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MESOZOIC ALKALI LAMPROPHYRES IN VARISCAN GRANITOIDS OF THE MALÉ KARPATY AND NÍZKE TATRY MOUNTAINS — GEOCHRONOLOGY AND GEOCHEMISTRY

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Abstract: Mesozoic alkali lamprophyres from the Malé Karpaty Mts and Nízke Tatry Mts granitoids have a similar petrographic pattern. The textures are phyric, with amphibole and clinopyroxene (Cpx) (and/or olivine) phenocrysts. Cpx are zonal and correspond to diopside. Amphibole are zoning too and correspond to kaersutites. On the basis of chemical composition they can be ranked with alkaline lamprophyres. The K/Ar age (approx. 100 Ma) of these dykes corresponds to the age of the Cretaceous alkaline basalt/basanite in the Krížna Nappe of the Central Western Carpathians.

Key words: Central Western Carpathians, Mesozoic, geochronology, geochemistry, alkali lamprophyres.

Introduction

In the Mesozoic complexes of the Central Western Carpathians, Cretaceous alkaline basalts/basanites form part of the Krížna Nappe, however less frequently, they also occur in cover sequences. Due to the basalts often being synchronous with the host sediments the influence of volcanic activity on the surrounding rocks can be observed frequently (Hovorka & Spišiak 1988). Stratigraphic data indicate the age of these rocks to be Berriasian to Albian (see Hovorka & Spišiak l.c.). Beside the dominating effusive and extrusive rock types in the Mesozoic sequences, dykes of basalts/lamprophyres are also locally present in the Variscan granitoids. Such dykes have been reported from the area of the Malé Karpaty Mts (Hovorka et al. 1982a) and from the Nízke Tatry Mts (Fig. 1) (Hovorka et al. 1982b; Spišiak et al. 1991). It is difficult to rank them stratigraphically on the basis of geological criteria, which has led us to use geochemical and geochronological methods to date them more precisely.

Fig. 1. Localization of dykes.

Method of K/Ar dating

Measurement of K/Ar ages was performed in the Institute of Nuclear Research of the Hungarian Academy of Sciences (ATOMKI), Debrecen. The samples were first crushed to 0.3–0.1 mm according to the grain size of the minerals. Whole rock samples and amphibole + pyroxene mineral concentrates were prepared by heavy liquids and magnetic separation. It was assumed that K was hosted mostly by amphibole, so the ages measured on the mineral concentrates were regarded as values close to the amphibole ages. Part of each sample was pulverized for K determination. An argon extraction line and a mass spectrometer, both designed and built in the ATOMKI, were used for argon measurement. The rock was degassed by high frequency induction heating, the usual getter materials (titanium sponge, getter pills of SAES St707 type and cold traps) were used for cleaning and transporting Ar. The ^{38}Ar spike was introduced to the system from a gas-pipette before the degassing was started. The purified Ar was directly introduced into the mass spectrometer. The mass spectrometer was a 90° magnetic sector type of 150 mm radius and was operated in the static mode. Recording and evaluation of the Ar spectrum was controlled by a microcomputer. Potassium was determined by flame photometry with a Li internal standard and Na buffer.

The interlaboratory standards Asia 1/65, HD-B1, LP-6 and GL-0 as well as atmospheric Ar were used for controlling and calibration of the analyses. Details of the instruments, the applied methods and results of calibration have been described elsewhere (Odin et al. 1982; Balogh 1985). The K/Ar ages were calculated using the constants proposed by Steiger & Jäger (1977).

Geology

A dyke 50–80 cm thick occurs in the area of the Malé Karpaty Mts, in the Modra granodiorite massif (approx. 3 km NNW from the quarry in the Cajlanská dolina Valley, Hovorka et al. 1982b). The dyke is subvertically orientated and can be traced as far as 200 m. There are rare amygdales (up to 2 mm) with chlorite filling, especially in the marginal parts of the dyke.

Two alkali lamprophyre dykes have been reported in leukocrate middle-grained strongly altered granites from the area of Liptovská Dúbrava, Nízke Tatry Mts (Hovorka et al. 1982a; Spišiak et al. 1991). Both the dykes are rather thin, between 30–50 cm. In general, the contact of the dykes with the surrounding granites is sharp and no wider contact zones can be observed here. This proves that the melt was moving and cooling quickly.

