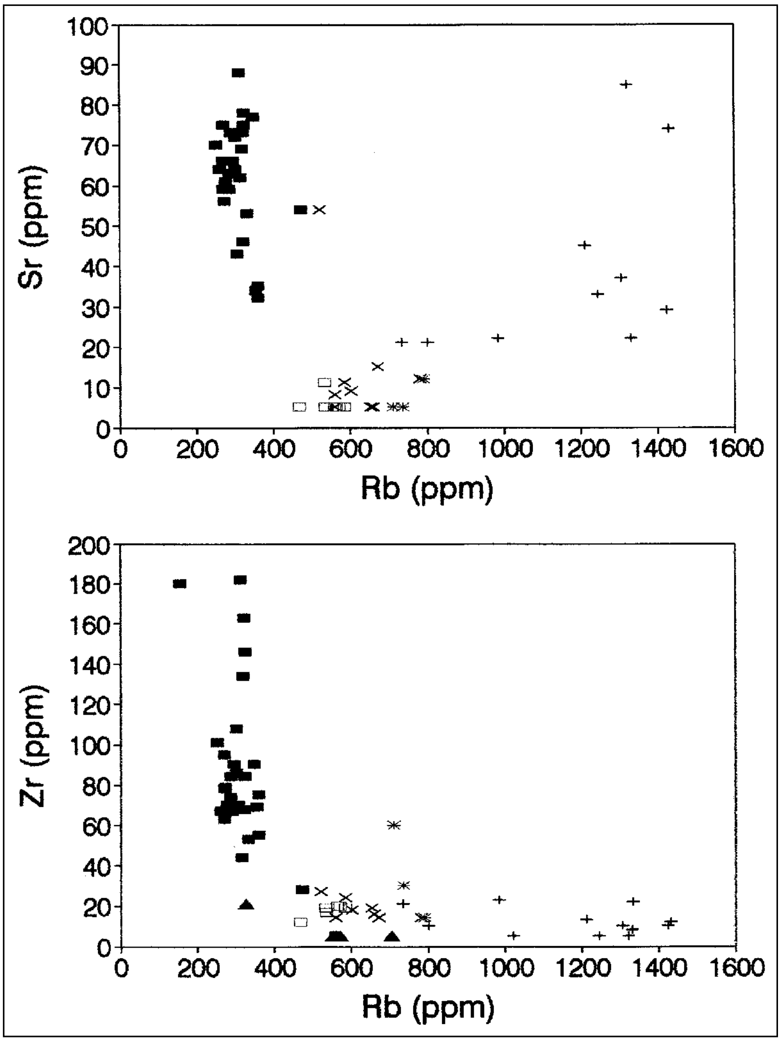


Text-Fig. 3.
Harker's diagrams of muscovite granites.
■ = Eisgarn granite s.l., □ = muscovite (+biotite) granite, ✕ = Galthof granite, ✼ = Pyhrabruck granite, ✚ = Homolka granite, ▲ = Šejby granites.

KOLLER et al. [1993], ČADKOVÁ et al. [1984], VELLMER and WEDEPOHL [1994] and unpublished data of the authors). Plotted values illustrate the scatter in the element concentration within the Eisgarn intrusions and the degree of affinity of the individual muscovite granite types to their parental melts.

The post-Eisgarn muscovite granites can be interpreted as the last crystallisation products of the melt from which the Eisgarn granite had solidified. All these granites are peraluminous with on average higher SiO_2 and higher Al_2O_3 contents, lower in total iron, MgO, and CaO than Eisgarn type. In contrast to Eisgarn type granite sodium mostly equals or even exceeds potassium in concentration. Characteristic is the enrichment of fluor (0.1–0.35 % F) and phosphorus (0.3–0.7 % P_2O_5) which enhanced the ability of the magma to concentrate ore-forming elements and reduced its viscosity during intrusion.

In comparison with their forerunner – the Eisgarn granite – they are enriched in rare alkalies (up to 800 ppm Rb, up to 220 ppm Li, up to 45 ppm Cs), and in rare metals (20–30 ppm Sn, 40–340 ppm Nb), and depleted in Ti, Fe, Mg, Ca, Ba, Sr and Zr. These chemical characteristics are well expressed by the Rb/Sr and Rb/Zr plots (Text-Figs. 4 and 5). The trends clearly indicate the growing degree of differentiation in the Eisgarn – Unterlembach – Ober-Lembach – Lagerberg – Pyhrabruck suite in the SW part of the pluton and in the Eisgarn – Galthof – Homolka suite in the



Text-Fig. 4.
Rb/Sr and Rb/Zr plots showing evolution of muscovite granites from parental melt.
Explanation see Text-Fig. 3.

