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TWO TYPES OF LEUCOGRANITES FROM THE BRANISKO MTS.: GEOTECTONIC IMPLICATIONS

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ABSTRACT

Leucocratic granites are widespread mainly in the southern part of the Patria crystalline basement of the Branisko Mts. The major and trace element geochemistry indicates their crustal source. Monazites from leucogranites were investigated by electron microprobe dating in order to record the age of magma emplacement. EMPA dating yielded age 342±15 for leucocratic granites forming a part of granite pluton in Patria complex and 386±19 Ma for leucocratic granites originated by partial anatexis during MP metamorphism during early Variscan collisional events. Younger leucocratic granites have been formed by crystal fractionation within main Meso-Hercynian (350-330 Ma) period as a part of S-type granite suite of the Western Carpathian basement complexes. It belongs to the Upper lithotectonic unit in sense of Bezák et al. (1997).

Key words: leucogranite, geochemistry, geochronology, EMPA dating, the Branisko Mts., Western Carpathians

INTRODUCTION

The granitoids from the Branisko Mts. were not still systematically investigated. The first evidence about the chemistry and a modal composition of the representative granitoid types from the Branisko Mts. results from Cambel and Walzel (1982) also Macek et al. (1982) research works. In more detail field petrographical relationships and modal variability of the granitoid rocks from the Branisko Mts. have been studied by Vozárová and Vozár (in Polák et al. 1997). Geochemical relations of the representative high-methamorphic rocks and granitoids similarly from the Branisko crystalline basement together with the first geochronological data have been resolved by Kohút et al. (2004). They have observed an intensive anatectic reworking of the Branisko crystalline basement ranging from 350 to 330 Ma, further a crustal origin and heterogeneous tonalit-leucogranite character of the granitoids. Some geochemical and geochronological characteristics of leucogranites from Branisko Mts. were described by Bónová et al. (2005).

This contribution should specify the register of geochemical-geochronological data about leucocratic granitoid rocks from the Branisko Mts. which have been formed during different Palaeozoic geodynamic settings. These granites rich in monazite are suitable for EMPA dating investigation and gained results fulfil the view on the granitoid genesis in this mountain range in the frame of the Variscan Western Carpathian magmatic evolution.

GEOLOGICAL SETTING

Leucogranites from Branisko Mts. belong to the high-metamorphic Patria crystalline complex, which consists from gneisses and migmatites with a little abundance of amphibolites (Rösing 1947, Vozárová and Vozár in Polák et al. 1997). The samples have been taken from the main plutonic body as well as from the area with HP metamorphic lithologies as orthogneisses and migmatites.

The Patria crystalline complex appertains to the Upper lithotectonic unit in the sense of Variscan constitution of the Tatric-Veporic crystalline basement of the Western Carpathians (Bezák et al. 1997). The relicts of granoblastites with mineral association indicating the high-temperature and high-pressure conditions were discovered by Vozárová (1993). The synkinematic metamorphism was replaced by isothermal decompression stage in a consequence of released anatectic melt which was injected into the gneiss-amphibolite complex, eventually independent magmatic bodies have developed (l.c.) (Fig. 1), which have been also undertaken for investigation as a second group or representative of leucogranites in Branisko Mts.

ANALYTICAL PROCEDURES

The leucogranite samples were taken from a natural outcrops and debries from the Kamenný vrch (sample BRA-4) and the Pod Braniskom – salaš (samples ZK-55, BRA-2) localities (Fig. 1). They were described petrographically. The concentrates of heavy minerals were obtained by standard separation process – crushing the rocks in the jawcrasher, grinding in the cylindric crusher, preliminary concentration using a Wilfley table and heavy liquid. The zircon morphology was studied using a binocular microscope.

Electron microprobe study of rock-forming minerals were carried out at the Dionýz Štúr Institute of Geology – Bratislava using a CAMECA SX-100 with an operating voltage of 15 kV, beam current of 20 nA. For mineral analyses were used as standards: K – orthoclase, Na – albite, Si and Ca – wollastonite, Al – Al_2O_3, Mg – MgO, Fe – hematite, Ti – TiO_2, Cr – chromite and Mn – rhodonite. The analytic procedure of monazite with respect to its dating by an identical instrument is shown by Konečný et al. (2004).

Statistical processing of the model ages of monazite were realised according to Montel et al. (1996). The analyses of the main and trace elements were performed at ACME Lab, Toronto by ICP–MS method and at laboratories of Petrological Institute, University of Vienna through XRF analyses (Table 1).

RESULTS

PETROGRAPHICAL DESCRIPTION

Leucocratic granite as the differenttiates of main granitoid pluton

Investigated leucogranite from the Pod Braniskom - salaš locality shows typical aplitic texture with an anhedral development of light components. K-feldspar (orthoclase, orthoclase-perthite), sericitized plagioclase (An_{0-5}) and quartz represent main components of rock. Two generations of K-feldspars are presented: older K-feldspars I are usually strong sericitized and enclosed in K-feldspar II. Clear K-fedspar II encloses plagioclases and oval quartz I. Xenomorphic quartz II is undulosed and sporadically recrystallized to fine-grained agregate. Myrmekite is developed sporadically at feldspars/quartz II interface. Minor biotite is usually baueritized. Muscovite I forms a moderate buckled lamellaes. Clean crystal termination of muscovite I and coarse grain size comparable to that of obviously magmatic phases might indicate its primary origin. Secondary origin of muscovite II results from its texture position–foliaceous muscovite overprints feldspars markedly. Accessory minerals are represented by zircon, rutile, monazite and apatite. The morphology of zircon crystals from the investigated leucogranites is represented by L (L_{1-3}) and low S (S_{1-4}, S_7) types (Fig. 2). Secondary paragenesis is represented by xenomorphic orthoclase-perthite (Kfs II), muscovite II and quartz II.