Mineralogy and petrology

Mineral compositions (Tables 1, 2) were determined with the use of a JEOL Superprobe 733 (operated with a beam current of 15 kV at 5nA) in the Slovak Geological Survey, Bratislava (analyst I. Holický). The data were reduced by ZAF corrections.

The petrographic patterns of the dykes from the Malé Karpaty and Nízke Tatry Mts are very close to each other and this is why we will describe them together.

The dykes show aphanitic, very rarely amygdaloidal structures. The textures are typically porphyric, with amphibole and clinopyroxene (Cpx) (and/or olivine) phenocrysts. In the dykes from the Nízke Tatry Mts, Cpx and olivines are totally replaced by chlorite-carbonate aggregates and nothing but pseudomorphoses after these minerals can be observed. The original vitreous matrix has been strongly devitrified and contains microlites of Cpx, amphibole and dark mica. Cpx from the dyke of the Malé Karpaty Mts are zonal (sectorial and oscillation zoning) and often form glomerophyric aggregates.

Table 1: Selected analyses of clinopyroxenes.

N. anal.	1Py	2Py	3Pr	5c	6c-r	7r	8Pr	10Py
SiO_2	48.90	47.90	45.02	49.04	47.10	46.29	41.67	45.15
TiO_2	3.05	2.87	3.85	2.03	2.55	3.51	5.45	3.75
Al_2O_3	5.92	5.47	8.17	4.73	4.98	7.62	9.95	8.23
Cr_2O_3	0.00	0.00	0.39	0.21	0.22	0.45	0.04	-
FeO^+	6.71	6.59	6.62	5.45	6.13	6.32	7.77	7.10
MnO	0.10	0.14	0.07	0.09	0.08	0.12	0.06	0.09
MgO	13.82	14.31	13.05	15.21	15.13	13.32	11.60	12.95
CaO	21.73	23.10	23.27	23.09	23.23	23.43	23.01	23.00
Na_2O	0.34	0.34	0.32	0.30	0.33	0.34	0.46	0.42
K_2O	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00
TOTAL	100.57	100.74	100.76	100.15	99.75	101.40	100.01	100.69
Formula based on 6 oxygens								
Si^{IV}	1.80	1.78	1.68	1.82	1.77	1.71	1.58	1.68
Al^{IV}	0.20	0.22	0.32	0.18	0.23	0.29	0.42	0.32
Al^{VI}	0.06	0.02	0.04	0.03	-	0.04	0.03	0.04
Ti	0.09	0.08	0.11	0.06	0.07	0.10	0.16	0.11
Cr	-	-	0.01	0.01	0.01	0.01	-	-
Fe^{2+}	0.21	0.20	0.21	0.17	0.19	0.20	0.25	0.22
Mn	-	-	-	-	-	-	-	-
Mg	0.76	0.79	0.72	0.84	0.84	0.73	0.66	0.72
Ca	0.86	0.92	0.93	0.92	0.93	0.93	0.94	0.92
Na	0.02	0.02	0.02	0.02	0.02	0.02	0.03	0.03
K	-	-	-	-	-	-	-	-

FeO^+ — total Fe as FeO, c = core, r = rim, Pr = prizmatic sector, Py = pyramidal sector

Fig. 2. Oscilation zoning of clinopyroxene. Loc. Cajla, Magn. 45×, X polars.

Fig. 3. Sector zoning of clinopyroxene. Loc. Cajla, Magn. 35×, X polars.

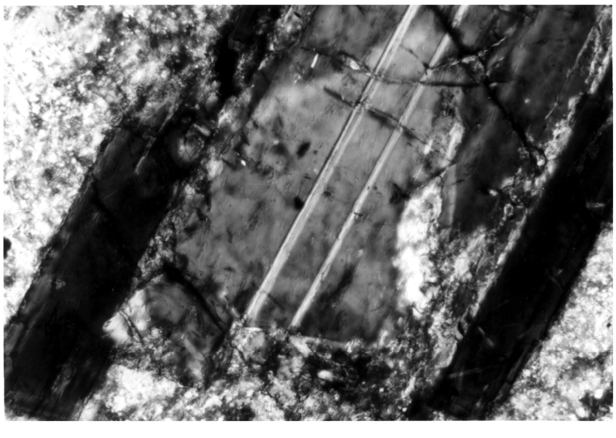

Fig. 4. Sector zoning of clinopyroxene, around clinopyroxene dark kaersutite. Loc. Cajla, Magn. 65×, X polars.