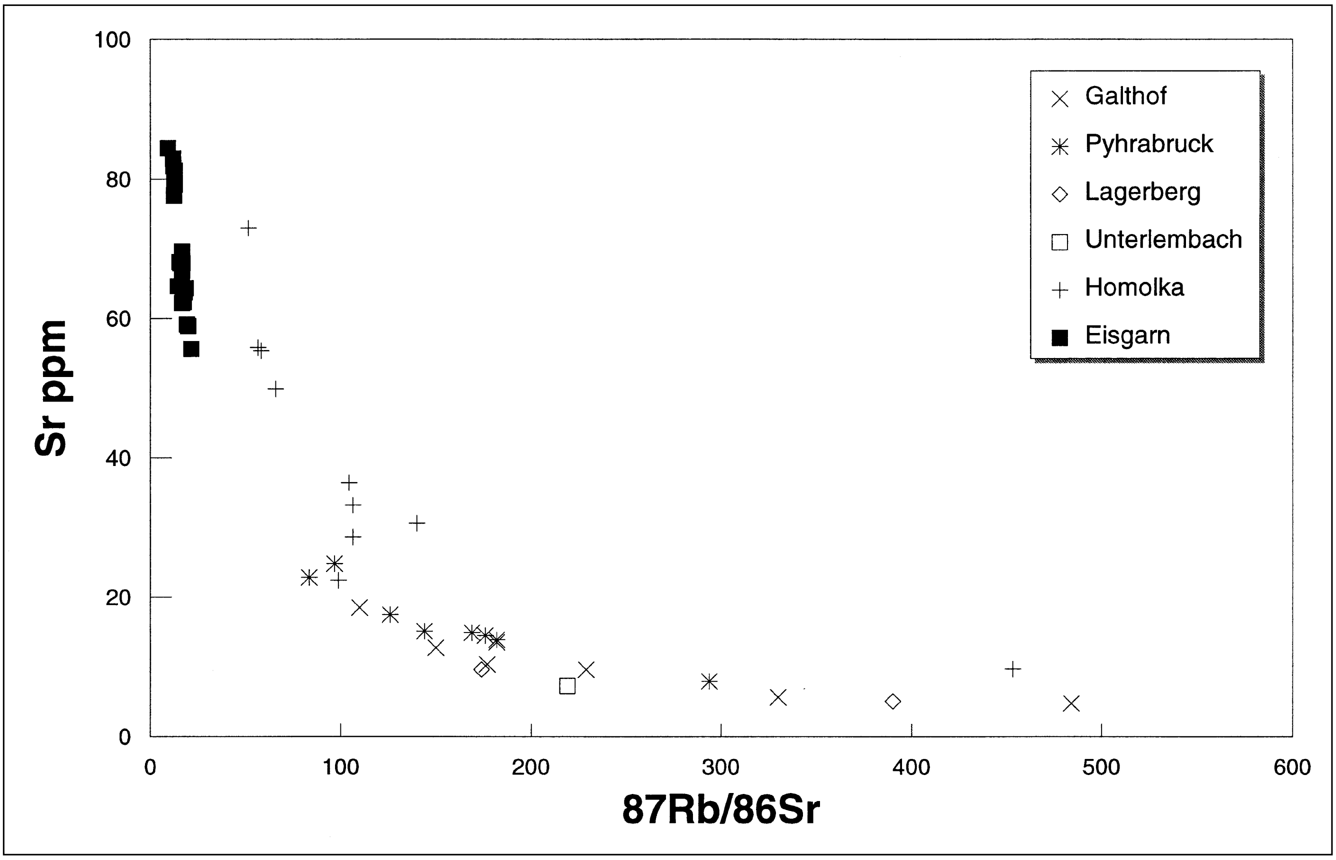
area N of Gmünd. The patterns of the REE (Text-Fig. 6) – decrease in LREE content, flattening of the curves and deepening of the Eu-anomaly – are conform to this evolution scheme.

The Šejby granite differs from all other muscovite granites by the highest content of Na and P, lower contents of K and Rb, the lowest contents of REE – typical for pegmatitic crystallisation products – together with the lowest Ce/Yb_{CN} ratio and a very small Eu-anomaly).