Leucogranites from the Pod Branisko – salaš locality represent an alkali feldspar granite to a syenogranite (Fig. 3).

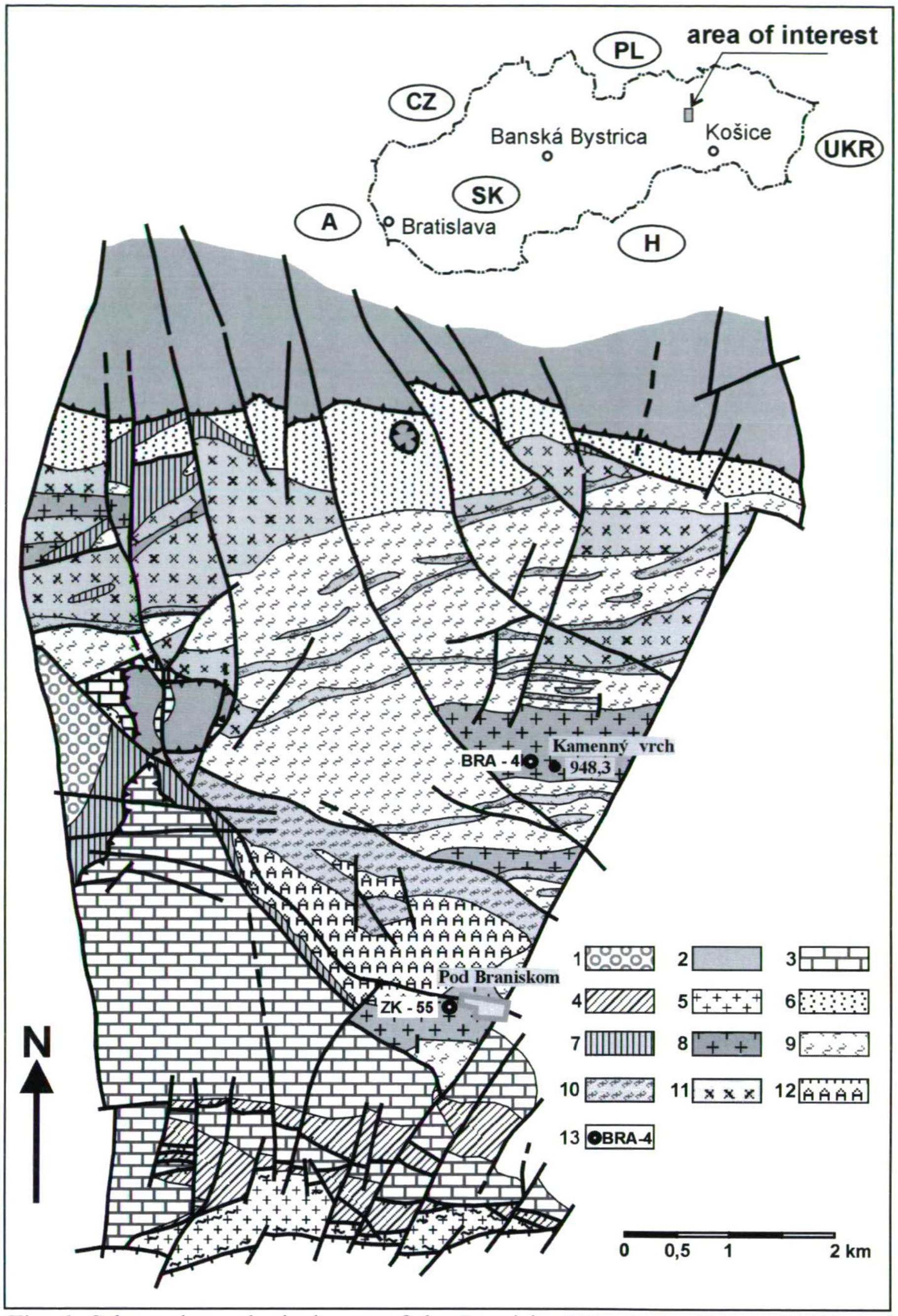

Fig. 1. Schematic geological map of the Branisko Mts. (according to Polák and Jacko et al., 1996). Legend: 1 –Paleogene sediments, 2 – the Choč nappe, 3 – Mesozoic envelope un-separated sequences: Veporicum, 4 – Permian un-separated sequences: Veporicum, 5 – aplitoid granites, 6 – Mesozoic envelope un-separated sequences: Tatricum – Northern Veporicum, 7 – Permian un-separated sequences: Tatricum – Northern Veporicum, 8 - fine-grained leucogranites, 9 – migmatites, 10 – garnet-biotite gneisses, 11 – coarse-grained granodiorites, 12 – amphibolites, 13 – sample localization.

Leucocratic granite as a minimum melt

Leucogranite from the Kamenný vrch location shows granitic texture. Plagioclase (An_{22-26}), K-feldspar (orthoclase, perthite and microcline) and quartz represent main components of rock. K-feldspars are formed by two generations: Hypidiomorphic K-feldspar I is represented by sericitized orthoclase which usually included the older quartz and plagioclases. Large porphyric and hypidiomorphic K-feldspars II usually enclose older K-feldspars, plagioclases, quartz and biotites. K-feldspars II are microclinesed and locally have thin albite rims. They are often disturbed and their cracks are filled by fine-grained muscovite. Myrmekite is developed sporadically between K-feldspars and quartz. Plagioclase I is markedly sericitized and usually included into hypidiomorphic unaltered plagioclase II with distinctly resorbed rims by tiny muscovite. Minute grains of muscovite

Table 1. Major (in wt. %), trace element (in ppm) and modal composition of studied granitoids.