Table 2: Selected analyses of amphiboles.

	1	2	3	4	5r	5c	1r	1c	2r	2c	3	4
Loc.	**Cajla (Malé Karpaty Mts)**						**Liptovská Dúbrava (Nízke Tatry Mts)**					
SiO_2	38.92	37.79	36.61	39.55	37.02	38.26	37.73	39.61	38.10	40.95	38.58	38.01
TiO_2	5.72	6.11	5.68	5.59	6.22	5.76	5.42	5.07	5.52	4.78	5.41	5.22
Al_2O_3	13.65	14.51	14.61	12.06	13.65	14.18	14.08	13.91	14.49	13.02	14.42	14.97
FeO^+	11.09	10.03	10.74	11.75	14.68	11.49	10.76	9.65	10.53	9.37	12.41	12.56
MnO	0.18	0.17	0.18	0.19	0.35	0.16	0.22	0.17	0.15	0	0.22	0.13
MgO	12.81	13.62	13.07	13.03	10.48	12.84	12.18	13.70	11.90	13.85	10.59	10.05
CaO	11.62	11.27	11.62	11.39	11.62	11.55	11.94	11.39	11.97	11.34	11.85	11.86
Na_2O	2.06	1.94	1.99	2.04	1.93	1.90	2.45	2.43	2.23	2.39	2.43	2.43
K_2O	1.61	1.69	1.78	1.47	1.63	1.77	1.10	1.55	1.06	1.29	1.16	1.16
TOTAL	97.66	97.13	96.28	97.07	97.58	97.91	95.88	97.48	95.45	96.99	97.07	96.39
Formula based on 23 oxygens												
Si	5.79	5.63	5.55	5.89	5.64	5.70	5.72	5.85	5.75	6.04	5.80	5.76
Al^{IV}	2.21	2.37	2.45	2.11	2.36	2.30	2.28	2.15	2.25	1.96	2.20	2.24
Al^{VI}	0.19	0.18	0.16	0.10	0.09	0.19	0.24	0.28	0.32	0.31	0.36	0.44
Ti	0.64	0.69	0.65	0.63	0.71	0.64	0.62	0.56	0.63	0.53	0.61	0.60
Fe^{2+}	1.38	1.25	1.36	1.47	1.87	1.43	1.36	1.19	1.33	1.16	1.56	1.59
Mn	0.02	0.02	0.02	0.03	0.04	0.02	0.03	0.02	0.02	0	0.03	0.02
Mg	2.84	3.02	2.95	2.89	2.38	2.85	2.75	3.02	2.68	3.05	2.37	2.27
Ca	1.85	1.80	1.88	1.82	1.90	1.84	1.94	1.80	1.93	1.79	1.91	1.93
Na	0.59	0.56	0.59	0.59	0.57	0.55	0.21	0.29	0.20	0.24	0.22	0.22
K	0.31	0.32	0.35	0.28	0.32	0.34	0.72	0.70	0.65	0.68	0.71	0.71

FeO^+ — total Fe as FeO, c = core, r = rim

Sector zoning can be seen through two clearly different sectors: pyramidal and prismatic (Figs. 2, 3, 4). There are optical and chemical differences between the sectors. Mostly the pyramidal sector is enriched with Si and Mg, and/or depleted in Al, Ti, Fe when compared to the prismatic one. With oscillation zoning, the central part of the crystal rather than the rim is enriched with Si and Mg and depleted in Ti, Al, Fe. With regard to crystal structure stability, zoning is a non-equilibrium state and later diffusion processes caused its wiping out. Whether it is preserved or not depends on the speed of crystallization and diffusion in the crystal. Due to this, sector zoning is usually preserved in rapidly cooling rocks. Another pyroxene type, which is characteristic of rapidly cooling basic rocks, are microlites in the matrix. They have irregular shapes and with their compositions they are close to prismatic sectors, and/or marginal parts of Cpx in the case of oscillation zoning. They represent the final phase of crystallization during the ascent of magma to the surface, that is they reflect decreasing pressure and rather quick cooling.