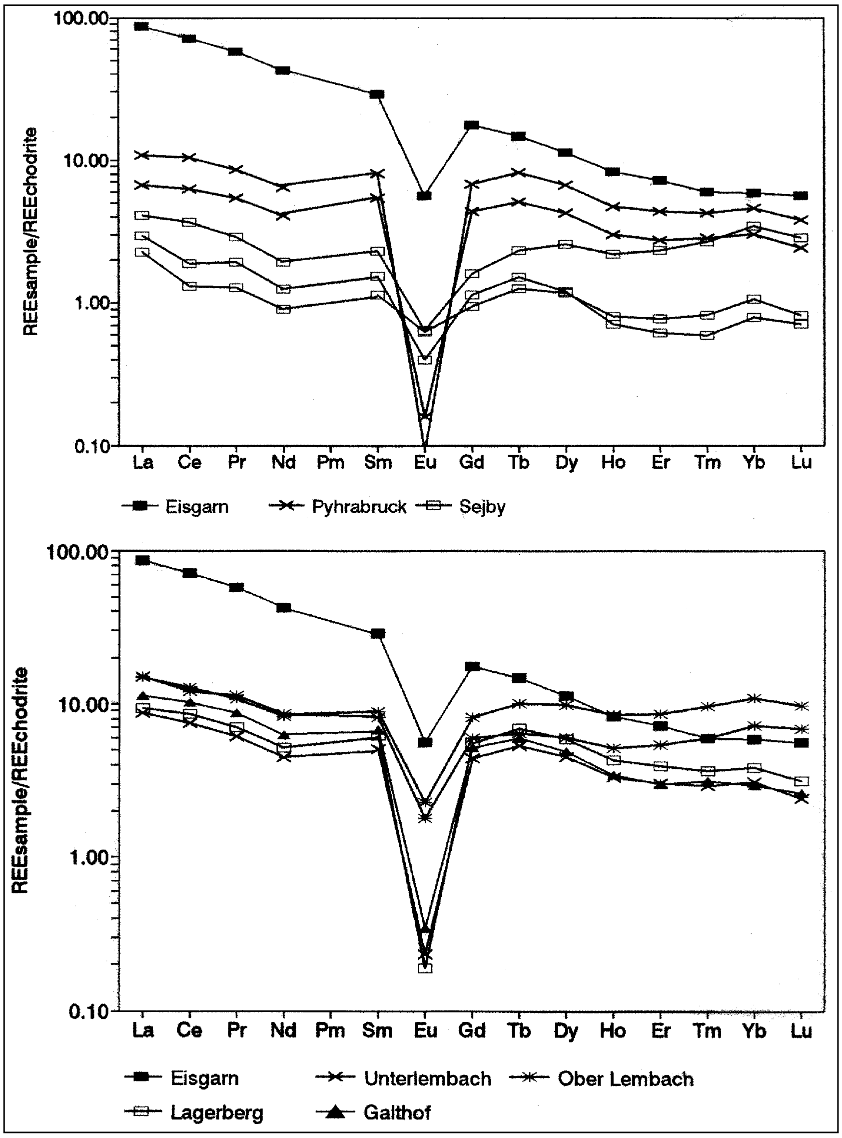
The Ober-Lembach dyke granite is in major element-chemistry similar with the Unterlembach granite, but shows no enrichment in lithophile trace elements Rb, Li, Cs, Sn etc.

Another remarkable feature of all muscovite granites is an anomalously high U/Th ratio detected by ground gamma-ray survey (GNOJEK, BREITER & CHLUPÁČOVÁ, 1996) and confirmed also by chemical analyses (see Tab. 2).

Text-Fig. 5. ▼▽▼
Sr vs. $^{87}Rb/^{86}Sr$ ratios of Eisgarn and muscovite granites.
The differentiation from parental Eisgarn melt is obvious, but a type like Homolka seems to have undergone some special geochemical evolution with extreme enrichment of Rb.



Text-Fig. 6.
Chondrite normalised rare earth elements patterns in muscovite granites.



3.3. Remarks on Mineralogy

Alkalifeldspars

Microprobe analyses confirmed that the plagioclases of all muscovite granites are nearly pure albites. The potash-feldspars, and to a lesser degree also albites, contain substantial amounts of phosphorus, which is a characteristic feature of all fractionated muscovite granites within the Moldanubicum (FRÝDA & BREITER, 1995; BREITER & SIEBEL, 1995). Phosphorus is concentrated in feldspars in highly peraluminous melts, where apatite nucleation and crystallisation is suppressed (LONDON et al., 1993). The P-content in alkalifeldspars, mainly in Kfs, is well correlated with the degree of fractionation of the rock, expressed for example by the Rb/Sr-ratio, and increases from the biotite-bearing muscovite granites (Lagerberg, Unterlembach) to the muscovite-topaz granites (Pyhrabruck). The highest P-content in Kfs is recorded from the Homolka granite (BREITER & FRÝDA, 1994; BREITER & SCHARBERT, 1995), and argues again for the highest degree of fractionation.

Muscovite

The chemical composition of muscovites is another good indicator for the degree of fractionation of a rock. All muscovites are enriched in fluorine, rubidium, lithium, and caesium. The contents of these lithophile elements increase from the Ober-Lembach granite to the Galthof and Unter-Lembach granites to the Pyhrabruck and Šejby granites: F from 1.0 to 1.7 %, Rb from 900 to 3000 ppm, Li from 300 to 1000 ppm, and Cs from 30 to 120 ppm (Tab. 3). The F and Rb contents in muscovites are well correlated with those of whole rocks, on the other hand, Li and Cs contents are more scattered.

All analysed muscovites are, according to their texture and chemistry, of primary magmatic origin (CLARKE, 1981).

