MITT.ÖSTERR.MINER.GES. 145 (2000)

TWO-MICA GRANITES OF THE SOUTHWESTERN PART OF THE SOUTH BOHEMIAN BATHOLITH

by

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Abstract

The aim of this paper that is supported by the Czech-Austrian project KONTAKT/AKTION, was to study the evolution of the two-mica granites in the southwestern part of the Southern Bohemian Batholith (SBB) in the area between the towns of Nové Hrady and Trhové Sviny. They are diveded into the equigranular Mrákotín subtype and the porphyritic Číměř subtype. Both are peraluminous, fractionated monzogranites with rather uniform major element geochemistry. They have high LREE/HREE, high contents of Rb and Th and low concentrations of Sr and Yb.

Introduction

The extensive granitoids of the exposed surface of the South Bohemian Batholith (SBB) are various types of two-mica granites. In Austrian the term Eisgarn granite is used for the two-mica granites. The Czech classification is based on field descriptions of granites in the central part of the batholith. Three subtypes occur between Řásná, Mrákotín, Číměř and Landštejn (KOUTEK, 1925; ZOUBEK, 1949). These have very similar mineralogical composition, but different textures and sometimes have been considered as three distinct magmatic phases. New geochemical and mineralogical data together with results of airborne- and ground gamma-ray spectrometry enable us to reconsider the evolution of these granites in the central part of the South Bohemian Batholith (BREITER et al., 1998; BREITER & KOLLER, 1999).

The two-mica granites of the SBB appear to have formed in three magmatic episodes. The evolution of the batholith began with the intrusion of a peraluminous granite of the Lásenice-Deštná subtype (KLEČKA et al., 1991; RENÉ et al., 1999). Low concentrations of compatible elements are characteristic of these granites. Some parts were affected by shear zones (KLEČKA & RAJLICH, 1994). The second magmatic phase started with the intrusion of high-K peraluminous Th- and Zr-rich melt; it crystallised as the porphyritic subtype Číměř and equigranular subtype Mrákotín. This granite melt was inhomogeneous. Granites of this intrusive phase form the largest part of the South Bohemian Batholith.

Further fractionation of the second phase of the peraluminous granite melt produced the Eisgarn s.s. granite in the central part of batholith between the towns of Nová Bystřice and Gmünd (BREITER & KOLLER, 1999). Fractionation of this granitic melt produced small bodies of F-, P, Rb-, Li-, Sn-, Nb- and Ta-rich muscovite granites (Šejby, Homolka, Nakolice; KLEČKA & MATÉJKA, 1992; BREITER & SCHARBERT, 1998). A fresh intrusion of Si-rich, but F-, Rb-, Li- and U-poor granite melt produced deep-seated coarse-grained granites (Zvůle, Melechov, Čeřínek).

Geology

Between Nové Hrady and Trhové Sviny, the two-mica granites of the South Bohemian Batholith occur in two subtypes: the equigranular Mrákotín and the porphyritic subtype Čímĕř type. These extend in the area of Slepičí Hory Mountains (STANÍK et al., 1978; VRÁNA et al., 1984). The boundaries of individual granite bodies are often tectonic. Shear structures are oriented mostly in NNE-SSW to NE-SW directions parallel to the regional shear zones in the southern part of the Bohemian Massif (Rodl shear zone, Kaplice fault, e.g. BRANDMAYR et al., 1995). The shear zones are sometimes filled by mylonite and quartz veins or by dykes of younger magmatic rocks (younger two-mica granites, aplites, rarely also granodiorite porphyries).
Older granites of the Weinsberg type also occur near Trhové Sviny as biotite granodiorites of the Freistadt type. The contacts of individual bodies of granitoids are covered by Tertiary and Quaternary sediments. The oldest magmatic phase is biotite of the Weinsberg type. Xenolithes of these granite type in the two-mica granites are of younger age, while large idiomorphic Kfs-phenocrysts represent older xenocrysts. These phenomena were best observed in a flooded quarry on the SSE outskirts of a village Besednice (see VRÁNA ET AL., 1984).

