GEOLOGICA CARPATHICA, 49, 3, BRATISLAVA, JUNE 1998
151–160

ZIRCON IN HIGHLY EVOLVED HERCYNIAN HOMOLKA GRANITE, MOLDANUBIAN ZONE, CZECH REPUBLIC: INDICATOR OF MAGMA SOURCE AND PETROGENESIS

Project No. 373

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(Manuscript received November 12, 1997; accepted in revised form March 24, 1998)

Abstract: The Homolka granite stock (southern Bohemia, Czech Republic) is a highly evolved topaz-bearing and phosphorus-rich intrusion penetrating the Lásenice and Číměř S-type granites of the late-Variscan South-Bohemian (Moldanubian) pluton, subvolcanic dykes of microgranite to granite porphyries are also widespread. Study of accessory zircon revealed an extensive amount of old inherited zircon in the Homolka granites. On the basis of back-scattered electron images and microprobe study, the inherited zircon of the Homolka Granite is identical to the zircon from the Lásenice and Číměř granites. This older zircon forms transparent crystals with oscillatory zoning and low Hf, Y, U and P contents. Younger zircon of the highly evolved Homolka Granite exhibits transparent crystals with oscillatory to irregular zoning and metamict grains with high Hf (up to 12.3 wt. % HfO_2), often also Y, U and P. If 30 to 50 vol. % of zircon is estimated to be inherited, the calculation of zircon saturation temperature gives T_S = 720–760 °C for the Číměř and 640–680 °C for the Lásenice zircon, and 610–650 °C for the Homolka zircon. The subvolcanic microgranite-porphyry dyke gave T_S = 690–730 °C. These zircon data indicate that the Homolka Granite is a product of advanced fractional crystallization from a magmatic source similar to the Číměř Member of the Eisgarn Suite.

Key words: Czech Republic, South-Bohemian (Moldanubian) pluton, Homolka Granite, zircon saturation temperature, electron microprobe, BSE, zircon typology, zircon.

Introduction

Accessory zircon of granitic rocks has been used as petrogenetic indicators for a long time. Its informative value lies mainly in the relatively high chemical stability of zircon during subsolidus stages, the dependence of between crystal morphology and genetic type of parental magma (zircon typology; Pupin 1980), the variety of internal crystal zoning as revealed by back-scattered electron images (BSE) and cathodoluminescence (Vavra 1990), Zr/Hf ratio as a principal indicator of magmatic fractionation (Fleischer 1955; Lyakhovich 1968; Černý et al. 1985); distribution of other trace elements, such as Y, REE's, P, U; a possibility to calculate zircon saturation temperature (Watson & Harrison 1983); numerous U-Pb isotope and FT dating, etc.

The aim of this paper is to demonstrate the ability of accessory zircon to indicate the possible magma source of the granite using the example of the Homolka highly evolved rare-element and phosphorus-rich granite.

Geological setting

The studied area is situated in the NW part of the late-Variscan South-Bohemian or Moldanubian pluton between the towns of Tábor and Gmünd. The pluton is represented here mainly by the two-mica Lásenice and Číměř granites (Fig. 1).

The fine-grained, mostly equigranular two-mica Lásenice Granite (represented here by sample HO-1) is relatively older and affected by the latest Variscan tectonic movements (Klečka & Rajlich 1984). The Lásenice Granite occurs along the NW contact of the pluton and also forms small bodies in the Moldanubian paragneisses. The accessory minerals, represented by andalusite, monazite-(Ce) and ilmenite (Table 1) as well as chemical compositions, very poor in HFSE and REE (Table 2), both classify the Lásenice Granite as a typical slightly fractionated metasedimentary S-type granite.

The younger, post-tectonic Číměř Granite (HO-3) forms the major part of the area. The Číměř Granite is medium-grained porphyritic, two-mica and relatively older subtype of the Eisgarn granite group. The ilmenite+monazite-(Ce) accessory assemblage (Table 1) and chemical composition (Table 2) indicate their high K-calc-alkaline S-type nature.

Both the Lásenice and Číměř granites are cut by a ca. 20 km long, N-S trending swarm of more than 30 dykes of granite porphyries and microgranites (HO-2). The individual dykes are 2–20 m thick and up to 1.5 km long. Some thicker dykes are zoned and exhibit fluidal rhyolitic texture along the contact, which passes gradually into granite porphyry towards the centre of the dyke.

In the central part of the dyke swarm, close to the Czech-Austrian border, a stock of leucocratic Homolka Granite crops out. Its surface of 6 km^2 is slightly elongated in the N-S