On the basis of Cpx classification (Morimoto et al. 1988), they correspond to diopsides (Fig. 5), and/or part of the analyses are shifted towards higher Ca values (especially grain rims, prismatic sectors). In comparison to Cpx from Mesozoic alkaline rocks of the Tatric Unit and Fatric Unit of the Western Carpathians, they show a striking coincidence of composition. The dependence of Cpx compositions on those of the melts they originated from, was used (Le Bas 1962; Letterrier et al. 1977 and others) for the determination of Cpx types. In these diagrams the Cpx from the studied dykes correspond to the Cpx from alkaline rocks. Cpx from the Mesozoic alkaline rocks of the Tatric Unit and Fatric Unit of the Western Carpathians have a similar position.

Amphiboles are typical minerals of the dykes. Like Cpx they are zonal (Fig. 6) and by their compositions they correspond to kaersutites (Table 2, Fig. 7). Zoning is not so clear

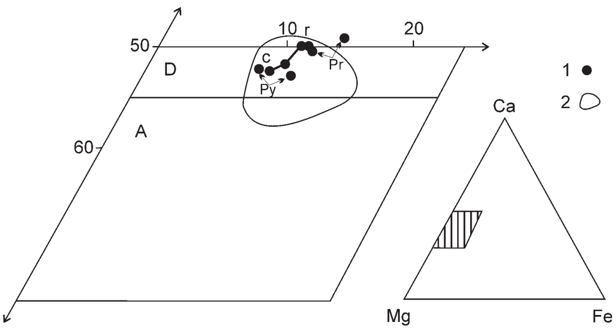

Fig. 5. Classification diagram of clinopyroxenes (according to Morimoto et al. 1988). **1** — analyses of clinopyroxenes from Table 1; **2** — analyses of clinopyroxenes from Mesozoic alkali basalt/basanites (Hovorka & Spišiak 1988).

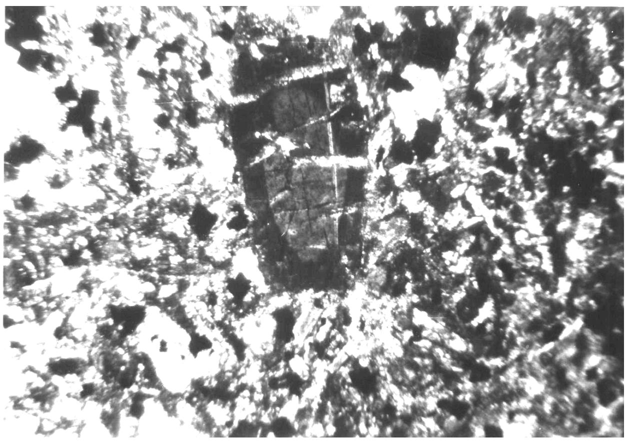

Fig. 6. Oscillation zoning of kaersutite. Loc. Liptovská Dúbrava, Magn. 25×, X polars.

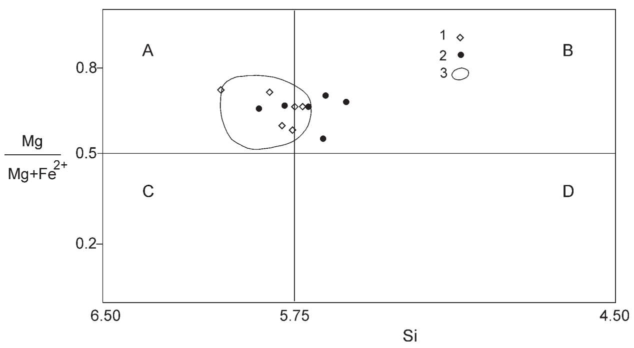

Fig. 7. Classification diagram of amphiboles (according to Leake et al. 1988). **1** — analyses of kaersutites from Liptovská Dúbrava, **2** — analyses of kaersutites from Cajla; **3** — analyses of kaersutites from Mesozoic alkali basalt/basanites (Hovorka & Spišiak 1988).

and is manifested through increasing Ti, Al and Fe contents and/or decreasing Si and Mg contents from core to rim.

Ti-biotites, plagioclases, apatites, chlorites and carbonates are also present in accessory amounts. Tiny (X mm), differently resorbed xenoliths, mostly of granite composition are also typical of the dykes.

Geochemistry

Major elements were analysed by X-ray fluorescence in the Geological Institute of the Slovak Academy of Sciences in Bratislava, some trace elements and REEs were analysed by ICP in the Slovak Geological Survey, Analytical Laboratory at Spišská Nová Ves and in the Geochemical Centre, Saint Mary's University in Halifax, Nova Scotia.