Mineralogical composition

The two-mica granites can be divided into several textured subtypes. The most extensive are medium- to fine grained two-mica granites of the Mrákotín subtype, that were quarried near the villages of Besednice, Slavče and Dobrkovská Lhotka. Medium- to coarse-grained, porphyritic granites of the Čímĕř subtype are less abundant. This subtype of two-mica granites occurs in the Kohout hills and between Olešnice and Nové Hrady. Difference in muscovite/biotite ratio are characteristic for the two-mica granites between Nové Hrady and Trhové Sviny, as well as differences in amounts of plagioclase and K-feldspar (see Fig. 1, that includes mineralogical data from STANÍK et al., 1978 and VRÁNA et al.,1984). The mineralogical composition suggests that granites of the Čímĕř subtype are typical monzogranites, but the granites of the Mrákotín subtype are monzogranites to syenogranites. As the anorthite component in some samples of the Mrákotín subtype is as low as $An_{1.8}$ (ČEKAL, 1995) these may be alkali feldspar granites. The most likely explanation of these differences in mineral composition is the difference in altitude of individual granite blocks. These were affected by vertical movement along NNE-SSW and NE-SW shear zones during the post-Variscic extension phase of evolution of the Bohemian Massif.

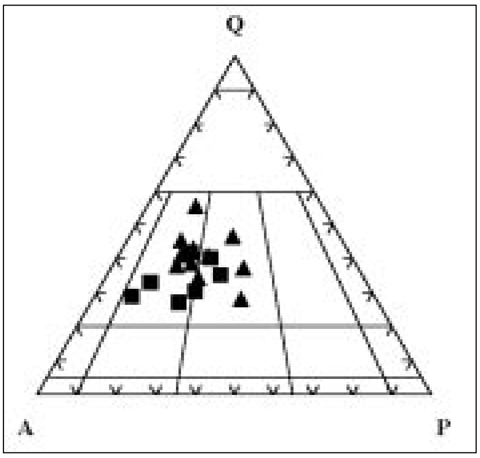


Fig. 1

Modal composition of the two-mica granites.
Full square: two-mica granites of the Cimer subtype.
Full triangle: two-mica granites of the Mrákotín subtype.

Medium- to fine-grained granites of the Mrákotín subtype are blue-grey to light grey, that weather to light yellow-white equigranular rocks. The granites of this subtype are sometimes subtly foliated and rarely contain Kfs phenocrysts 1–2 cm in size. Around the villages Besednice and Dobrkovská Lhotka large xenocrysts of K-feldspar (4–8 cm) occur. K-feldspar is composed by perthitic microcline that forms hypidiomorphic to allotriomorphic grains of 0.6–1 mm, rarely 2–4 mm in size. Plagioclase is $An_{1.8–26}$; its grains are hypidomorphic to allotriomorphic, 0.5–1 mm in size and it is frequently zoned. Quartz forms tiny allotriomorphic grains and minute grained aggregates. Biotite mostly forms individual bars or bar aggregates, sometimes together with muscovite. Biotite is pleochroitic, red-brown along X and Z and yellow-brown along X. Biotite is sometimes chloritized. Accessory minerals are apatite, zircon, ilmenite, and also sillimanite, cordierite and andalusite occur in some samples. Garnet (almandine) occurs in granites near the village of Březí, west of Trhové Sviny (ČEKAL, 1995).
Medium to coarse-grained porphyritic granites of the Číměř subtype contain K-feldspar phenocrysts (2–3 cm). K-feldspar is perthitic with significant microcline. It is also the part of the ground mass, where it usually forms allotriomorphic grains 1–2 mm in size. The length of the micas bars (muscovite and biotite) is up to 5 mm. Plagioclase grains are sometimes 4 mm in size and their compositional range is $An_{2.1–34}$ with a medium value of An_{15}. Accessory minerals are apatite, zircon, ilmenite, and rare sillimanite and andalusite.