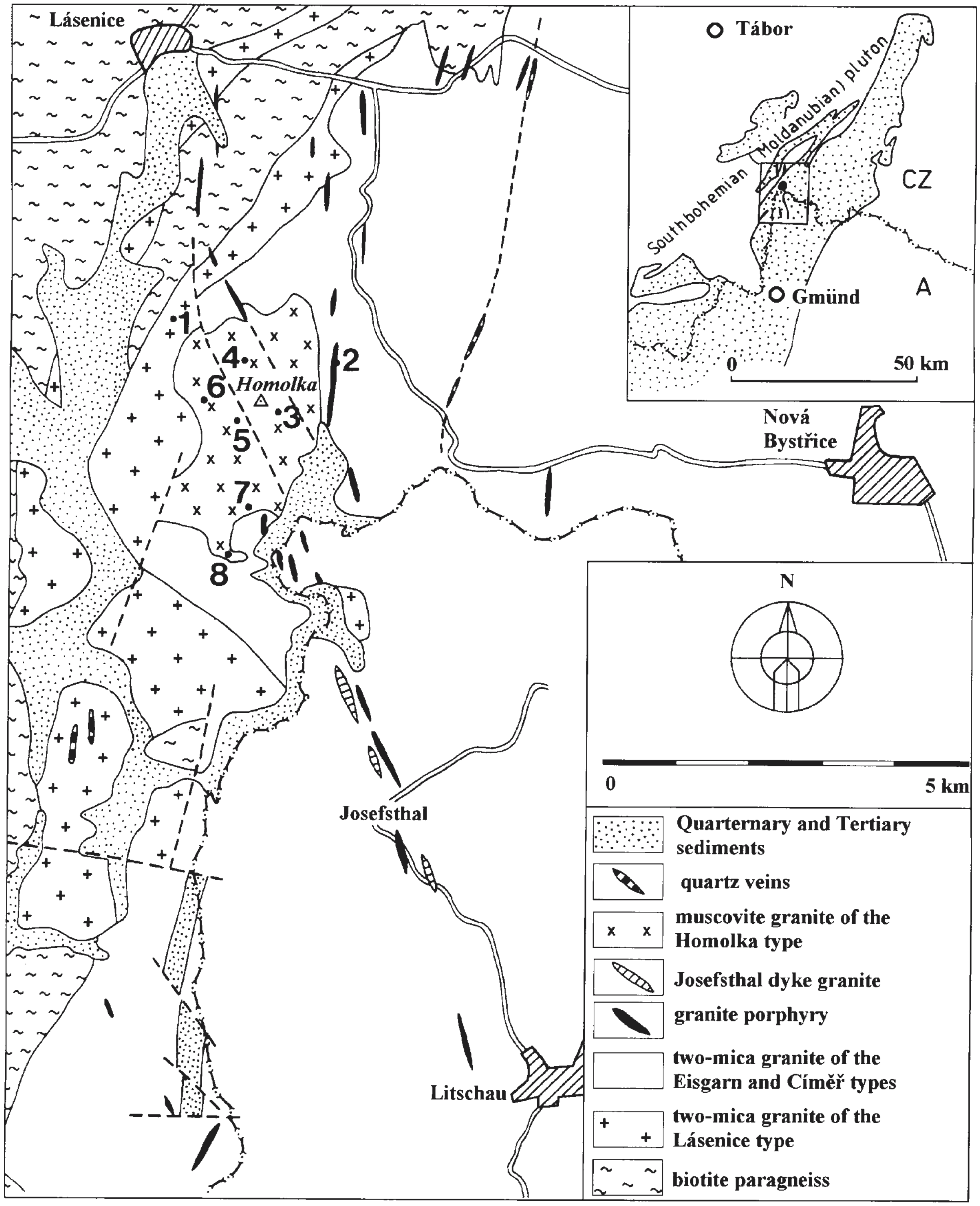

Fig. 1. Geological map of the Homolka granite area.

direction and forms a morphological elevation of the Homolka Hill. Several xenoliths of the Číměř Granite and granite porphyry up to a few hundred square metres in area are found in the central part of the granite body.

The Homolka stock (HO-4 to 8) is composed mainly of equigranular medium-grained leucocratic alkali feldspar granite. Only some schlieren of porphyritic variety are developed in the western part of the body, and they contain up to 1 cm large quartz and K-feldspar phenocrysts in a fine-grained groundmass. Schlieren and/or dykes of fine-grained aplitic variety are found in several places. A marginal pegmatite, "stockscheider" (HO-7) with large K-feldspars floating in a fine-grained groundmass, develops in some parts of the SE, W and N contact of the stock. It forms a rim around the major xenoliths in the central part of the body.

All textural varietes of the Homolka Granite contain quartz, albite (An_{00-05}), P-rich K-feldspar and Li, Rb, Zn- and F-rich muscovite. Topaz is frequent, apatite, childrenite-eosphorite, cassiterite, Nb,Ta-rich rutile, titanian ixiolite and ferrocolumbite are the main accessory minerals (Breiter & Scharbert 1995; Frýda & Breiter 1995; Uher et al. in prep.) — Table 1. Post-magmatic processes are restricted to rare quartz veinlets with greisen rims, patchy chloritization, veinlets of a barren milky quartz and flakes of U-micas in fissures (Litochleb et al. 1991; Lochman 1992). The Homolka Granite belongs to the rare type of ore-bearing P-rich peraluminous magmatites, highly enriched in Li, Rb, Cs, Sn, Nb, Ta and F (Table 2) and with a high initial Sr isotopic ratio I_{Sr}=0.716±0.010 (Breiter & Scharbert 1995). It represents one of the youngest Variscan magmatic events within the Moldanubian; the Rb/Sr whole-rock isochrone gave an age of 319±7 Ma, the muscovite Ar-Ar plateau ages are 317±2 and 315±3 Ma, which indicate a relatively rapid cooling of the intrusion (Breiter & Scharbert 1995).

Experimental methods

We studied zircon from eight rock samples — for their description see Appendix. Zircon concentrates were obtained from 5–10 kg of solid rocks by standard methods: crushing, sieving, heavy liquid (bromophorm) and electromagnetic separation.

Back-scattered electron images (BSE) were performed on the JEOL JSM-840 scanning electron microscope at the Geological Survey of the Slovak Republic, Bratislava, Slovakia, under an accelerating potential of 25 kV.

Electron microprobe analyses (EMPA) of separated and polished zircon crystals were carried out on the Cameca SX50 wavelength dispersion instrument at the Department of Geological Sciences, University of Manitoba, Winnipeg, Canada. A beam diameter of 1–2 µm was used. An accelerating potential of 15 kV, beam current of 20 nA and counting time of 20 s were applied for P, Si, Zr, Hf, Al, Fe, Sc, Y, Ca, F and Cl; 20 kV, 30 nA and 40 s, for Th, U, Ce, Sm, Tb, Dy, Er and Yb. The following standards were used: monazite (for P $K\alpha$), zircon (Si $K\alpha$, Zr $L\alpha$), metallic Hf (Hf $M\alpha$), kyanite (Al $K\alpha$), almandine (Fe $K\alpha$), $NaScSiO_4$ (Sc $K\alpha$), YAG (Y $L\alpha$), diopside (Ca $K\alpha$), fluor-riebeckite (F $K\alpha$), tugtupite (Cl $K\alpha$), ThO_2 (Th $M\alpha$), UO_2 (U $M\beta$), REE3 (Ce $L\alpha$), REE2 (Sm $L\alpha$, Yb $L\alpha$), REE1 (Tb $L\alpha$) and REE4 (Dy $L\beta$, Er $L\alpha$). The data were reduced according to the PAP routine (Pouchou & Pichoir 1985).

Table 1: Accessory minerals of the Lásenice Granite (HO-1), microgranite-porphyry dyke (HO-2) Čímĕř Granite (HO-3), and Homolka granites (HO-4 to HO-8). For petrographic types, see Appendix. **XX**: very abundant, **xx**: abundant, **x**: rare accessory mineral.