4. Geochronology

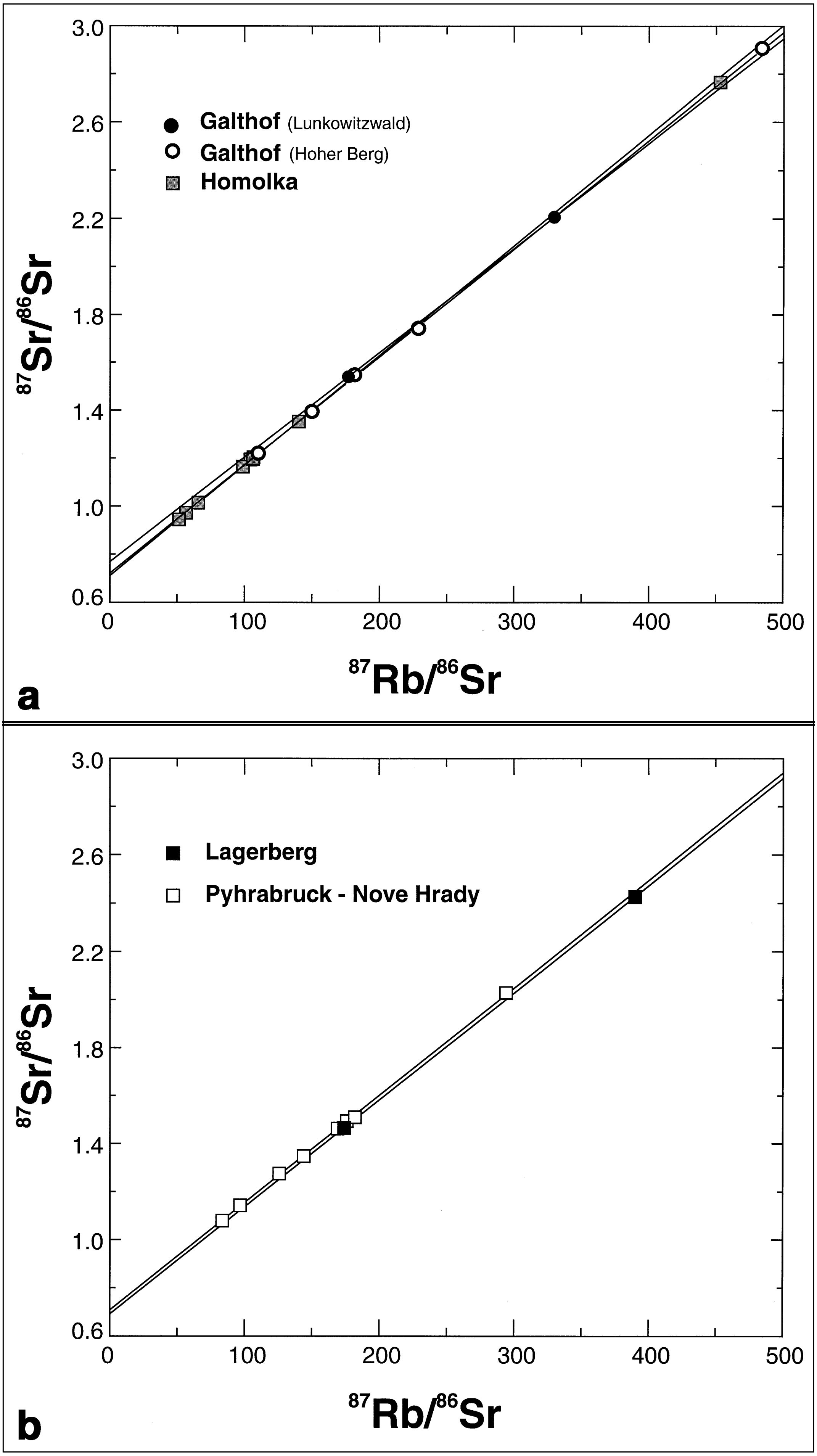
The sequence of emplacement of the main granite types of the SBP is obvious from field evidence and matches the scheme given in chapter 2: Weinsberg type – fine-grained granites – Eisgarn types – muscovite bearing granites. Wether the various bodies of the latter group of granites are coeval or represent the products of a time depending fractionation of parental Eisgarn type melt was not known. Therefore the point of interest was to determine the accurate time of intrusion of the highly evolved muscovite bearing granites.

Samples of ten to twenty kilogramm size have been collected 1994 and 1996 in the Pyhrabruck-Nakolice and Lagerberg body, 1995 in the Galthof stocks for Rb-Sr total rock analyses. One sample from Unterlembach was investigated years before (FRANK et al., 1990). Because the composition of these rock types is too inhomogenous for Rb-Sr dating, Ober-Lembach and Šejby were sampled for muscovite dating by $^{40}Ar–^{39}Ar$ only.

The procedures of rock and mineral sample treatment, of chemical separation and mass spectrometry have been shortly described in a previous paper (BREITER & SCHARBERT, 1995). Age cal-

Table 3.
Contents of F, Li, Rb, and Cs in micas (F in wt.-%, others in ppm).
Analyses by wt chemistry in the laboratory of CGS Praha.

		F	Li	Rb	Cs
Ober-Lembach	muscovite	0.96	267	901	26
Unter-Lembach	muscovite	1.24	212	1305	-10
	biotite	1.32	942	2314	109
Nakolice-Pyhrabruck	muscovite	1.68	1028	2976	90
Šejby	muscovite	1.28	603	1943	41
	muscovite	1.36	768	2085	116
Homolka	muscovite	2.61	4853	6310	n.a.



Text-Fig. 7.
Rb-Sr isochron plots.
a) Galthof type muscovite granites compared to Homolka.
b) Pyhrabruck – Nakolice and Lagerberg type muscovite granites.

culations were done with the programme by K. LUDWIG (1993) and the IUGS recommanded constants (STEIGER & JÄGER, 1977).

The results of isotope analyses are documented in table 4. For completion the data of more samples investigated from the Homolka intrusion and a previously published data on Unter-Lembach type are added. The graphic presentation is shown in Text-Fig. 7.