			BRA-2				
SiO_2	72.69	Nb	6.6	V	24	Qtz	33.40
TiO_2	0.24	Zr	32.1	Ce	24.1	Pl	5.46
Al_2O_3	14.83	Y	6.1	Ba	681	Kfs	56.70
Fe_2O_3	1.27	Sr	215	La	10	Bt	0.40
MnO	0.03	Rb	97.9			Ms	3.66
MgO	0.75	Ga	16.5			Acc	0.40
CaO	0.43	Zn	14				
Na_2O	4.06	Cu	7.5				
K_2O	3.55	Ni	5.3				
P_2O_5	0.12	Co	3.9				
Total	97.97	Sc	3				
			BRA-4				
SiO_2	71.43	Nb	5	V	40	Qtz	30.46
TiO_2	0.32	Zr	140	Ce	56	Pl	19.53
Al_2O_3	15.13	Y	7	Ba	1481	Kfs	39.26
Fe_2O_3	2.13	Sr	639	La	33	Bt	3.26
MnO	0.04	Rb	64			Ms	4.40
MgO	0.87	Ga	16			Ep	2.00
CaO	1.64	Zn	36			Ore	0.46
Na_2O	4.1	Cu	6			Acc	0.6
K_2O	3.62	Ni	2				
P_2O_5	0.11	Co	<2				
L.O.I.	0.88	Cr	9				
Total	99.39	Sc	7				

Major elements by X-ray fluorescence (wt.%).
Trace elements by ICP-MS (ppm).
Modal composition (vol. %).

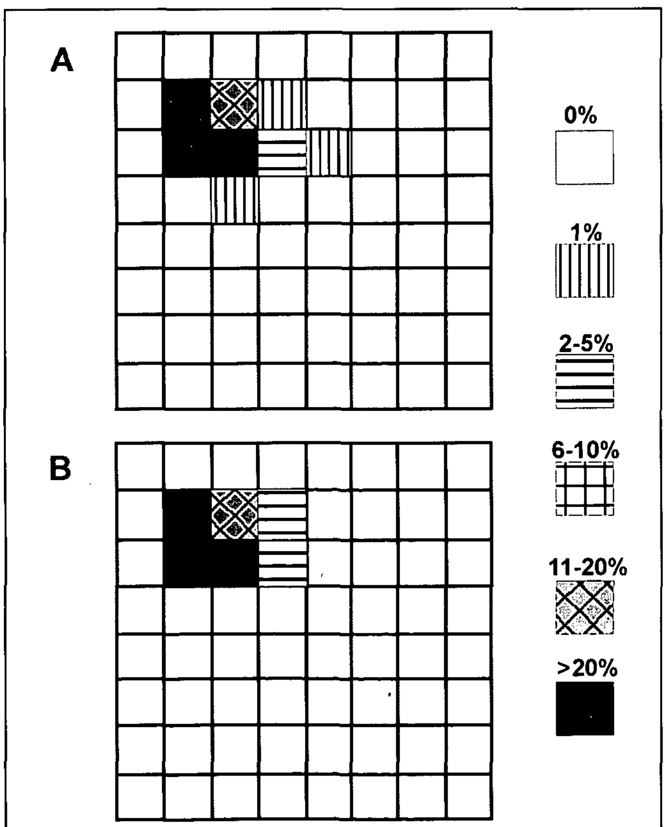

Fig. 2. Matrix of morphologic types of zircon: ***(A)*** sample BRA-2, ***(B)*** sample BRA-4.

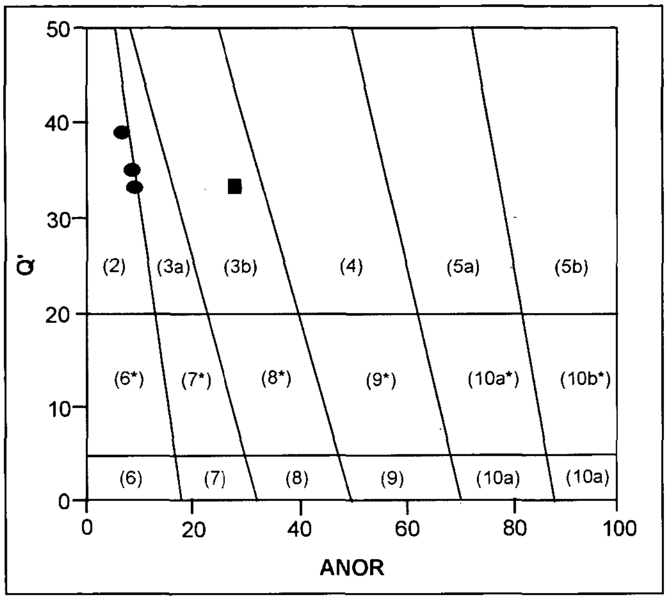

Fig. 3. Classification Q'ANOR diagram (Streckeisen & Le Maitre, 1979); circles – samples: ZK-55, BRA-2; square – sample BRA-4.

usually penetrate feldspars. Finely chloritized and baueritized biotite is accumulated along light components of rock and is usually altered by hypidomorphic epidote or muscovite. Accessory minerals are represented by zircon, rutile, monazite, xenotime, apatite and garnet. The morphology of zircon crystals from the investigated leucogranites is represented by L (L_{1-3}) and low S (S_{1-3}) types (Fig. 2). Specimen from the Kamenný vrch location can be classified as monzogranite (Fig. 3).