	HO-1	HO-2	HO-3	HO-4	HO-5	HO-6	HO-7	HO-8
ZIRCON	x	x	x	x	x	x	x	x
APATITE	XX	XX	XX	xx	x	xx	XX	xx
MONAZITE-(Ce)	x	xx	xx	x	-	x	x	x
XENOTIME-(Y)	-	-	-	x	-	-	x	-
CHILDRENITE	-	-	-	XX	-	XX	-	XX
ANDALUSITE	xx	-	-	-	-	-	-	-
SCHORL	xx	x	-	-	-	xx	-	x
TOPAZ	-	-	-	xx	XX	-	-	xx
CASSITERITE	-	-	-	xx	xx	x	-	x
COLUMBITE	-	-	-	xx	x	x	-	xx
Nb,Ta RUTILE	-	-	-	-	-	xx	-	-
RUTILE	-	-	x	-	-	-	x	x
ANATASE	x	x	-	-	-	x	-	-
ILMENITE	xx	XX	XX	-	-	x	-	x
GAHNITE	-	x	-	x	-	x	x	-
URANINITE	-	-	-	-	x	x	-	x
PYRITE	x	x	x	-	-	x	x	-
MOLYBDENITE	x	-	-	-	-	-	x	-
LÖLLINGITE	-	-	-	-	x	x	xx	x

Table 2: Chemical analyses of the Lásenice (HO-1), microgranite-porphyry dyke (HO-2), Čímĕř (HO-3) Granite, and Homolka granites (HO-4 to HO-8). For petrographic types, see Appendix. Main oxides are in weight %, trace elements in ppm. Determined by XRF (main oxides, Rb, Sr, Y, Zr, Nb, Ga, Sn and Pb) and INAA (Cs, Ce, Hf, Th, U, Ta and Zn).

	HO-1	HO-2	HO-3	HO-4	HO-5	HO-6	HO-7	HO-8
SiO_2	74.36	73.61	72.46	73.95	73.30	74.67	69.57	73.73
TiO_2	0.11	0.17	0.24	0.03	0.02	0.06	0.04	0.00
Al_2O_3	14.43	14.43	14.90	15.19	15.18	14.67	17.07	15.16
Fe_2O_3t	0.94	1.36	1.61	0.74	0.66	0.88	1.08	0.32
MnO	0.04	0.05	0.04	0.11	0.06	0.07	0.04	0.07
MgO	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
CaO	0.54	0.57	0.14	0.41	0.51	0.36	0.34	0.40
Na_2O	3.36	2.87	2.88	3.59	4.47	3.69	2.71	5.32
K_2O	4.71	5.12	5.55	4.00	3.50	3.98	7.14	2.92
P_2O_5	0.24	0.28	0.25	0.58	0.76	0.47	0.60	0.65
Total	98.73	98.46	98.07	98.60	98.46	98.85	98.59	98.57
Rb	249.0	338.0	343.0	1156.0	1312.0	814.0	962.0	1052.0
Cs	6.4	14.2	18.6	56.0	69.6	49.4	101.2	53.4
Sr	60.0	46.0	60.0	32.0	21.0	13.0	26.0	103.0
Ce	23.8	74.3	97.8	5.5	5.3	12.3	6.7	<3.4
Y	13.0	19.0	18.0	27.0	24.0	22.0	22.0	19.0
Zr	39.0	76.0	105.0	26.0	<5.0	21.0	27.0	<5.0
Hf	1.1	2.7	3.6	2.4	1.0	1.2	0.5	<0.4
Th	2.9	11.1	17.6	2.1	0.5	1.9	1.1	0.7
U	1.5	7.4	4.3	3.4	5.3	4.1	3.4	10.0
Nb	14.0	22.0	17.0	45.0	65.0	34.0	48.0	61.0
Ta	1.4	2.5	1.6	16.0	24.1	12.2	11.2	41.0
Zn	25.0	146.0	108.0	161.0	190.0	144.0	140.0	134.0
Ga	14.0	21.0	19.0	29.0	23.0	24.0	30.0	23.0
Sn	<10.0	<10.0	<10.0	114.0	89.0	58.0	59.0	39.0
Pb	36.0	30.0	31.0	16.0	10.0	22.0	16.0	<10.0

Results

Zircon typology

Zircon typology (Pupin 1980) clearly subdivided the studied rocks into two clusters (Figs. 2, 3):

(1) The Čímĕř and Lásenice Granite as well as subvolcanic microgranite-porphyry shows a relatively low I.A as well as I.T values which correspond to the peraluminous continent-related S-type granites. These values indicate high Al-activity of the parental magma and a moderate temperature of 650–700±50 °C.