The analyses for major and rare earth element contents were used to solve the petrogenesis and geotectonic position of the Cretaceous alkaline volcanics. Although the rocks from the dykes underwent secondary alterations to different degrees, most major elements, HSFE, REE, Th, as well as transition elements were not significantly mobilized.

On the whole, Cretaceous lamprophyres from granites are characterized (Table 3) by low SiO_2 contents (ca. 39 weight %), enhanced contents of TiO_2 and P_2O_5 (3.2, and/or

Table 3: Chemical composition of rocks.

Sample	D-51	D-56	MV-77	MV-78	MV-79	MV-64	MV-66	MV-69	LAM-1	LAM-2	LAM-3
Locality	Dúbrava	Dúbrava	Dúbrava	Dúbrava	Dúbrava	Cajla	Cajla	Cajla	Cajla	Cajla	Cajla
SiO_2	38.96	38.97	38.94	40.21	41.33	40.36	37.22	39.38	39.45	38.40	41.24
TiO_2	3.40	3.38	3.64	3.72	3.73	3.47	3.23	3.28	3.17	3.27	3.72
Al_2O_3	12.61	12.57	12.64	13.48	13.29	13.32	10.74	11.83	13.34	10.71	13.61
Fe_2O_3	6.46	6.07	14.03*	14.16*	13.76*	13.26*	12.89*	12.78*	4.80	4.48	5.07
FeO	7.22	7.43							7.85	8.34	7.29
MnO	0.20	0.19	0.18	0.18	0.17	0.17	0.19	0.19	0.18	0.17	0.17
MgO	7.71	7.97	8.15	7.30	7.66	7.45	11.15	10.93	10.08	9.86	7.68
CaO	8.41	8.63	8.57	7.63	8.79	10.49	14.12	12.34	12.12	13.90	9.40
Na_2O	2.17	2.00	2.00	2.34	2.25	2.59	1.55	1.45	1.48	2.03	3.01
K_2O	2.41	2.54	2.48	2.40	2.40	2.26	0.85	1.75	1.88	1.01	2.46
P_2O_5	0.97	0.99	0.98	1.03	1.03	0.99	0.79	0.85	0.49	0.48	0.55
LOI	8.94	8.85	8.20	7.60	5.70	5.50	6.60	4.60	4.95	7.02	5.66
Total	99.46	99.59	99.81	100.05	100.11	99.86	99.33	99.38	99.79	99.67	99.86
Cr	106.1	177.3	105.0	87.0	104.0	180.0	481.0	402.0	330.0	309.0	118.0
Ni	65.6	69.5	99.0	77.0	79.0	91.0	245.0	199.0	160.0	171.0	84.0
Co	40.8	44.3	51.0	43.0	43.0	40.0	54.0	51.0	39.0	42.0	32.0
V	147.2	158.7	249.0	261.0	249.0	296.0	277.0	273.0	226.0	200.0	237.0
Pb	24.6	18.1	337.0	405.0	141.0	ND	ND	ND	ND	ND	ND
Zn	ND	ND	147.0	160.0	148.0	106.0	106.0	115.0	ND	ND	ND
Rb	ND	ND	82.0	86.0	61.0	68.0	28.0	58.0	30.0	16.0	54.0
Ba	581	700	589	605	689	1318	1286	1578	1620	1290	1470
Sr	1770	3000	877	814	1001	990	684	746	930	720	1070
Ta	ND	ND	ND	4.25	ND	ND	ND	4.44	ND	ND	ND
Nb	ND	ND	85.00	113.50	92.00	95.00	70.00	105.20	ND	ND	ND
Hf	ND	ND	ND	10.16	ND	ND	ND	6.19	ND	ND	ND
Zr	419	440	396	457	423	308	262	313	267	216	276
Y	29.50	37.90	32.00	32.00	33.00	28.00	23.00	25.00	26.00	22.00	28.00
Th	ND	ND	12.00	7.56	9.00	8.00	6.00	6.06	ND	ND	ND
U	ND	ND	7.00	7.00	3.00	ND	ND	ND	ND	ND	ND
La	62.80	77.20	44.00	69.23	92.00	74.00	56.00	67.30	87.00	75.00	96.00
Ce	131.00	160.50	155.00	143.13	156.00	144.00	90.00	129.44	ND	ND	ND
Pr	15.30	20.20	ND	17.19	ND	ND	ND	14.79	ND	ND	ND
Nd	68.20	76.30	71.00	68.27	64.00	65.00	49.00	56.86	ND	ND	ND
Sm	11.80	14.00	ND	12.94	ND	ND	ND	10.31	ND	ND	ND
Eu	3.90	4.90	ND	3.98	ND	ND	ND	3.17	ND	ND	ND
Gd	10.20	12.50	ND	10.88	ND	ND	ND	8.27	ND	ND	ND
Tb	ND	ND	ND	1.43	ND	ND	ND	1.10	ND	ND	ND
Dy	7.40	8.70	ND	7.74	ND	ND	ND	5.76	ND	ND	ND
Ho	1.22	ND	ND	1.37	ND	ND	ND	1.03	ND	ND	ND
Er	2.93	3.82	ND	3.41	ND	ND	ND	2.54	ND	ND	ND
Tm	0.30	0.46	ND	0.42	ND	ND	ND	0.32	ND	ND	ND
Yb	2.07	3.17	ND	2.46	ND	ND	ND	1.81	ND	ND	ND
Lu	0.28	0.40	ND	0.34	ND	ND	ND	0.26	ND	ND	ND