GEOCHEMISTRY OF ROCKS

The investigated leucocratic granitoids are plotted in the field of the syncollisional granitoid rocks (Batchelor and Bowden 1985) (Fig. 4A). They show peraluminous character: A/CNK = 1,108 – 1,311, silica-rich (SiO_2 = 71-74 wt. %) and poorly/middle fractionation stage (TiO_2 ~ 0,24). Molar Na_2O/K_2O > 1 indicates the increase Na_2O in all investigated rocks. It is proved by a presence of albite. The REE contents are controlled by accessory minerals mostly by monazite and apatite (moderate enrichment at LREE; La_N/Yb_N ~ 19; Eu anomaly is slightly negative). The contents of trace elements are variable: Ba ~ 681 – 1481 ppm, Rb ~ 64 – 110 ppm, Sr ~ 215 – 639 ppm. The amount of Ba and Sr are significantly higher at leucocratic granite from the Kamenný vrch locality in comparison with leucogranite from the Pod Braniskom – salaš location and ratio Rb/Sr < 1 for both samples. These Rb-Sr contents indicate poorly to middle evolved granite stage (Fig. 4B). The crustal nature of source is suggested by $\varepsilon Nd_{(0)}$ values (from -5.21 to –7.49), contents $\delta O^{18}_{(SMOW)}$ from 9.5 to 11.3 ‰ and lead isotopes $^{206}Pb/^{204}Pb$ = 18.834 – 19.333 also $^{207}Pb/^{204}Pb$ = 15.713 – 15.738 (Kohút et al. 2003ab). According to zircon classification based on the distribution of zircon morphological types Branisko leucogranites belong to the anatectic crustal granitoids (Pupin 1980).

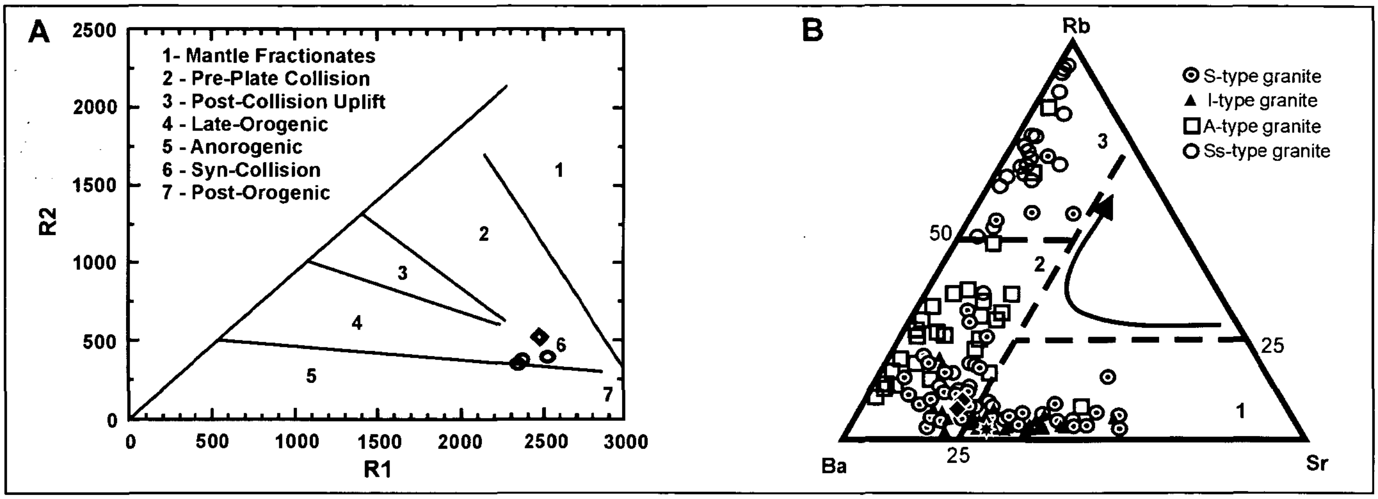

Fig. 4. ***(A)*** Multication diagram (Batchelor & Bowden, 1985). ***(B)*** Rb-Ba-Sr discrimination diagram of the granitic rocks from the Branisko Mts. in comparison with granitoids from the Western Carpathians (Broska & Uher, 2001). Explanations: 1 – poorly evolved granites, 2 – middle evolved granites, 3 – highly evolved granites. Rhombs – samples: ZK-55, BRA-2; star – sample BRA-4.

GEOCHEMISTRY OF SOME ROCK-FORMING MINERALS

Leucocratic granite as the differentiates of main granitoid pluton

Chemical composition of plagioclases from leucogranites from the Pod Braniskom - salaš locality suggests the higher contents of Ab-component (An_{0-2}) in comparison with leucogranites from the Kamenný vrch locality. The content of An-component in plagioclases slightly increases towards the grain boundary. Loomis (1982) has interpreted such reversed zoning in plagioclases of igneous rocks as cooling change or influence of volatiles, alternatively it may indicate dynamic magmatic environment or acid-acid mixing (cf. Grogan and Reavy, 2002). K-feldspars are nearly stoichiometric pure end-members with max. 3.7 % content of albite molecule. Anorthite molecule has not never exceed 0.3 %.

Monazite grains from investigated leucogranite (sample ZK-55) comprise 5.7 – 7.1 wt. % ThO_2 (Table 2). The contents of UO_2 get around from 0.1 to 0.5 wt. % and the PbO concentration is 0.1 – 0.2 wt. %. However, the mentioned element concentrations are similar in an individual grains relatively. The concentrations of oxide listed above, low yttrium concentration and the presence of brabandite component within the range from 3 to 12 wt. % in monazites indicate their primary origin (Bea 1996).

Temperature of the leucogranites from Pod Braniskom – salaš location calculated from monazite saturation REE-thermometry (Montel 1993) is around 750 °C.

Leucocratic granite as a minimum melt

Chemical composition of plagioclases from investigated leucocratic granite shows higher content of An-component (An_{22-25}). The content of An-component in plagioclases slightly increases towards the grain boundary. The presence of antiperthite is typical feature for leucogranites from the Kamenný vrch locality. K-feldspars show max. 6.3 % content of albite molecule. Anorthite molecule, except K-feldspars which are enclosed in plagioclase, (they have only 0.3 % An-contents here) has not exceed 0.1 %.