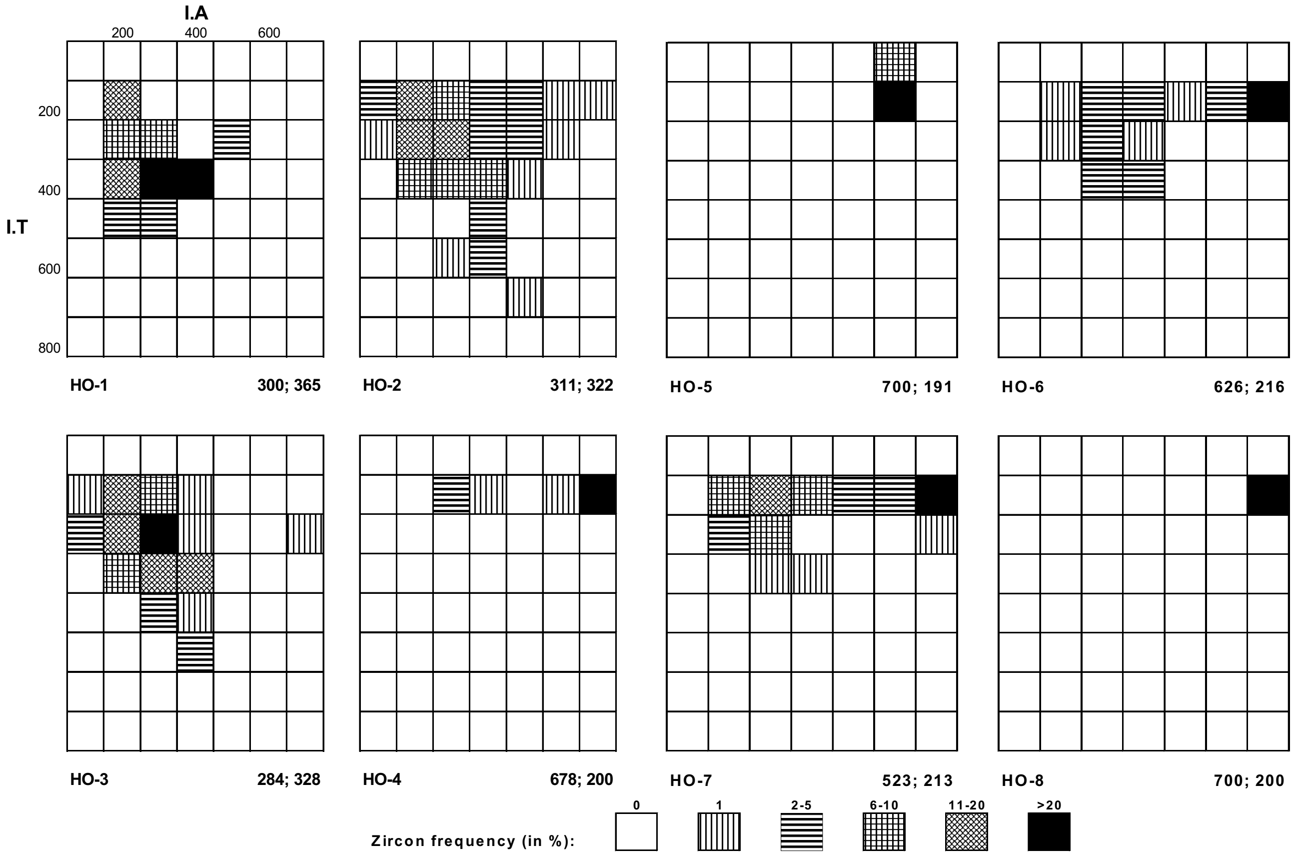

Fig. 2. Zircon typological diagrams (Pupin 1980) of the studied granitic rocks, for sample description (bottom left corners) see Appendix. I.A — alkalinity index; I.T — temperature index. The two values at the bottom right corners are the coordinates of the mean typological point, I.A; I.T.

(2) The Homolka granite stock reveals similar patterns characterized by medium to high I.A = 520–700 and very low I.T = 190–240. All samples lie in the field of Sn-W-F granites (Pupin 1980) and typology indicates high alkalinity and low temperature of the parental magma (~600±50 °C). However, some samples show a slighly different pattern with bimodal subtype distribution (G_1 vs. $L_{1\text{-}3}$, $S_{1\text{-}2}$) — Fig. 2. This fact can be explained by contamination of the magma with inherited older zircon.

Internal texture and zoning

The internal texture of zircon crystals evaluated by BSE clearly reveal their complex growth history and at least two different parts in both the older Lásenice and Číměř, and the younger Homolka granites (Figs. 4, 5): a core or inherited zircon and an outer zircon zone.

The Lásenice and Číměř granites as well as the granite porphyry dyke have a typical concentric oscillatory zonality often with a visibly different central part (Fig. 4). These central parts of oval shape are probably remnants of older inherited zircon or they represent a partly magmatic corroded (melted) primary zircon. Locally, inclusions of monazite-(Ce) appear near the rims of the crystals.

Zircon from the Homolka stock reveals more complicated textural patterns. All petrographic types in BSE have clear-

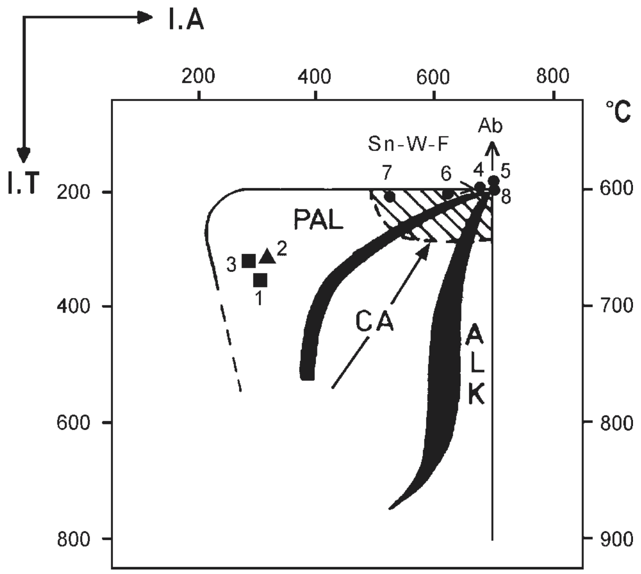

Fig. 3. Zircon typological diagram of the mean typological points (Pupin 1980) of the studied granitic rocks. I.A, I.T values explanation, see Fig. 2. PAL — peraluminous anatectic collision related granites; CA — calc-alkaline mainly subduction related granites; ALK — alkaline post- to anorogenic granites; Sn-W-F field (shaded) — granites with Sn, W, F-mineralization; Ab — albitized granites. The numbers correspond to the HO samples, see Appendix.