Chemical composition

Analyses of typical samples of two-mica granites are shown in table 1. Data from ČEKAL (1995), HEŘMÁNEK (1995) and GERDES (1997) are used for discussion. Major and some trace elements (Rb, Ba, Sr, Zr, Nb) were determined by X-ray fluorescence spectrometry on a Siemens SRS-1 spectrometer (Uranium Industry Enterprise, analyst J. Bouška) and Philips PW-1408 (Unigeo Ostrava, laboratory Brno, analyst J. Janáčková, University of Salzburg, Austria, analyst F. Schitter). U and Th were determined by gamma spectrometry using a multi-channel gamma spectrometer NT-512 (Geofyzika Brno, analyst M. Škovierová). The REE contents were determined by ICP-MS (Activation Laboratories Ltd., Ancaster, Canada).

	Re-1222	Re-1229	Re-1230	Re-1493	Re-1494	Re-1505
Subtype	Mrákotín	Mrákotín	Mrákotín	Mrákotín	Mrákotín	Čímĕř
SiO_2	73.16	73.80	73.57	70.46	70.39	71.45
TiO_2	0.21	0.16	0.24	0.36	0.37	0.17
Al_2O_3	14.12	13.73	13.66	15.46	15.67	15.88
Fe_2O_3 tot.	1.28	1.19	1.87	2.31	2.32	1.29
MnO	0.02	0.03	0.03	0.03	0.03	0.02
MgO	0.40	0.25	0.50	0.62	0.56	0.27
CaO	0.69	1.02	0.64	0.86	0.61	0.79
Na_2O	2.77	3.38	2.88	2.16	2.23	2.55
K_2O	5.53	5.02	4.81	5.68	5.72	6.14
P_2O_5	0.22	0.11	0.20	0.17	0.17	0.22
LOI	1.10	0.80	1.10			
Total	99.50	99.49	99.50	98.11	98.07	98.78
Ba (ppm)	395	900	384	444	449	328
Rb (ppm)	282	208	204	285	281	269
Sr (ppm)	84	148	103	101	105	85
Zr (ppm)	105	105	103	138	150	71
U (ppm)	3.9	3.9	2.8			
Th (ppm)	15.5	18.5	26.0	27	35	14

Table 1

Representative analyses of two-mica granites from the area between Nové Hrady and Trhové Sviny.
Re-1222: abandoned quarry, Chlum hill, Locenice; Re-1229: abandoned quarry, Besednice;
Re -1230: abandoned quarry, Blansko; Re-1493: abandoned small quarry, Dobrkovská Lhotka;
Re-1494: abandoned quarry, Dobrkovská Lhotka; Re-1505: abandoned small quarry, Zár;

The majority of the samples are peraluminous granites with an aluminium saturation index between 0.98 and 1.42 (mean value 1.18). High K-granites occur between Besednice and Nové Hrady with high Zr, Th and REEs. Changes of Rb and Zr (Fig. 2) and Ba - Sr show gradual fractionation of granite melt. Some fine-grained granites of the Mrákotín subtype from Besednice and Dobrkovská Lhotka have higher contents of Ba and Sr. Both subtypes of the granites show very similar distribution of LREE, but some significant differences HREE (Fig. 3). A higher negative Eu-anomaly is typical. In comparison with the composition of upper continental crust (Fig. 4) there are higher contents of Rb and Th and lower contents of Sr and Yb.
The good correlation between Th and Ce suggests that the major host of Th in both granite subtypes is monazite. The positive correlation between Th and Zr can be explained by similar behaviour of these elements during fractionation of the granite magma. Both monazite and zircon are included in biotite.