Table 2. Selected microprobe analyses (in wt. % oxide) of monazite from the leucogranites (the Branisko Mts.).

	Sample BRA-4									
Point	**1**	**1-2**	**1-3**	**2**	**2-2**	**3**	**3-2**	**3-3**	**4**	**4-2**
SiO_2	0.25	0.21	0.21	1.12	0.33	0.60	0.60	1.21	0.63	1.09
Al_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	1.83	1.78	1.73	0.75	1.05	0.74	0.65	0.77	0.68	0.72
PbO	0.16	0.16	0.15	0.13	0.10	0.10	0.11	0.13	0.09	0.13
UO_2	0.33	0.32	0.33	0.22	0.15	0.11	0.12	0.29	0.17	0.20
ThO_2	8.25	7.68	7.56	6.51	4.87	4.88	4.63	6.91	4.46	6.49
Y_2O_3	0.88	0.76	0.79	0.63	0.71	0.93	0.73	0.85	0.45	0.64
Ce_2O_3	27.66	28.34	27.95	28.86	29.02	29.28	29.58	28.39	30.72	29.03
La_2O_3	15.09	15.60	15.54	14.54	14.08	14.04	14.51	13.88	15.75	14.10
Gd_2O_3	3.39	3.28	3.39	3.53	3.76	3.81	3.71	3.64	3.50	3.66
Yb_2O_3	0.09	0.09	0.01	0.11	0.07	0.11	0.00	0.19	0.03	0.04
Sm_2O_3	1.14	1.07	1.12	1.35	1.71	1.82	1.51	1.57	1.28	1.66
Pr_2O_3	2.71	2.88	2.81	2.95	3.21	3.35	3.28	3.11	3.21	3.11
Er_2O_3	0.13	0.00	0.02	0.00	0.07	0.25	0.27	0.00	0.09	0.00
Nd_2O_3	9.83	9.20	9.79	11.57	12.06	11.79	12.02	11.47	11.29	12.00
P_2O_5	27.85	27.78	27.83	26.18	27.50	27.34	27.11	26.34	27.05	26.11
Total	99.57	99.15	99.20	98.46	98.66	99.14	98.83	98.73	99.39	98.97

Table 2. continued

calculated on the basis 4 O										
Si	0.040	0.034	0.034	0.186	0.054	0.098	0.099	0.199	0.103	0.181
Al	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	0.318	0.310	0.300	0.134	0.184	0.130	0.114	0.137	0.119	0.127
Pb	0.007	0.007	0.006	0.006	0.004	0.004	0.005	0.006	0.004	0.006
U	0.012	0.012	0.012	0.008	0.005	0.004	0.004	0.011	0.006	0.008
Th	0.304	0.284	0.280	0.246	0.182	0.182	0.173	0.260	0.166	0.245
Y	0.076	0.066	0.069	0.056	0.062	0.081	0.064	0.075	0.039	0.057
Ce	1.642	1.688	1.664	1.756	1.742	1.752	1.781	1.718	1.844	1.765
La	0.903	0.936	0.932	0.892	0.851	0.846	0.880	0.846	0.953	0.864
Gd	0.182	0.177	0.183	0.195	0.204	0.206	0.202	0.199	0.190	0.201
Yb	0.004	0.005	0.001	0.006	0.003	0.005	0.000	0.009	0.002	0.002
Sm	0.064	0.060	0.063	0.077	0.097	0.102	0.086	0.089	0.072	0.095
Pr	0.160	0.171	0.166	0.178	0.192	0.200	0.196	0.187	0.192	0.188
Er	0.006	0.000	0.001	0.000	0.004	0.013	0.014	0.000	0.004	0.000
Nd	0.569	0.534	0.568	0.687	0.706	0.688	0.706	0.677	0.661	0.711
P	3.822	3.827	3.830	3.684	3.816	3.783	3.774	3.686	3.755	3.670
Mo	85.07	85.73	86.05	90.83	91.24	92.51	93.09	90.33	93.13	91.10
Br	13.99	13.47	13.15	4.77	7.49	5.16	4.56	4.94	4.45	4.67
Hu	0.94	0.80	0.79	4.39	1.27	2.33	2.35	4.73	2.42	4.23