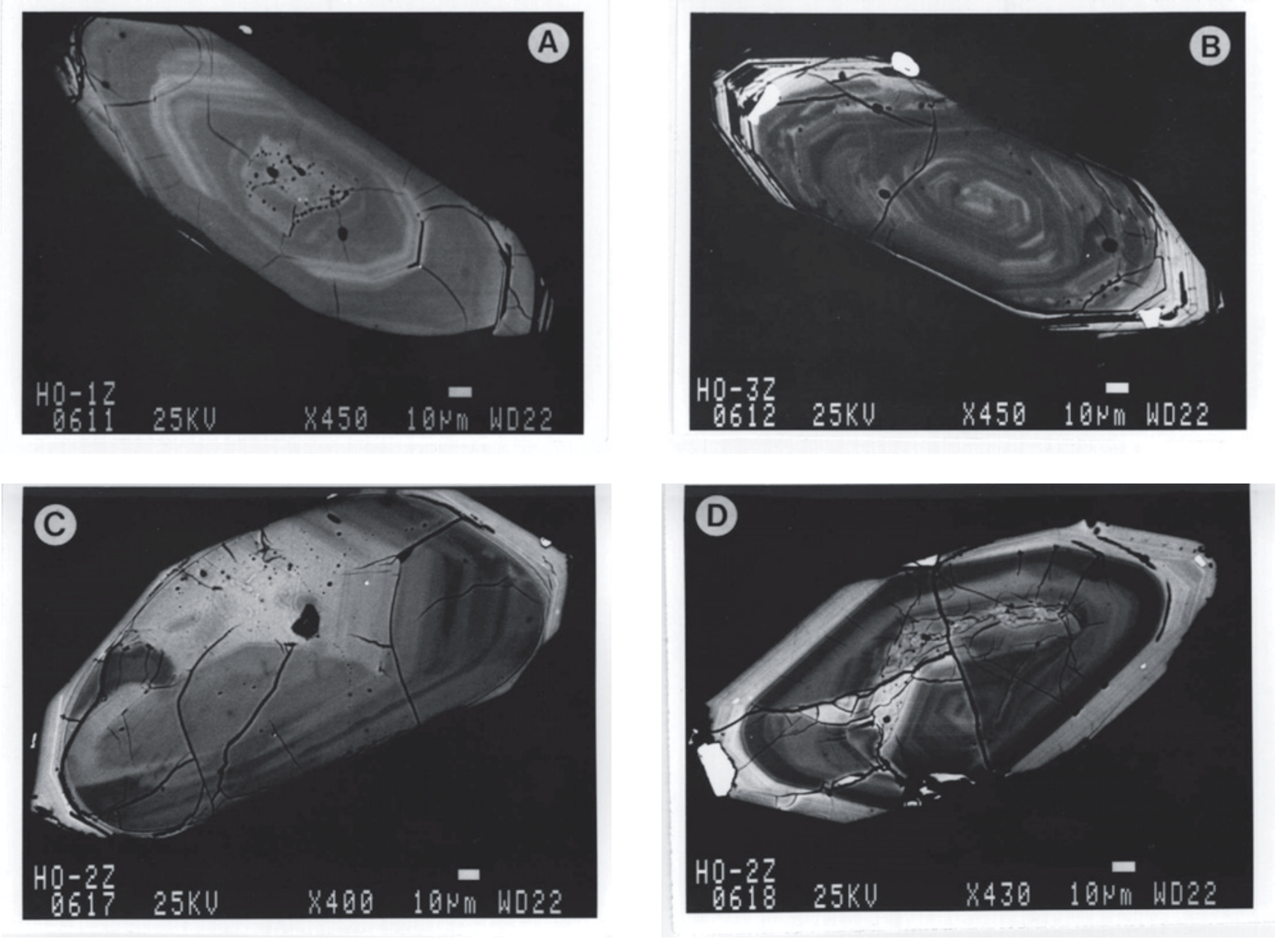

Fig. 4. BSE microphotographs of zircon, locally with monazite-(Ce), rarely xenotime-(Y) inclusions (white): **A** — Lásenice Granite, **B** — Čímĕř Granite, **C-D** — microgranite-porphyry dyke.

ly visible cores of inherited nature. They are always darker and with lower electron density, mainly due to their higher Zr/Hf ratio and lower U content (see next paragraph), overrimed by lighter rim (Fig. 5A–D).

The cores exhibit either homogeneous, diffuse or oscillatory zoning and are often oval in shape (Fig. 5A, B). In other cases, cores show primary crystal shape but are clearly incorporated in the outer parts of zircon (Fig. 5C, D). We estimate the proportion of the inherited zircon cores to be between 10 to 80 vol. %, 30 to 50 vol. % on average. Locally, the inherited zircon cores or whole crystals exhibit oscillatory zoning similar to that of zircons from the Lásenice and especially Čímĕř Granite (cf. Fig. 4A, B and Fig. 5D). Zircon of the Homolka medium-grained granite, porphyritic granite and marginal pegmatite (HO-4, 6 and 7) is transparent and homogeneous to oscillatory zoned (Fig. 5A, B). On the contrary, the Homolka aplite and fine-grained granite zircon (HO-5 and 8) is usually non-transparent and metamict (Fig. 5C–F). Small anhedral to euhedral inclusions (up to 20 μm in size) of monazite-(Ce), rarely xenotime-(Y), ferrocolumbite and uraninite occur in both oscillatory and metamict zircon (Fig. 5). Monazite-(Ce) and xenotime-(Y) from the Homolka granites occur only as tiny (up to 30 μm large) inclusions in zircon, often in or near inherited cores (Fig. 5A, C, D), which also indicates their possible partial inheritance into the Homolka rocks. In addition, very similar tiny monazite-(Ce) inclusions in zircon but also separate monazite-(Ce) crystals (0.1–0.3 mm large) occur in the Čímĕř Granite.

Chemical composition

Representative microprobe compositions of zircon are given in Table 3. The Lásenice and Čímĕř granite zircon (HO-1 and 3) both show relatively uniform Hf contents in their core (1.1 to 1.4 wt. % HfO_2). Their P, U and Y contents are negligible. The outer parts of zircon show generally higher Hf contents than the cores: 1.4 to 1.6 and 1.9 to 2.6 wt.% HfO_2 for the Lásenice and Čímĕř granites respectively, other trace elements are again low, only uranium of the Čímĕř zircon reaches up to 0.7 wt.% UO_2. Zircon from the subvolcanic microgranite-porphyry dykes has a chemical composition similar to that found in the host Lásenice and Čímĕř granites in Hf (1.1 to 2.1 wt.% HfO_2), but with slightly higher contents of P, U and Y at the margin of crystals.

The two different parts of Homolka zircon which are visible under BSE, were also well confirmed by EMPA. The