The muscovite bearing granites intruding the main Eisgarn type body have an apparent Rb-Sr age around 320 m.y. (Homolka 320±4 m.y.; Galthof, subtype Hoher Berg 317±8 m.y.) One small stock, subtype Lunkowitzwald, can be distinguished from the main Galthof intrusion by geochemistry and is obviously several million years younger (see Tab. 4 and Text-Fig. 7a). Though this age is poorly defined by two but highly radiogenic samples the result is corroborated by the muscovite Ar data (in prep.).

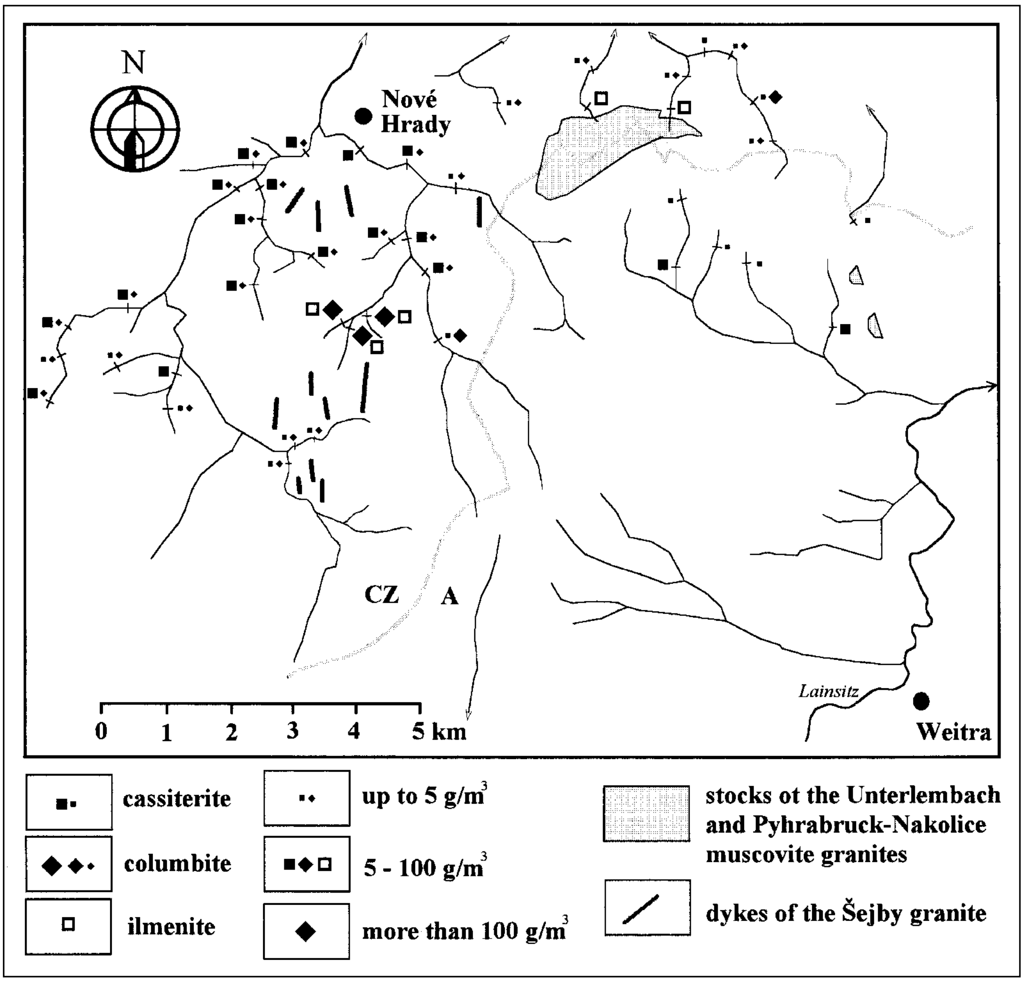
In contrast the young stocks in the western Eisgarn body have an age around 314 m.y. Due to their high Rb/Sr ratios it is not possible to calculate exact initial Sr ratios which in the case of Lager-

Table 4.
Isotope data of muscovite-bearing granites.
*) including previously published data.

rock type	sample	Rb ppm	Sr ppm	87Rb/86Sr	87Sr/86Sr	error
Galthof	3/95	616	12.7	150	1.39513	0.00023
	4/95	690	9.61	229	1.74263	0.00039
	5/95	656	4.76	484	2.90642	0.00055
	6/95	670	18.5	110	1.21805	0.00017
	7/95	786	13.5	182	1.54739	0.00022
(Hoher Berg)	**age 317±8 m.y.,Sr initial 0.7209 ±0.0226, MSWD 2.3**					
	8/95	588	10.4	177	1.53960	0.00015
	9/95	560	5.63	330	2.20633	0.00033
(Lunkowitzwald)	**age 306±7 m.y.,Sr initial 0.7683±0.0232**					
Homolka	20/94	1080	55.3	58.0	0.97443	0.00010
	21/94	1065	55.8	56.6	0.97148	0.00011
	42/94	732	22.4	98.8	1.16387	0.00011
	43/94	1270	73.0	51.5	0.94419	0.00011
	age 320±4 m.y.,Sr initial 0.7136±0.0055, MSWD 3.0*					
Pyhrabruck	44/94	814	14.9	169	1.46277	0.00011
	45/94	634	22.8	83.5	1.07942	0.00017
	46/94	709	15.1	144	1.34812	0.00006
	47/94	818	14.5	176	1.49351	0.00023
	48/94	797	24.8	96.8	1.14238	0.00011
	49/94	714	7.94	294	2.02834	0.00027
	50/94	813	13.9	182	1.51038	0.00019
	52/94	721	17.5	126	1.27514	0.00013
	age 314±6 m.y.,Sr initial 0.707±0.012, MSWD 2.1					
Lagerberg	6/96	537	9.61	174	1.46578	0.00025
	7/96	586	5.07	390	2.42707	0.00073
	age 313±7 m.y.,Sr initial 0.691±0.019					
Unterlembach	1/89	502	7.3	219	1.7272	0.00020

berg is even unrealistically low. Still they seem to be lower than in the other younger intrusions of the central Eisgarn body (compare Text-Fig. 7b).