* Total Fe as Fe_2O_3

0.8 weight %) and elevated contents of Cr (280 ppm) and Ni (190 ppm), elevated contents of incompatible elements such as Ba (650 ppm), Sr (700 ppm) and L REE as well as those of Nb (78 ppm), V (245 ppm) and Zr (305 ppm). The rocks of the dykes were ranked either as alkaline, and/or calc-alkaline ones on the basis of a ternary diagram by Rock (1987; Fig. 8). In this diagram the projection points of the analyses of the rocks from the dykes in granites are plotted in the field of alkaline lamprophyre rocks. A generally negative correlation Al_2O_3/CaO vs. Mg* (MgO/[MgO+FeO] in mole %) suggests that the rocks underwent clinopyroxene dominated fractionation. Although lamprophyre dykes penetrate through continental crust complexes, no significant crustal contamination can be observed. This is proved by a low Th/La ratio which is close to the ratios in primitive mantle (Sun & McDonough 1989). Cretaceous lamprophyres from granites do not satisfy the compositional criteria for identifying primary upper mantle partial melts (Green 1971; Sato 1977). They were evidently derived by a certain degree of fractional crystallization from more primitive magma. A high concentration of strongly compatible elements (including Ni and Cr; Table 3) and the presence of olivine phenocrysts indicated that the rocks are relatively primitive. Similar trace element characteristics of lamprophyres of the two localities under consideration suggest that they could be formed by similar degrees of partial melting of a common/similar mantle source.

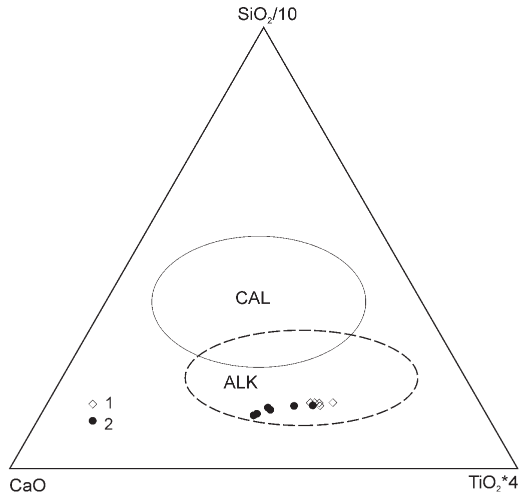

Fig. 8. Classification ternary diagram CaO–SiO_2/10–TiO_2*4 for lamprophyric rocks (according to Rocks 1987). **1** — analyses of rocks from Liptovská Dúbrava; **2** — analyses of rocks from Cajla, **ALK** — alkaline lamprophyres; **CAL** — calc-alkaline lamprophyres.