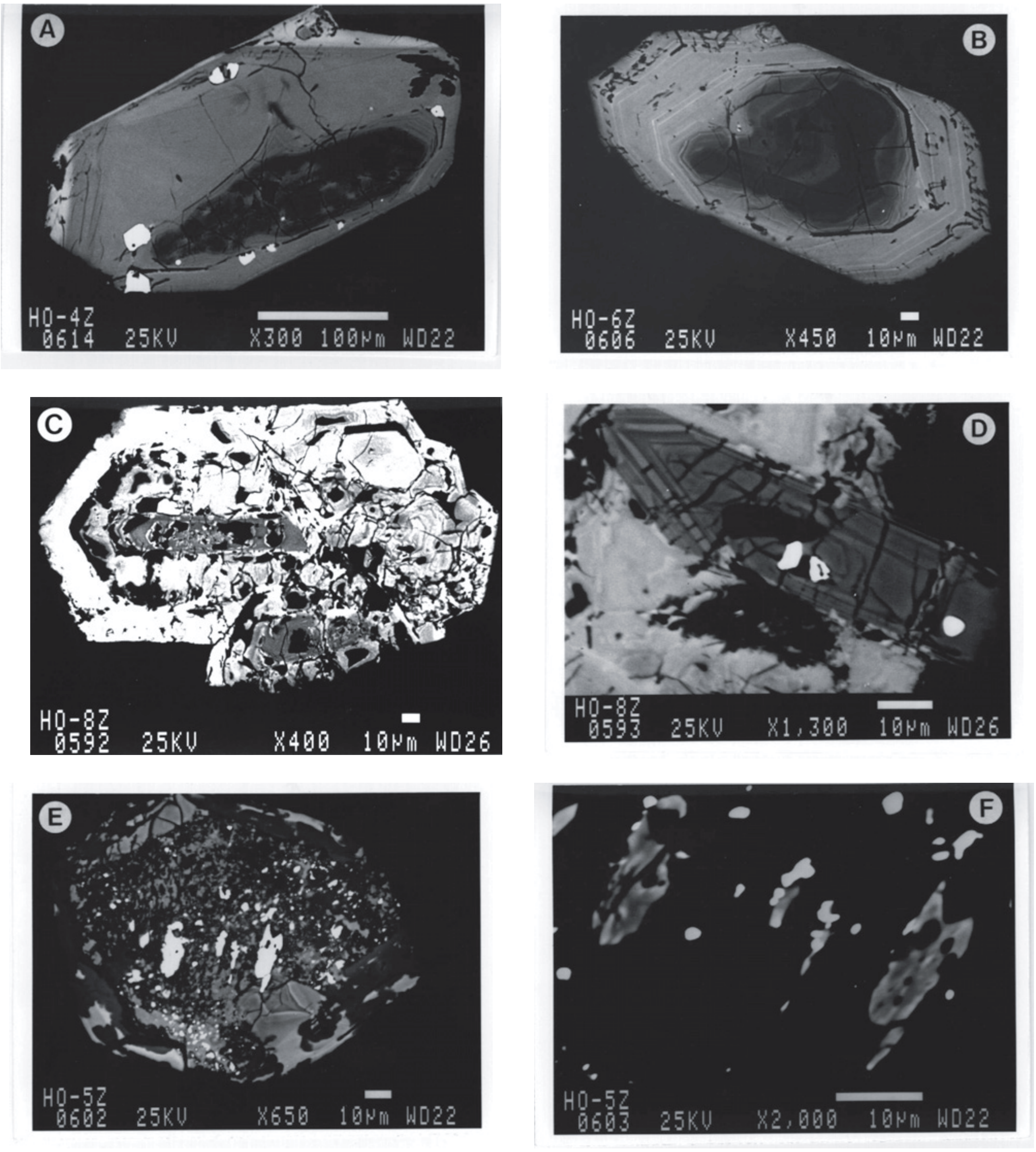

Fig. 5. BSE microphotographs of zircon from the Homolka stock. **A–D**—older inherited zircon cores overrimed by younger Hf-rich zircon with monazite-(Ce), rarely uraninite inclusions (white). **E**—metamict zircon with ferrocolumbite and uraninite inclusions (white). **F**—detail of E: inclusions of ferrocolumbite (grey) and uraninite (white) in the host zircon (black).

cores show generally low Hf (1.1–1.5 wt.% HfO_2) and other elements, which are strikingly similar to the Lásenice and Čímĕř zircon. On the other hand, the outer zone could be characterized by extensive enrichment in Hf, and locally also P, U and Y. The fine-grained granite (HO-8) and aplite (HO-5) zircon crystals reach the maximum Hf contents: 4.8–12.3 and 4.1–6.4 wt.% HfO_2, respectively (Table 3). The medium-coarse grained granite (HO-4), porphyric granite (HO-6) and marginal pegmatite (HO-7) display lower values: up to 3.5 wt.% HfO_2. High uranium content is also characteristic for the outer zircon zone of the Homolka stock, and reaches 0.3 to 2.8 wt.% UO_2. The maximal values are found again within crystals of the fine-grained granite and aplite.

Zircon saturation temperature

Zircon saturation temperature (T_S) was calculated according to the partly modified formula of Watson & Harrison (1983):

T_S [^oC] = $\{12900/[\ln(493000/(Zr_\Sigma - Zr_i)_{ROCK}) + 0.85M + 2.95]\} - 273$,

where M = molar $[(2Ca + Na + K)/(Si.Al)]_{ROCK}$, and $Si + Al + Fe + Mg + Ca + Na + K + P = 1$,

Zr_Σ [ppm] — total concentration of Zr in the host rock,

Zr_i [ppm] — concentration of Zr in old inherited zircon of the host rock.

The Zr_i value is estimated on the basis of the proportion of inherited zircon (core zone) on the BSE microphotographs, assuming that 100 % of the Zr in the host rock is incorporated into zircon and Zr concentrations in biotite, muscovite and feldspars are negligible. Thus, the $(Zr_\Sigma - Zr_i)_{ROCK}$ value indicates the concentration of Zr in the melt, as required in the equation of Watson & Harrison (1983). A similar calculation and suggestion was used by Broska et al. (1995) for the Southern Bohemian Batholith.

The calculated T_S are given in Table 4. On the basis of the BSE observations, we have estimated the amount of inherited and/or core zircon to be 30 to 50 % for the Homolka Granite. The presence of older inherited zircon is less evident for the Lásenice and Číměř Granite and microgranite-porphyry; we evaluate their amount between 20 to 50 % on average. If we accept these ranges of amounts of inherited zircon, T_S are following: 720 to 760 ^oC for the Číměř and 640 to 680 ^oC for the Lásenice zircon, the subvolcanic microgranite-porphyry dykes gave T_S = 690 to 730 ^oC and 610 to 650 ^oC for the Homolka stock.

Discussion and conclusions

The zircon typology indicates the crystallization of the Lásenice and Číměř granites from an aluminium-rich and relatively low-temperature magma, which is also confirmed by their saturation temperature interval (Table 4). Zircon typology and accessory mineral assemblage with monazite-(Ce) + ilmenite ± andalusite (Table 1) agree well with their S-type geochemical trend (Liew et al. 1989; Vellmer & Wedepohl 1994). Their chemical composition, especially the weight Zr/Hf ratio near 40 is also characteristic for the orogenic and calc-alkaline granite suites (Pupin 1992). The zircon cores (up to 50 vol.%), interpreted as the remnants of older inherited zircon, are in accordance with crustal protoliths. Broska et al. (1995) estimated the amount of inherited zircon from the Eisgarn Granite, a continuation of the Číměř type in Austria, at 40 to 60 % and T_S = 710–750 ^oC, which is in a good agreement with our results.

The zircon typology, internal zonality and chemical composition as well as the geochemical and mineralogical characteristics of the microgranite to granite porphyry dykes are similar to those of the adjacent Číměř and Lásenice granites. They do not belong genetically to the Homolka granites.