Intrusions were followed immediately by uplift and cooling since the Ar ages of muscovite are close to the whole rock ages (BREITER & SCHARBERT, 1995, 1996).



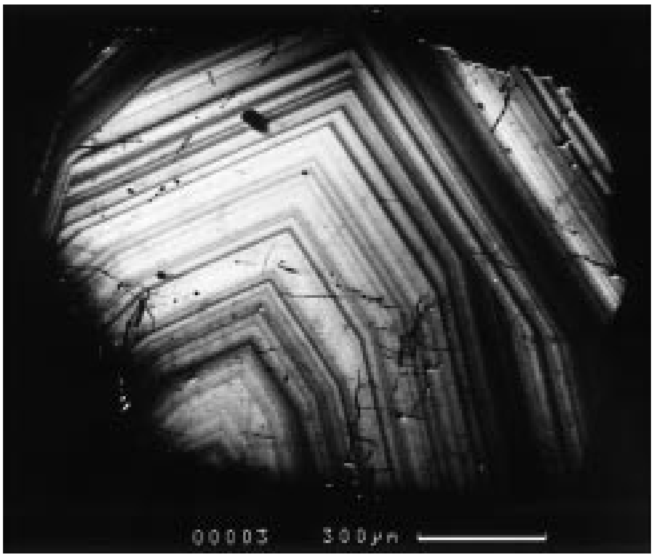
Text-Fig. 8.
Map of selected heavy mineral concentrations in recent sediments in the Weitra – Nové Hrady area according to GÖD (1988), TENČÍK (1981) and authors' sampling.

5. Indications of Mineralization

Tin, Niobium, Tantalum

During heavy mineral concentrate prospection, conducted on both sides of the border (TENČIK, 1982; GÖD, 1988), several occurrences of cassiterite, wolframite and topaz have been recorded, but their source has not been investigated. Only lately, the indications E and SE of Nové Hrady were localised by students' field-courses of Charles University Praha (unpublished). It turned out that the wolframite is columbite indeed. The highest concentrations of columbite, found N of Šejby was about 600 g/m³ (Text-Fig. 8).

Text-Fig. 9.
Oscillatory zoned columbite crystal from Šejby.
Photo: J. FRÝDA.



The potential ore-bearing capacity of muscovite granites of Nakolice-Pyhrabruck body and Šejby-dykes were first suggested by KLEČKA & MATĚJKA (1992). Some mineralogical features were reported by NOVÁK et al. (1994).

Ilmenite, cassiterite, columbite, and topaz were recognised in accessory amounts in the Pyhrabruck granite, columbite and ilmenite in the Šejby dyke-granite. Ore minerals form mainly inclusions in micas (0.X mm), but in placers grains up to 5 mm were found. Cassiterite is Nb- and Ta-rich, which may point to its magmatic origin. Columbite is obviously Nb- and Fe-rich, which is consistent with other occurrences in sodic granites (ČERNÝ & ERCIT, 1989). Many columbite crystals from Šejby show sharp oscillatory zonation in Nb/Ta ratio (Text-Fig. 9), other crystals change composition from a Nb-rich core to a Ta-enriched zone and again to a Nb-rich rim (Text-Fig. 10).

In the area N of Gmünd several anomalies of cassiterite in stream sediments also occur (GÖD, 1988), but no cassiterite in primary rocks was recognised.

Uranium

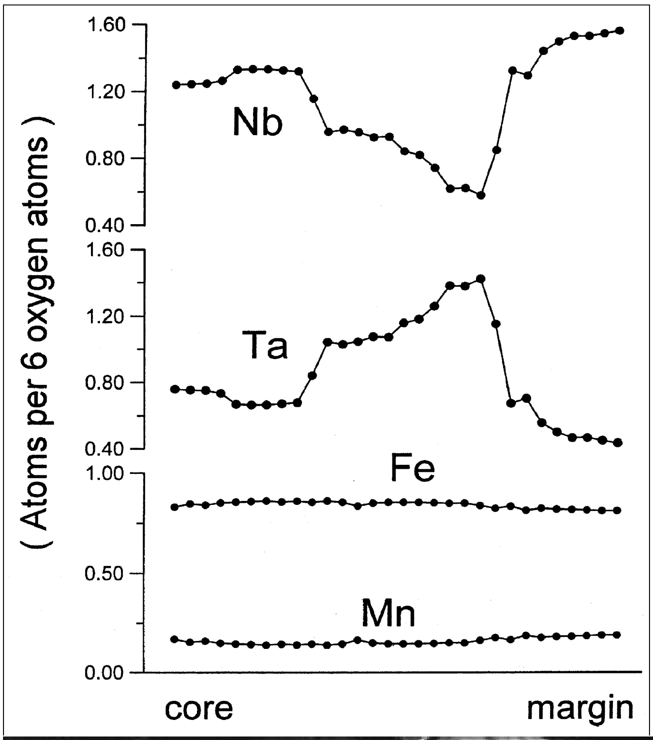
An accumulation of secondary uranium minerals was described in the muscovite granite stock north of Unterlembach. It was discovered by airborne gamma-spectrometry measurements (SEIBERL & HEINZ, 1986) and subsequently studied in detail (GÖD, 1988, 1989; GÖD in BREITER et al., 1994). The main uranium carrier is the mineral meta-uranocircite (NIEDERMAYR et al., 1990). The mineralization is caused by circulation of meteoric waters in a tectonic zone, by leaching of the uranium from the granite and by reprecipitation under near-surface oxidizing conditions. The exploration provided negative results, since this is only an occurrence, not a deposit.