Table 2. continued

	Sample ZK-55									
Point	**1**	**1-2**	**1-3**	**1-4**	**1-5**	**1-6**	**1-7**	**2**	**2-2**	**2-3**
SiO_2	0.24	0.98	1.04	0.24	1.10	1.07	0.32	0.28	1.18	1.09
Al_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	1.39	1.03	0.99	1.56	1.00	0.98	1.29	1.36	0.81	0.86
PbO	0.14	0.11	0.12	0.15	0.12	0.13	0.12	0.13	0.13	0.11
UO_2	0.41	0.13	0.15	0.48	0.14	0.11	0.30	0.28	0.13	0.13
ThO_2	6.37	6.88	7.09	7.03	7.55	7.14	6.46	6.43	7.10	7.03
Y_2O_3	1.83	0.98	1.13	1.95	1.26	1.00	1.79	1.61	0.79	0.93
Ce_2O_3	26.63	27.06	25.88	25.94	25.91	26.63	26.54	26.66	27.15	27.08
La_2O_3	12.55	12.14	11.25	11.89	10.96	11.93	11.95	12.57	12.46	12.25
Gd_2O_3	3.87	3.87	4.29	3.89	4.26	3.86	3.93	3.87	3.70	3.63
Yb_2O_3	0.01	0.00	0.05	0.11	0.01	0.00	0.09	0.03	0.00	0.05
Sm_2O_3	2.04	2.11	2.56	1.98	2.59	2.16	2.17	2.04	1.94	2.07
Pr_2O_3	2.88	3.11	3.04	2.81	3.20	3.25	3.16	2.89	3.15	3.16
Er_2O_3	0.02	0.06	0.17	0.24	0.25	0.00	0.00	0.13	0.03	0.14
Nd_2O_3	11.32	12.92	13.14	11.08	13.12	13.22	12.03	11.79	13.02	12.98
P_2O_5	26.78	26.21	25.66	27.43	25.55	25.99	27.02	27.24	25.72	25.97
Total	96.47	97.59	96.56	96.76	96.99	97.47	97.18	97.29	97.29	97.48
	calculated on the basis 4 O									
Si	0.040	0.163	0.176	0.040	0.187	0.180	0.054	0.046	0.199	0.183
Al	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	0.250	0.184	0.180	0.276	0.181	0.176	0.230	0.242	0.146	0.155
Pb	0.006	0.005	0.006	0.007	0.005	0.006	0.006	0.006	0.006	0.005
U	0.015	0.005	0.006	0.018	0.005	0.004	0.011	0.010	0.005	0.005
Th	0.243	0.262	0.274	0.265	0.291	0.273	0.245	0.242	0.272	0.268
Y	0.163	0.087	0.102	0.171	0.114	0.089	0.158	0.142	0.070	0.083
Ce	1.635	1.655	1.607	1.573	1.606	1.634	1.615	1.617	1.674	1.663
La	0.776	0.748	0.703	0.726	0.684	0.738	0.733	0.768	0.774	0.758
Gd	0.215	0.214	0.241	0.213	0.239	0.214	0.217	0.213	0.207	0.202
Yb	0.000	0.000	0.003	0.005	0.000	0.000	0.005	0.001	0.000	0.002
Sm	0.118	0.121	0.149	0.113	0.151	0.125	0.124	0.116	0.113	0.120
Pr	0.176	0.189	0.188	0.169	0.197	0.198	0.191	0.174	0.194	0.193
Er	0.001	0.003	0.009	0.012	0.013	0.000	0.000	0.007	0.001	0.007
Nd	0.678	0.771	0.796	0.655	0.793	0.792	0.714	0.698	0.783	0.778
P	3.801	3.707	3.683	3.846	3.661	3.689	3.804	3.821	3.668	3.687
Mo	88.11	89.38	89.22	86.71	88.86	89.34	88.57	88.33	90.03	89.90
Br	10.95	6.77	6.64	12.34	6.67	6.44	10.16	10.60	5.28	5.79
Hu	0.94	3.85	4.14	0.95	4.37	4.23	1.27	1.08	4.09	4.31

Table 2. continued

Point	2-4	2-5	2-6	3	3-2	3-3	3-4	3-5	3-6
				Sample ZK-55					
SiO_2	0.78	0.75	0.73	0.82	1.20	0.26	0.26	1.13	0.78
Al_2O_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.98	0.97	0.97	0.93	0.46	1.28	1.33	0.86	0.92
PbO	0.12	0.11	0.11	0.12	0.13	0.14	0.14	0.13	0.10
UO_2	0.13	0.12	0.12	0.15	0.11	0.42	0.31	0.11	0.12
ThO_2	6.06	6.26	6.25	6.23	6.62	5.79	6.31	7.12	5.74
Y_2O_3	1.19	1.25	1.16	1.23	1.49	1.86	1.64	0.83	1.26
Ce_2O_3	26.70	27.09	27.12	27.06	27.27	26.88	26.70	26.81	27.08
La_2O_3	12.00	11.97	11.82	11.68	12.40	12.50	12.29	12.19	11.77
Gd_2O_3	4.11	3.95	4.08	3.93	4.05	4.04	3.69	3.71	4.00
Yb_2O_3	0.22	0.00	0.07	0.04	0.06	0.13	0.10	0.06	0.09
Sm_2O_3	2.25	2.41	2.35	2.41	2.32	1.99	2.02	2.01	2.32
Pr_2O_3	3.18	3.27	3.44	3.37	3.05	3.03	2.85	3.14	3.22
Er_2O_3	0.02	0.24	0.04	0.36	0.18	0.25	0.00	0.04	0.11
Nd_2O_3	12.86	12.79	13.00	12.91	12.60	11.44	11.80	12.93	12.97
P_2O_5	26.30	26.65	26.38	26.55	26.05	27.23	27.17	25.93	26.21
Total	96.90	97.83	97.64	97.77	98.00	97.23	96.60	96.99	96.67
				calculated on the basis 4 O					
Si	0.131	0.124	0.122	0.136	0.200	0.043	0.043	0.190	0.132
Al	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Ca	0.176	0.173	0.174	0.166	0.083	0.227	0.238	0.154	0.165
Pb	0.005	0.005	0.005	0.005	0.006	0.006	0.006	0.006	0.005
U	0.005	0.004	0.004	0.005	0.004	0.016	0.011	0.004	0.004
Th	0.232	0.236	0.238	0.236	0.251	0.218	0.239	0.272	0.220
Y	0.106	0.111	0.103	0.109	0.133	0.164	0.146	0.075	0.113
Ce	1.641	1.647	1.659	1.647	1.666	1.631	1.628	1.652	1.668
La	0.743	0.733	0.729	0.717	0.763	0.764	0.755	0.757	0.731
Gd	0.229	0.217	0.226	0.217	0.224	0.222	0.204	0.207	0.223
Yb	0.011	0.000	0.003	0.002	0.003	0.006	0.005	0.003	0.004
Sm	0.130	0.138	0.136	0.138	0.134	0.113	0.116	0.116	0.135
Pr	0.195	1.198	0.209	0.204	0.185	0.183	0.173	0.192	0.197
Er	0.001	0.013	0.002	0.019	0.010	0.013	0.000	0.002	0.006
Nd	0.771	0.759	0.776	0.767	0.751	0.677	0.702	0.777	0.779
P	3.737	3.747	3.732	3.738	3.680	3.821	3.831	3.694	3.734
Mo	90.29	90.22	90.24	90.38	91.97	89.13	88.43	89.78	90.84
Br	6.62	6.84	6.89	6.41	3.29	9.86	10.54	5.72	6.07
Hu	3.08	2.94	2.86	3.21	4.74	1.01	1.03	4.50	3.10