The granitic rocks of the Homolka stock intruded older Lásenice and Číměř granites. In addition, the latter type also occurs as xenoliths up to 200 m in size in the Homolka medium to coarse-grained granite (sample HO-3). Zircon typology, internal texture and chemistry clearly document some mass contribution of the older adjacent granitic material to the younger Homolka magma. The zircon typology of the Homolka granites also reveals the presence of “exotic” zircon types (L_{1-2}, S_{1-2}), which are practically identical to the zircon typology of the Lásenice and Číměř granites (Fig. 2). The Zr/Hf ratio of the inherited zircon in Homolka Granite is also very similar to the Zr/Hf zircon ratio of the Lásenice and Číměř granites (Table 3). The common presence of older inherited zircons overrimed by younger rims is a widely accepted idea, documented recently by numerous BSE, electron and ion microprobes as well as SHRIMP data, where inherited partly dissolved cores gave apparently older U-Pb ages than rims (Miller et al. 1992; Paterson et al. 1992). A very similar case of wall-rock derived zircon xenocrysts has been documented in the neighbouring Freistadt granodiorite in Austria (Finger et al. 1991) and the amount of inherited zircon from the South-Bohemian pluton varies between 10 and 70 % (Broska et al. 1995). The BSE study of the internal texture of the Homolka zircon revealed small to large inherited cores (10 to 80, 30 to 50 vol.% on average), often oval in shape, which could indicate their magmatic dissolution (Fig. 5), locally also discrete zircon xenocrysts occur (HO-6, 7). The oscillatory zoning, presence of monazite-(Ce) inclusions and chemical composition of the cores, especially their low Hf-content, are conspicuously similar to the zircon of the Lásenice and especially Číměř granites (Table 3). Thus, we suggest that zircon cores are partly dissolved xenocrysts inherited from the mentioned source rocks. In addition, it is not excluded that at least a part of the monazite-(Ce) and rarely xenotime-(Y) were also incorporated into the Homolka magma from the Číměř source. A possibility of the inherited nature of monazite-(Ce) and xenotime-(Y) cores in granites is a less common phenomenon than in the case of zircon, due to the higher solubility of these phosphates in granitic melt, however some BSE and discordant U-Pb data indicate this possibility (Miller et al. 1992).

Consequently, our zircon study shows that the most probably source rocks for the Homolka zircon cores were the Lásenice and/or Číměř-like granite, however a source from some older metamorphic rocks of the Moldanubian Unit (gneisses, granulites) is not excluded. The field and geochemical evidence reveals spatial and genetic links between the Číměř and Homolka intrusions and the inherited nature of the Homolka zircon cores corresponds to granite evolution in the South-Bohemian (Moldanubian) pluton. The oldest Lásenice granite represents the first “minimum” melt, very poor in accessory minerals, chemically expressed by very low contents of HFSE and REE, it did not play a direct genetic role in the origin of the Homolka Granite. The younger Eisgarn Granite Suite was melted at a higher temperature and fractionated according to the sequence: (1) Eisgarn Granite *s.s.* with Číměř type, (2) moderately fractionated muscovite granite (Galthof and Lembach types), (3)

Table 3: Representative compositions of zircon form the Lásenice Granite (HO-1), microgranite-porphyry dyke (HO-2), Číměř (HO-3) Granite, and Homolka granites (HO-4 to HO-8). For petrographic types, see Appendix. Oxides are in weight %, c: cores, r: rims (HO-1 to 3), **C**: inherited cores in the Homolka zircon, **R**: Hf-rich mainly rim parts of the Homolka zircon. Zr/Hf_w: weight ratio, Hf #: atomic 100Hf/(Hf+Zr). Note the compositional identity between c, r and **C**.

	HO-1r	HO-2c	HO-3c	HO-4**C**	HO-4**R**	HO-6**C**	HO-6**R**	HO-8**C**	HO-8**R**	HO-8**R**
P_2O_5	0.11	0.08	0.01	0.00	0.75	0.08	0.71	0.65	0.16	0.75
SiO_2	31.87	31.83	32.48	32.39	31.42	32.30	31.71	31.32	31.82	30.78
ZrO_2	65.48	64.95	65.47	66.04	60.55	66.29	61.53	63.37	59.45	52.94
HfO_2	1.46	1.11	1.43	1.30	5.29	1.37	3.51	1.29	7.60	12.33
ThO_2	0.02	0.01	0.01	0.00	0.00	0.00	0.00	0.04	0.00	0.00
UO_2	0.07	0.00	0.06	0.06	0.83	0.00	0.31	0.29	0.43	0.56
Al_2O_3	0.00	0.00	0.01	0.00	0.01	0.00	0.00	0.00	0.05	0.05
Fe_2O_3	0.02	0.00	0.03	0.00	0.02	0.00	0.00	0.02	0.00	0.00
Sc_2O_3	0.01	0.00	0.00	0.00	0.03	0.01	0.31	0.17	0.03	0.02
Y_2O_3	0.04	0.00	0.00	0.00	0.58	0.00	0.18	0.54	0.00	0.44
Ce_2O_3	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.01
Sm_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.00
Tb_2O_3	0.01	0.05	0.00	0.00	0.03	0.01	0.00	0.00	0.02	0.00
Dy_2O_3	0.02	0.05	0.00	0.04	0.06	0.03	0.01	0.00	0.02	0.00
Er_2O_3	0.05	0.00	0.00	0.02	0.05	0.00	0.02	0.05	0.05	0.03
Yb_2O_3	0.03	0.00	0.03	0.00	0.06	0.01	0.04	0.04	0.01	0.02
CaO	0.00	0.02	0.01	0.01	0.00	0.00	0.01	0.02	0.02	0.04
F	0.10	0.01	0.00	0.06	0.00	0.00	0.20	0.01	0.06	0.00
Cl	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total	99.26	98.11	99.54	99.89	99.68	100.13	98.49	97.81	99.70	97.97
Formulae based on 16 oxygens										
P^{5+}	0.012	0.008	0.001	0.000	0.080	0.008	0.075	0.069	0.017	0.083
Si^{4+}	3.953	3.982	4.005	3.984	3.943	3.968	3.964	3.932	4.016	4.017
Zr^{4+}	3.961	3.962	3.937	3.961	3.705	3.971	3.751	3.879	3.658	3.369
Hf^{4+}	0.052	0.040	0.050	0.046	0.189	0.048	0.125	0.046	0.274	0.459
Th^{4+}	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000
U^{4+}	0.002	0.000	0.002	0.002	0.023	0.000	0.009	0.008	0.012	0.016
Al^{3+}	0.000	0.000	0.001	0.000	0.001	0.000	0.000	0.000	0.007	0.008
Fe^{3+}	0.002	0.000	0.003	0.000	0.002	0.000	0.000	0.002	0.000	0.000
Sc^{3+}	0.001	0.000	0.000	0.000	0.003	0.001	0.034	0.019	0.003	0.002
Y^{3+}	0.003	0.000	0.000	0.000	0.039	0.000	0.012	0.036	0.000	0.031
Ce^{3+}	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000
Sm^{3+}	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000
Tb^{3+}	0.000	0.002	0.000	0.000	0.001	0.000	0.000	0.000	0.001	0.000
Dy^{3+}	0.001	0.002	0.000	0.002	0.002	0.001	0.000	0.000	0.001	0.000
Er^{3+}	0.002	0.000	0.000	0.001	0.002	0.000	0.001	0.002	0.002	0.001
Yb^{3+}	0.001	0.000	0.001	0.000	0.002	0.000	0.002	0.002	0.000	0.001
Ca^{2+}	0.000	0.003	0.001	0.001	0.000	0.000	0.001	0.003	0.003	0.006
F^-	0.039	0.004	0.000	0.023	0.000	0.000	0.079	0.004	0.024	0.000
Cl^-	0.002	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
O^{2-}	15.959	15.994	16.000	15.977	16.000	16.000	15.921	15.996	15.976	16.000
$\sum$ cat.	7.989	7.999	8.002	7.995	7.993	7.999	7.975	7.998	7.995	7.993
Zr/Hf_w	39.1	51.1	40.0	44.3	10.0	42.2	15.3	42.9	6.83	3.75
Hf #	1.30	1.00	1.25	1.15	4.85	1.19	3.22	1.17	6.97	12.0