For a more precise geotectonic classification of the rocks from dykes we used different ternary diagrams (Fig. 9a,b,c). In the diagram MnO–TiO_2–P_2O_5 (Fig. 9a) the projection points of analyses of the studied lamprophyres lie in the OIA (oceanic island alkali) field and most points coincide with the field of Mesozoic alkaline basalts from the Central Western Carpathians. Three of the points are shifted to the TiO_2 peak due to lower values for this oxide in the analyses. In the following diagram Ti–Zr–Y (Fig. 9b) projection points of the analysed lamprophyres are plotted in the field or on the boundary of the WPB (within-plate basalts) field. In the last diagram Zr–Nb–Y (Fig. 9c) within-plate basalts are divided into alkaline and tholeiite ones. The lamprophyres under study as well as Mesozoic alkaline basalts of the Central Western Carpathians being compared are plotted in WPA (within-plate alkali) field. Similarly, the course of the normalized REE curve (Fig. 10) is clearly declined in the direction of low HREE contents with-

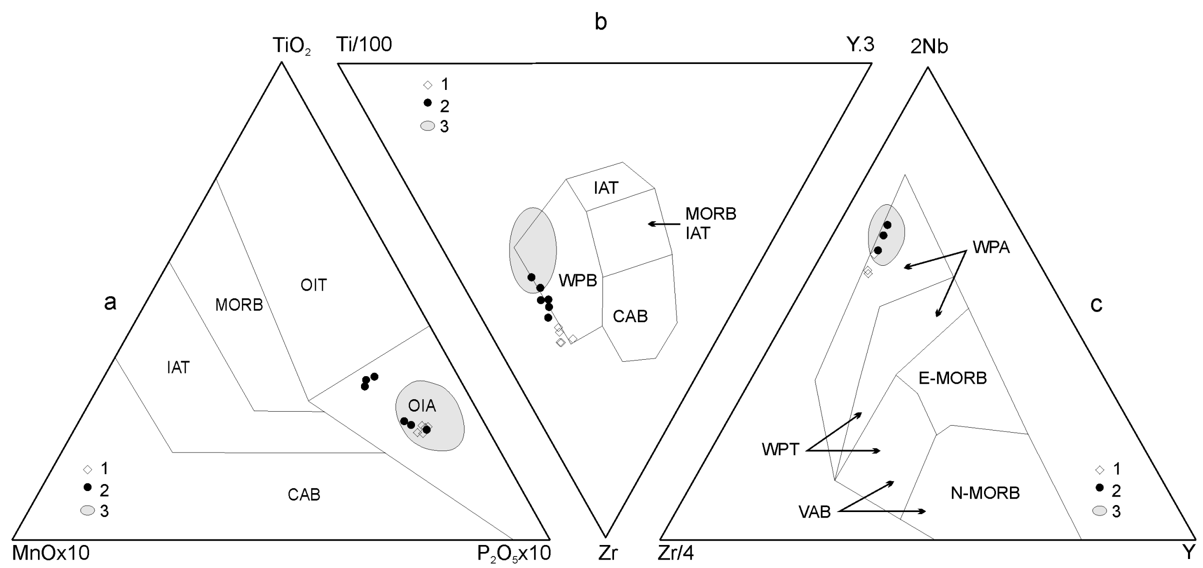

Fig. 9. Discrimination diagram for basalts: **a** — MnO×10–TiO_2–P_2O_5×10 (Mullen 1983); **b** — Zr–Ti/100–Y.3 (Pearce & Cann 1973); **c** — Zr/4–2Nb–Y (according to Meschede 1986). **1** — analyses of rocks from Liptovská Dúbrava, **2** — analyses of rocks from Cajla, **3** — analyses of Mesozoic alkali basalt/basanites (Hovorka & Spišiak 1988; Spišiak & Hovorka 1997; Hovorka et al. 1999). **OIT** = oceanic island tholeiites, **OIA** = oceanic island alkali basalts, **CAB** = calc-alkaline basalts of volcanic arcs, **IAT** = island arc tholeiites, **MORB** = middle oceanic ridge basalts, **WPB** = within plate basalts, **WPA** = within-plate alkali basalts, **E-MORB** = E-type middle oceanic ridge basalts, **N-MORB** = N-type middle oceanic ridge basalts, **VAB** = volcanic arc basalts, **WPT** = within-plate tholeiites.