Upper molar A/CNK, around 1.5 value in biotite, compared with molar A/CNK value in whole-rock sample indicates more alumina character of biotite than its host rocks. TiO_2 content is rather high (to 3.8 hm. %) in biotite though its volume decreases towards the rim of grains. Biotites from investigated leucocratic granite shows typically the high Fe /(Fe+Mg) = 0.56 – 0.58 values and ${}^{IV}Al$ = 2.54 – 2.66 content. Al^{VI} is markedly concentrated in the core and Mg is mainly occurred in the grain periphery. Relatively high content of Al^{IV} indicates a biotite derivation from peraluminous melt. Chemical composition of biotite from leucogranite (high FeO, TiO_2 contents and low Al_2O_3, MgO contents) relative to biotite composition of the surrounding gneisses (Vozárová 1993) doesn't suggest a restite origin of biotite. However, low contents of FeO, MgO and TiO_2 in whole-rock sample are consistent with a biotite-free partial melting.

Contents of ThO_2 in monazite from monzogranite (sample BRA – 4) vary at intervals from 4 to 8 wt. %, contents of UO_2 show intervals from 0.1 to 0.3 wt. % and PbO concentration is within the range from 0.1 to 0.2 wt. %. The oxide concentrations listed above, further the presence of brabandite component within the range from 4 to 14 % and low yttrium concentration included with steep LREE profiles in monazites indicate their primary origin (Bea 1996, Förster 1998).

REE thermometry of the leucogranites from the Kamenný vrch locality derived from monazite saturation experiments (Montel 1993) indicate temperature to 730 °C.

Geochronology

CHIME (chemical isochrone method) of monazite in leucogranite or alkali feldspar granite (Pod Braniskom – salaš location) which is differentiated member of granite plutonism in Patria massive shows age 342 ± 15 Ma (Fig. 5). This age may represent the formation eventually emplacement of the main granitoid pluton in Lower Missisipian or "Lower Carboniferous". One grain within this measurement set showed anomalous high age 386 ± 19 Ma (Table 3) which can indicate the presence „an inherited grain", perhaps even the recycling of an older crust.

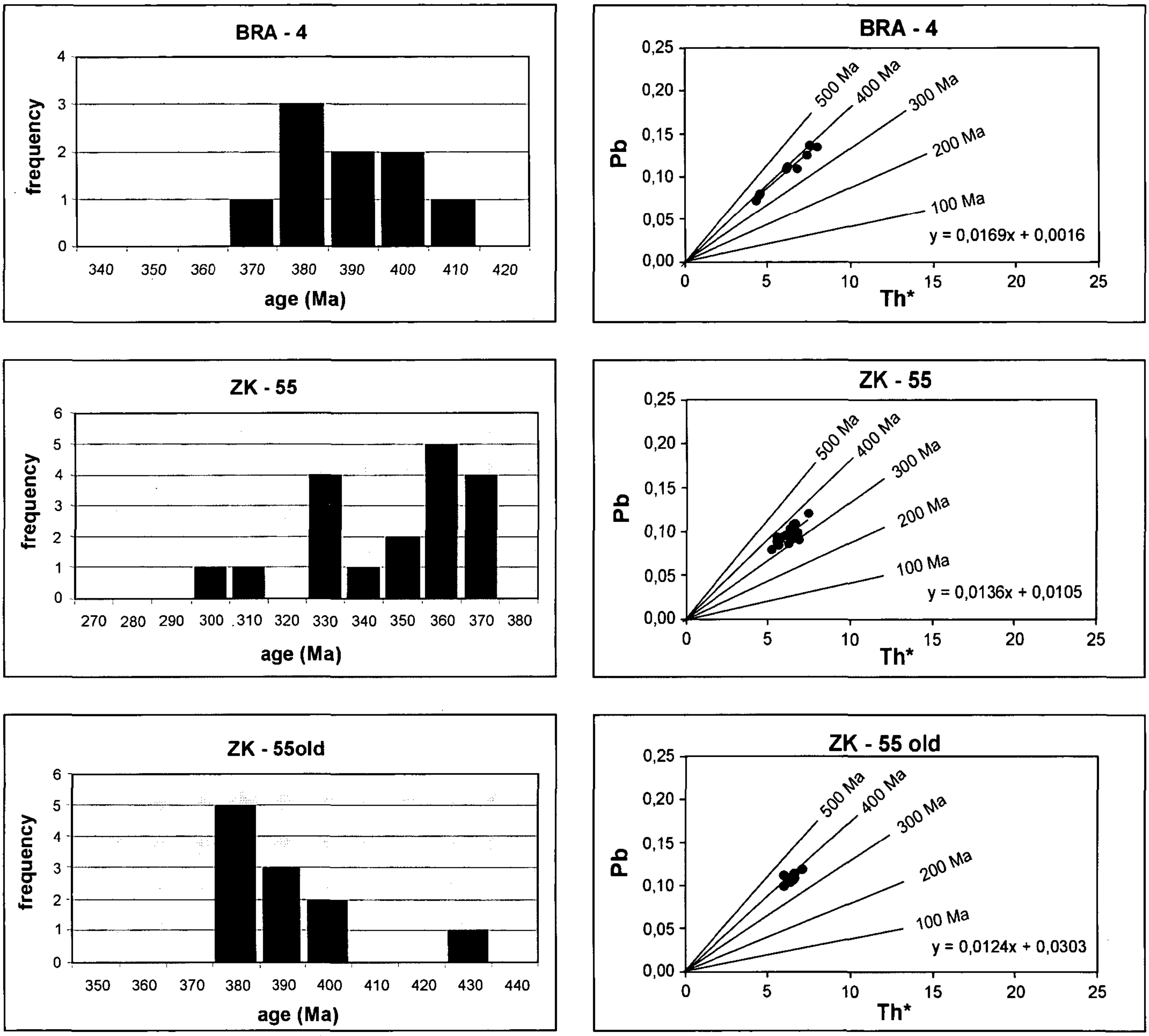

Fig. 5. Histogram representations of mean EMPA monazite ages (Montel et al., 1996) from all investigated leucogranite samples.