strongly fractionated Homolka Granite (Breiter & Scharbert 1995).

Two basic processes could be suggested to explain the origin of the Homolka magma: (1) the partial low-degree disequilibrium melting of the adjacent Číměř Granite with unmelted portions represented by zircon cores, or (2) advanced magmatic fractionaction of some Číměř-like member of the Eisgarn Granite Suite, eventually with some contamination of the magma from the already solidified Číměř *s.s.* Granite. Both mechanisms could explain the presence of inherited zircon cores in the Homolka Granite.

We prefer the advanced magmatic fractionaction as the process leading to the origin of the Homolka Granite for the following reasons:

Table 4: Zircon saturation temperatures of studied granites, calculated for 20 and 50 % (HO-1 to 3) or 30 and 50 % (HO-4 to 7) of inherited zircon. For details see the text.

Lásenice	HO-1	640-680 °C
felsic dyke	HO-2	690-730 °C
Číměř	HO-3	720-760 °C
Homolka	HO-4	620-650 °C
	HO-6	610-630 °C
	HO-7	620-640 °C

(1) The origin of REE-depleted S-type leucogranites via disequilibrium dehydration melting of metapelites with muscovite and/or biotite breakdown is suggested by some authors (e.g. Nabelek & Glascock 1995) but these granites do not reach a geochemical specialization (extreme Li, Rb, Cs, Ta and P contents) similar to that of Homolka. On the contrary, magmatic fractionaction is suggested as the main process for

highly evolved P-rich albite-Li-mica-topaz granites (Cuney et al. 1992; Breiter et al. 1997) with mineralogical and geochemical analogies to the Homolka Granite (Tables 1, 2). The Hf-content of zircon from some Homolka members, especially from the fine-grained granite locally reached very high values, up to 12.3 wt.% HfO_2 (Table 3). These unusually high Hf values and low Zr/Hf ratios reflect an extreme fractionation level of the Homolka granites, similar Hf concentrations are typical only for extremely fractionated rare-element granitic pegmatites (Černý et al. 1985) or for highly evolved rare-element granites. For example, zircon from the Beauvoir Granite, France, contains up to 19 wt.% HfO_2 (Wang et al. 1992), zircon from Ta-rich granite related felsic dykes from the Central Eastern Desert, Egypt, also contains up to 25 wt.% HfO_2 (Renno 1995) and zircon from the apical part of the Suzhou granite, China, reaches up to 35 wt.% HfO_2 (Wang et al. 1996). In contrast, zircon from the marginal pegmatite (stockscheider) of the Homolka stock is surprisingly Hf-poor: only 1.7–2.5 wt.% HfO_2 in the outer part of the crystals. We explain this fact by the extensive influence of secondary contamination and the resulting dilution of Hf-richer pegmatite magma by the adjacent Hf-poor Číměř Granite.

(2) The zircon typology and saturation temperature (T_S) of the Homolka stock indicate highly alkaline and low temperature, volatile-rich magma. Calculated T_S between ca. 600 and 650 °C is interpreted as the temperature of magmatic zircon saturation from the parental magma. These temperatures are too low for disequilibrium melting of source rock of metapelite or similar composition by muscovite or biotite breakdown, where a temperature around 850–875 °C is required for extensive fluid-absent melting and a melt proportion below 850 °C is too small to move and form an independent pluton (Vielzeuf & Holloway 1988). On the other hand, low magmatic temperatures are easily compatible with experimental data on the highly evolved P, F, B-rich felsic magmas, e.g. Macusani glass, Peru, rare-element pegmatites (Pichavant et al. 1988; London et al. 1989; London 1992) and highly evolved granites, such as the Beauvoir Granite, France (Cuney et al. 1992).

Acknowledgements: The autors thank B. Bonin, I. Broska and an anonymous referee for helpful comments that improved the manuscript. The study was supported by a NSERC Scientific Grant (Canada) to P. Černý during PDF of P.U. and a VEGA Grant No. 4078 (Slovakia) to I. Petrík. The paper is a contribution to the IGCP Project No. 373.

Appendix: sample description

HO-1: Muscovite-biotite granite, Lásenice type.
HO-2: Felsic granite porphyry dyke, Terezský Dvůr.
HO-3: Muscovite-biotite porphyritic granite, Číměř type, xenolith in the Homolka body.
HO-4: Muscovite granite, Homolka type.
HO-5: Aplite dyke, Homolka type.
HO-6: Porphyritic granite, Homolka type.
HO-7: Marginal pegmatite (stockscheider), Homolka type.
HO-8: Fine-grained muscovite granite, Homolka type.

The location of all samples (with the exception of HO-2) is the Homolka Hill area, 5 km SSE from Lásenice village (Fig. 1).

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