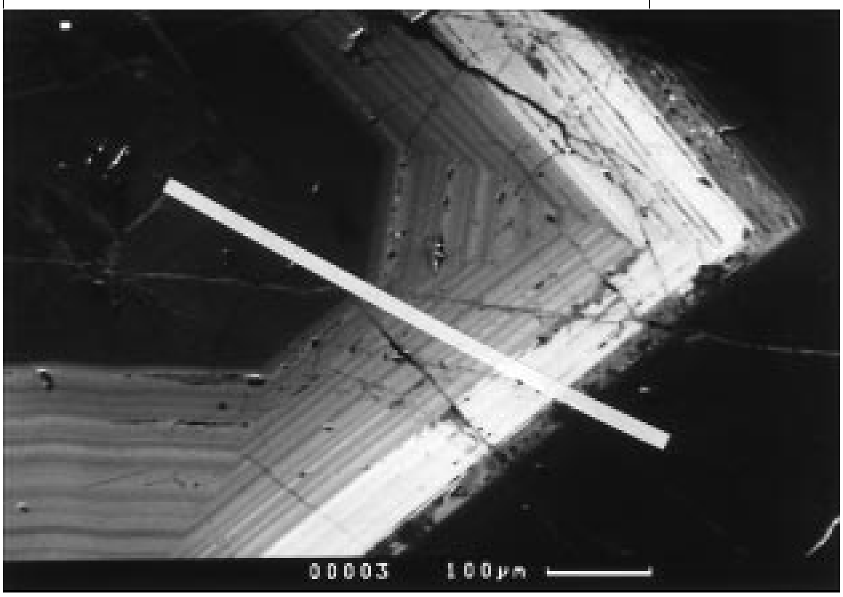
6. Discussion

In the following we try to answer the question wether the muscovite granites are the youngest product of the Eisgarn-melt fractionation, or represent a new input of leucocratic melt.

From field evidence and geochronological investigations the muscovite bearing granites described above belong to the youngest intrusions of that part of the SBP, that is represented by the Central Moldanubian Pluton.

The age of the intrusions is higher in the northeastern part of the Eisgarn pluton that extends from Gmünd N into Bohemia: Homolka and Galthof granites are of the same age within limits of error (320 and 317 m.y., and an error of 4 resp. 8 m.y.). The granites of Pyhrabruck-Nakolice and Lagerberg in the body of Eis-





Text-Fig. 10.
Zoned columbite crystal from Šejby.
Photo and microprobe analyses J. FRÝDA.

garn type granite around Weitra are around 314 m.y. old. In both Eisgarn type granite areas occur intrusions as young as approximately 308 m.y. (Galthof – Lunkowitzwald and Šejby respectively).

In the muscovite bearing granites intruded in the NE Eisgarn type the initial Sr ratios increase with decreasing age indicating prograde melt evolution. In the SW Eisgarn realm the initial Sr ratios of the Pyhrabruck and Lagerberg granites are poorly defined. Obviously they are lower than those in the eastern area (Tab. 4). Similarly low initial Sr ratio was observed in the Nebelstein intrusion. If these observations hold true we must assume that additional components of different Sr isotopy played a role in the formation of late muscovite granites.

All the described muscovite granites are leucocratic, in various degree enriched in volatilies (F, and namely P), rare alkalies (Rb, Li, Cs), and rare metals (Sn, Nb, Ta) and strongly depleted in REE. These granites can not be a minimum melt of meta-sedimentary lithologies produced during the thermal climax of the Variscan metamorphism or in large shear-zones like for example the Altenberg granite (FINGER et al., 1994) or the Lásenice granite (BREITER & SOKOL in print). Minimum melt granites should be poor in all elements mentioned above. The muscovite granites described also can not be the product of dry melting of meta-igneous or highly metamorphosed lithologies, while this type of melts, although rich in rare alkalies and heavy metals, should be P-poor and REE-rich. All chemical features of the granites studied suggest an extensive fractionation of large volumes of a water-rich peraluminous melt, such as the parental melt of the Eisgarn type granite (VELLMER & WEDEPOHL, 1994).