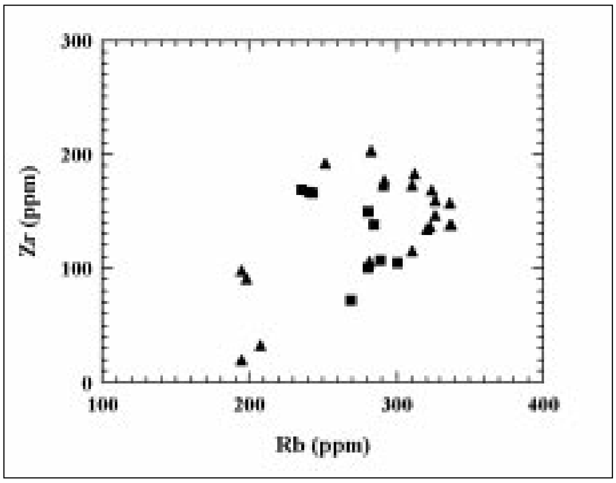


Fig. 2

Variation diagram of Zr and Rb for the two-mica granites. Symbols see Fig. 1.

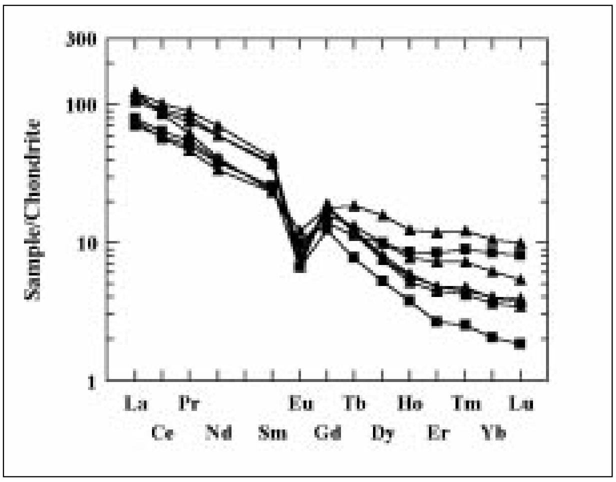


Fig. 3

Chondrite-normalized REE pattern for the two-mica granites. Normalizing values are from TAYLOR & McLENNAN (1985). Symbols see Fig. 1.