Table 3. Range of Th, U and Pb abundance and calculated ages in monazites from EMPA dating of leucogranites.

Sample	Point	Th	U	Pb	Th*	T (Ma)	Mean (Ma)
BRA-4	1	7.249	0.301	0.146	8.05	374	384±21
	1-2	6.746	0.293	0.147	7.54	404	
	1-3	6.639	0.299	0.136	7.45	376	
	2	5.724	0.202	0.120	6.25	398	
	2-2	4.277	0.136	0.090	4.62	388	
	3	4.291	0.102	0.091	4.52	389	
	3-3	6.073	0.264	0.121	6.79	360	
	4	3.919	0.157	0.079	4.34	371	
	4-2	5.704	0.184	0.119	6.17	398	
ZK-55	1	5.597	0.370	0.129	6.67	364	342±15
	1-2	6.049	0.120	0.098	6.29	305	
	1-3	6.232	0.138	0.115	6.53	344	
	1-4	6.178	0.434	0.143	7.44	364	
	1-5	6.632	0.128	0.107	6.89	296	
	1-6	6.278	0.103	0.122	6.46	379	
	1-7	5.681	0.271	0.115	6.43	329	

Table 3. continued

Sample	Point	Th	U	Pb	Th*	T (Ma)	Mean (Ma)
ZK-55	2	5.650	0.250	0.120	6.33	358	
	2-2	6.238	0.119	0.117	6.48	366	
	2-3	6.179	0.115	0.106	6.40	327	
	2-4	5.326	0.117	0.107	5.58	367	
	2-5	5.497	0.108	0.106	5.72	355	
	2-6	5.491	0.106	0.105	5.70	356	
	3	5.473	0.134	0.107	5.78	354	
	3-2	5.819	0.102	0.122	6.01	388	386±19
	3-3	5.087	0.384	0.127	6.22	381	
	3-4	5.542	0.281	0.126	6.32	379	
	3-5	6.253	0.104	0.124	6.44	392	
	3-6	5.042	0.109	0.093	5.27	330	
	3-7	5.319	0.113	0.102	5.56	353	
	3-8	5.682	0.114	0.113	5.92	375	
	3-9	5.464	0.098	0.099	5.65	334	
	30	5.879	0.093	0.106	6.04	350	
	31	5.595	0.122	0.125	5.86	423	
	32	5.576	0.296	0.126	6.41	373	
	33	5.924	0.114	0.123	6.15	394	
	34	6.213	0.116	0.123	6.44	376	
	35	6.263	0.239	0.138	6.89	388	
	36	5.893	0.317	0.119	6.78	321	

CHIME (chemical isochrone method) monazite dating from monzogranite (sample BRA – 4; Kamenný vrch location) which represents the minimum melt occurred probably during isobaric decompression within 384 ± 21 Ma which was the age reported also by Kohút (2005). This age is synchronous to the forming of Variscan metamorphosis resulted in the origin of orthogneisses in this area.

Conclusions

Mineralogical and geochemical data, the accessory mineral assemblage e.g. the absence of magnetite and zircon typology in the investigated rocks clearly indicate the crustal origin of leucogranites from the Branisko Mts. and their competence to S-type granitoid rocks (sensu Broska and Uher 2001). The crustal origin is indicated by oxygen and lead isotopes as well (Kohút et al. 2003ab).

The monazite age data from the Branisko leucogranites show relation to main Meso-Hercynian stage (cca 340 Ma). An appearance of leucogranites (sample BRA – 4) from the Kamenný vrch locality is probably associated with the early collision stage of Variscan orogeny (384 ± 21 Ma). This leucocratic granite represents a minimum melt occurring in migmatites and orthogneisses. These new melt portion create the small bodies following the foliation of metamorphic rocks with eastern-western direction (Fig. 1). Moreover, the age conformity between leucogranites and gneisses (397 ± 16 to 314 ± 7 Ma) (Kohút et al. 2004) indicates that the processes might have been related to the similar tectonometamorphic event i.e. the leucocratic granite formation is synchronous to the partial anatexis of the gneiss complex beside medium-pressure Variscan metamorphic events (Vozárová 1993, Faryad 1996, Vozárová and Faryad 1997, Faryad et al. 2005).

EMPA dating of monazites in leucogranite or alkali feldspar granite (Pod Braniskom – salaš location) shows age 342 ± 15 Ma. Leucogranite represents the differentiated member of granite plutonism in Patria massive. Its formation results from collision processes and subsequent crust thickness apparently and from the occurrence of the felsic magmatism in Early-Carboniferous period (around 350 Ma) during the Palaeozoic evolution of the Western Carpathian basement complexes. Gained old age record - 386 ± 19 Ma (middle Devonian) in the same sample can indicate the presence of „an inherited grain" in rock, perhaps even the recycling of older crust. According to Kohút (2005) Devonian period constitutes the initial stage formation of the continental crust collisional processes leading to the orthogneiss precursor production and the reactivation of old fundament in the Western Carpathian realm. However, the occurrence of older ages from gneiss-amphibolite rocks (380 Ma and around 750 Ma) indicates the participation rocks of older orogenic events in geological structure of Branisko crystalline complex (l.c.).

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