P-rich muscovite granites crop out only in spatial connection with the Eisgarn type granite. They have not been found in other parts of the SBP. The Galthof body is situated in the central, younger part of the Eisgarn pluton and corresponds well with the theoretical position of a small amount of residual melt in a zoned pluton. Other bodies of muscovite granites are situated in the pericontact zone of the Eisgarn pluton and represent small portions of residual melt injected along tectonically imposed structures of older subintrusions of the pluton (Homolka, Lembach, Pyhrabruck) or in gneisses of its envelope (Šejby).

A similar situation has been found in Western Bohemia and Oberpfalz, where stocks of leucocratic P-rich rare-metal granites intruded after a large volume of peraluminous two-mica granites of Bärnau and Flossenbürg plutons (BREITER & SIEBEL, 1995).

The chemical compositions of individual muscovite (+biotite) granites (Unterlembach, Lagerberg) and the Galthof granite are well correlated to each other and also with their supposed source – the Eisgarn granite. Their silicium content increases, aluminium and iron slightly desrease, Sr and Zr decrease rapidly (compare element ratios on Text-Figs. 3 and 4). The chemistry of even more fractionated Pyhrabruck and Homolka granites is influenced by a reversed trend of Si and Al, which is mineralogically expressed by an increase of the albite/quartz ratio in these rocks. Aluminium, phosphorus, and sodium increased distinctly, which caused decreasing of silicium.

The elements Al, P, and Na are well correlated in the group of strongly fractionated granites. The only exception is the Šejby dyke granite, which is also the only P-granite intruded into paragneisses. Here, the increase of Al and Na is compensated by rapid decrease of K and Si remains nearly constant. The very high Na/K ratio in the Šejby granite can explain the highest Nb and Ta occurrence here.

The most fractionated part of the whole sequence is the Homolka granite (BREITER & SCHARBERT, 1995), where the rare alkalies and rare metals are extremely enriched.

Taking all chemical parameters into consideration the chemical trends go from Eisgarn via closely related Galthof and muscovite (biotite) granites to Pyhrabruck-Nakolice intrusions. The highly fractionated Homolka granite slightly lies off the trendline of Text-Figs. 4 and 5 which is caused by Sr concentrations much higher than the normal trend. The geochemical trend is not congruent with the age of intrusions. It seems more likely that the geochemical evolution of the stocks does not depend on time but is a phenomenon of local melt evolution in various locations at different times.

Another type of leucocratic two-mica to muscovite granite in the area around Weitra mapped by BREITER forms meter to tens of meters thick dykes cutting the Weinsberg granite. These granites are relatively rich in Ca and Sr, poor in Rb, Li, Cs, F, and rare metals, and represent a residual portion of the Weinsberg melt.

Muscovite granites as a source of ore minerals

The muscovite granites are undoubtedly sources of cassiterite, columbite and other ore minerals in stream sediments. Cassiterite, ilmenite, columbite and other Nb-Ta-Ti oxides have been found in the thin sections of granites (NOVÁK et al. [1994] from Šejby, P. UHER, pers. commun., from Homolka) and in concentrates from granitic eluvium (Pyhrabruck, Homolka). Ore minerals form mainly inclusions with diameters in 0.x mm in micas, larger grains have been found only in stream sediments (up to 5 mm in Šejby). In all localities, the ores are disseminated in the rocks. Mineralisation of economic interest has not been found.

7. Conclusions

The main granites of SBP in the area South Bohemia – Northern Waldviertel are accompanied by two suites of leucocratic muscovite (+biotite) to muscovite granites:

1) unfractionated dykes in the Weinsberg suite,
2) several types of muscovite bearing granites of different degree of fractionation as a product of Eisgarn-melt evolution.

The suite Oberr-Lembach – Unter-Lembach – Pyhrabruck illustrates the evolution of the Eisgarn-residual melt in the area W of Gmünd, the suite Galthof – Josefsthal (in prep.) – Homolka represents the evolutionary path in the central part of the Eisgarn pluton N of Gmünd.

There is a significant time difference between the two areas in respect to the formation of the fractionated granites (around 320 and 314 m.y. respectively). No age difference can be distinguished between the types of different grade of fractionation e.g. Lagerberg and Pyhrabruck or Galthof and Homolka).

All granites are peraluminous, enriched in rare alkalies and rare metals. Characteristic is an enrichment in phosphorus, which is concentrated mainly in alkali feldspars.

No greisen- or vein-like mineralizations have been found. Ore minerals disseminated in Pyhrabruck- and Šejby-granites have been observed, elsewhere they are concentrated in stream sediments.

Rare metal-bearing P-rich granites are widespread through the whole Moldanubicum in areas where peraluminous two-mica granites like Eisgarn type, or Flossenbürg – Bärnau granites in Oberpfalz, occur.

The melts were formed locally and intruded at significantly different times. The cooling ages of muscovites are close to the intrusion ages.

Acknowledgements

We thank J. FRÝDA for help with microprobe analyses and Dr. R. SELTMANN from GFZ Potsdam for the trace element analyses performed on ICP-MS.

The skilfull help of Ing. Monika JELENC in isotope chemistry is highly appreciated. J. SEITLER helped with sample preparation.

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Manuskript bei der Schriftleitung eingelangt am 28. Oktober 1997