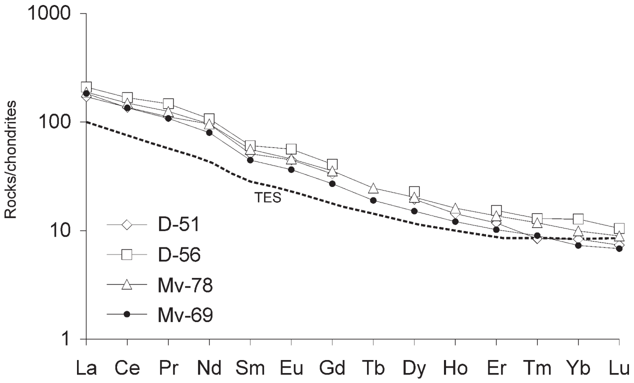

Fig. 10. Chondrit-normalized REE abundance (normalized according to Sun 1982) of the studied lamprophyres (analyses from Table 3) and **TES** — teschenite (Rossy et al. 1992).

Table 4: Age of the lamprophyres.

Sample	Locality	K weight %	^{40}Ar(rad) 10^{-6} cm^3/g	^{40}Ar(rad) %	Age Ma ± σ
MV-56	Cajla	1.340	4.982	72.0	93.2±3.6
MV-56*	Cajla	1.280	4.777	65.9	93.4±3.4
MV-69	Cajla	0.736	3.397	73.4	115.0±4.5
MV-69*	Cajla	0.696	3.229	69.1	115.6±4.5
MV-76	Liptovská Dúbrava	2.390	9.623	79.4	100.7±3.8
MV-79	Liptovská Dúbrava	2.220	9.114	84.6	102.6±3.8

Separates marked with * are more dense than bromoform and nonmagnetic. So amphiboles and pyroxenes should concentrates in them. Since they resulted similar ages, the ages are likely original ones.

out a considerable Eu-anomaly. Such a course of normalized curve is typical of ocean island (OIB), continental alkaline volcanic suites of Central and Western Europe (Wilson & Downes 1991; Wedepohl et al. 1994) as well as of Mesozoic alkaline rocks from different parts of Europe (Moravian alkali rocks; Dostal & Owen 1998, North-Pyrenean rift zone; Azambre et al. 1992, Northern Calcareous Alps; Trommsdorff et al. 1990, etc.). Studies of Cenozoic alkali basalts in Europe showed that these magmas were derived from a HIMU-type (mantle with high U/Pb ratio, Zidler & Hart 1986) mantle source (Wilson & Downes 1991). This source was interpreted as mainly of sub-lithospheric origin and results of a three-component mixing primary between a HIMU component and the DM (depleted mantle) with a subordinate addition of an enriched mantle component (EM, Wilson & Downes 1991). A similar development is considered by Dostal & Owen (1998) in the case of Moravian Cretaceous lamprophyres and a similar source is very likely in the case of these rocks.

Geochronology

It was a problem to determine the ages of the given rocks. It was possible only on the basis of a comparison of geochemical characteristics, and the similarity to Cretaceous volcanics suggested a Cretaceous age (Hovorka & Spišiak 1988; Spišiak et al. 1991). Two fresh samples from each mountain range were analysed for K /^{40}Ar contents (Table 4). The results offered rather coherent values for the Malé Karpaty Mts 93.4 ± 3.4 Ma, and/or 115 ± 4.5 Ma and in case of Liptovská Dúbrava (Nízke Tatry Mts) 100.7 ± 3.8 Ma, and/or 102.6 ± 3.8 Ma. Geochronological settings show a good correlation between chemical and mineral compositions and the age of the dykes in Variscan granites and Cretaceous alkaline basalts/basanites in the Krížna Nappe of the Western Carpathians.

Conclusion

Cretaceous lamprophyres from granites are similar to Mesozoic alkali rocks from the Tatric Unit and Fatric Unit of the Western Carpathians. The detected ages (approx. 100 Ma) prove that. These data correspond to the new geochronological data pointing to the K/Ar age of approx. 110 Ma (Grabowský — unpublished data) or ^{40}Ar/^{39}Ar 122 Ma (Lucińska-Anczkiewicz et al. 2002). On the basis of their mineral and chemical compositions they can be ranked with alkaline lamprophyres. Their trace element composition is similar to that of oceanic island basalts (intra-plate provenience), which suggests an analogous deep-seated mantle source (HIMU). Continental within-plate basalts with the given signs are often interpreted as a result of mantle diapirs (Weaver 1991). A low volume of lamprophyres on the whole does not suggest their binding to mantle diapir. This magmatic activity is likely to have been synchronous with Cretaceous volcanism in the Westen Carpathians and was bound to fault systems connected with forming basins. This idea counts on melting due to a passive upwelling of a mantle material caused by lithosphere depletion during an extensional tectonic regime.

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