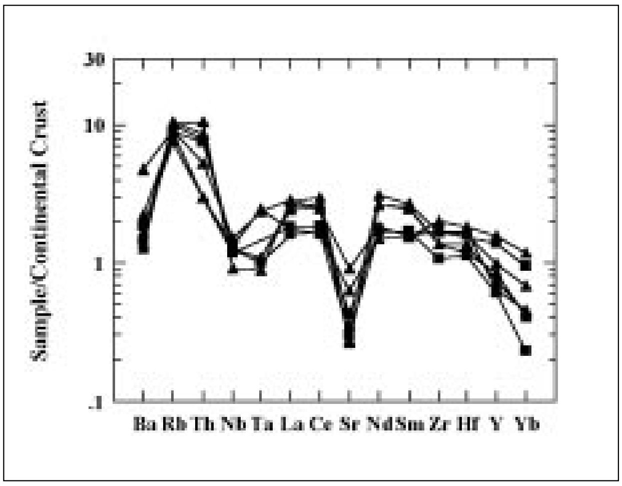


Fig. 4

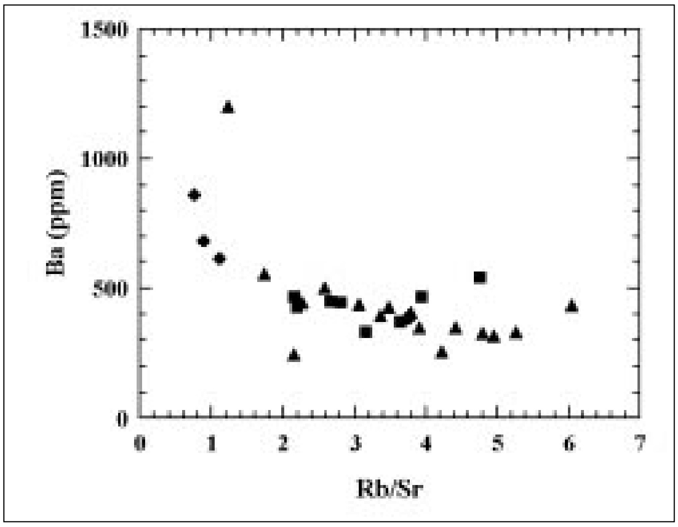
Spiderdiagram of selected element normalized to average upper continental crust for two-mica granites. Normalizing values are from TAYLOR & McLENNAN (1985). Symbols see Fig. 1.

Discussion

Small differences in chemical composition of granites of the Mrákotín and the Čímĕř subtypes agree with the observations of BREITER & KOLLER (1999) from the main body of the South Bohemian Batholith. The chemical evidence suggests Mrákotín subtype is only a locally evolved variety of the Čímĕř granite magma. Similar fractionation of the granite magma (Fig. 5) is characteristic of both granite subtypes. The higher content of Ba and Sr in some of the Mrákotín subtype from Besednice can be compared with the higher content of Ba and Sr in fine- to medium-grained granites from Weitra (GERDES, 1997). These are probably due to interaction between Weinsberg and Eisgarn granite melts.

Fig. 5

Variation diagram of Ba and Rb/Sr for two mica granites. Symbols see fig. 1; full rhombs: two-mica granite of the Weitra subtype.



The granite composition can be compared with the products of fluid-absent melting experiments under crustal P-T conditions (see GERDES, 1997). There is a general decrease in compatible elements, LREE, Th, Zr with increasing Rb contents (Fig. 2). This is best explained if the highest Rb two-mica granites represent the lowest degrees of partial melting. Higher-degree partial melts will contain larger amounts of restite and will be produced by higher degrees of partial melting of phases such as plagioclase and biotite (e.g. HARRIS & INGER, 1992). The major and trace element distribution can be explained by 30–50 vol.% partial melting of pelite-dominated graywackes with a composition similar to common metasediments of the Variscan belt (VELLMER & WEDEPOHL, 1994; GERDES, 1997; GERDES et al., 2000). The higher content of Ba can be explained by interaction of the granite melt with older melt of biotite granite of the Weinsberg type. Varying degrees of partial melting were therefore probably the dominant process forming the two-mica granites from southwestern part of the SBB.

The chemical composition of granites from the southwestern part of the South Bohemian Batholith is comparable with the composition of leucogranites from the Massif Central and South Armorican massif in France (BERNARD-GRIFFITHS et al., 1985; WILLIAMSON et al., 1996).

Conclusion

Between Nové Hrady and Trhové Sviny the Mrákotín subtype and the porphyritic Číměř subtype of the granites of the South Bohemian Batholith are present. Both subtypes represent monzogranites. The major element geochemistry of all granites is uniform. All these granites are peraluminous and include high-K granites. In comparison with the composition of the upper continental crust these granites have higher contents of Rb and Th and lower contents of Sr and Yb. The peraluminous composition and the distribution of compatible trace elements indicate that granites from the southwestern part of the SBB are S-type granites, formed by partial melting of crustal metasediments.

Acknowledgements

This paper is part of a study of the two-mica granites of the South Bohemian Batholith made with the financial support by the Czech-Austrian foundation AKTION/KONTAKT (Project No. 12/1999). I thank Dr. K. Breiter, Dr. D. Matějka and Prof. F. Finger for discussions. Ross Taylor is thanked for reviewing the manuscript and correcting the English.

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bei der Redaktion eingegangen: 29. Mai 2000

Manuskript angenommen: 23. Juni 2000