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ALKALIES IN THE GRANITOIDS OF THE WEST CARPATHIANS

(Tabs. 4, Figs. 19)

Abstract: The authors evaluate the contents of Na, Li, K, Rb, Cs, Ba and Sr, taking into consideration also the ratios of these elements. Analytical data are treated statistically and presented graphically (histograms, two-component correlation graphs). The evaluation was effected on the regional basis, according to the mesonormative classification and modal classification, in the sense of the IUGS convention, 1973. A satisfactory picture of the common as well as different features of the individual granitoid types has been obtained, in particular by the correlation graphs.

Investigations of alkalies have confirmed a palingenic origin of the granitoid magma, and suggest that it developed from a complex predominating in sediments with a low content of potassium and containing tholeiitic basic rocks of mantle derivation. They also revealed a low differentiation of this magma. The Variscan Tatro-Veporide granitoids of the West Carpathians, mainly their principal types, are characterized by sodium prevailing over potassium, by low contents chiefly of rubidium and cesium and increased amounts of barium and strontium, when compared with the Gemeride granites.

Резюме: Авторы в работе оценивают содержание Na, Li, K, Rb, Cs, Ba и Sr и учитывают и некоторые отношения этих элементов. Аналитические данные статистически разработаны и графически оценены (истограммы, двукомпонентные корреляционные отношения). Оценка была сделана с регинональной точки зрения согласно мезонормативной классификации и модальной классификации в смысле IUGS договора, 1973. Главным образом корреляционные графы дали достаточную картину о общих, но и разных чертах отдельных типов гранитоидов.

Исследования щелочей подтверждают палингенетическое происхождение гранитоидной магмы и указывают на ее возникновение из комплекса с превосходством осадков с незначительным содержанием калия и с содержанием толеитовых основных пород мантийного происхождения, и на малую дифференцированность этой магмы. Татровепоридные варисские гранитоиды Западных Карпат характеризованы в основных типах превосходством натрия над калием и низкими содержаниями особенно рубидия и цезия при повышенных содержаниях бария и стронция по сравнению с гемеридными гранитами.

Introduction

The paper presents an evaluation of alkali contents in selected samples of the West Carpathian granitoids, which are studied integratedly by a team of workers of the Geological Institute, Slovak Academy of Sciences. The set of about 130 samples of the granitoids is labelled by symbol "ZK".

In 1981 Cambel et al. published their results concerning the contents of alkalic elements in the granitoids of the Malé Karpaty, the westernmost Core Mountain range of the West Carpathians. Whereas the primary analytical determination of the Malé Karpaty granitoids (53 samples) was performed by flame photometry in the IGFM laboratories in Kiev (U. S. S. R.), the samples

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of the "ZK" set were analysed using the AAS method by one of the co-authors (Ing. E. Martiny, CSc., Geol. Institute of the Slovak Acad. Sci., Bratislava). The results of the two analytical procedures were compared. Several analyses were made in the laboratories of the Geologický Prieskum, Spišská Nová Ves, by the AAS method, and some others in Kutná Hora by means of the INAA method.

The authors proceeded to the evaluation of the alkali contents only after the investigation of the alkalies in the amphibolites of the Tatro-Veporide region (West Carpathians — Cambel et al., 1979) and in the granitoids and metapelites of the Malé Karpaty (Cambel et al., 1981) had been terminated. Contents of alkalies in potassium feldspars of the granitoids and pegmatites of the West Carpathians were evaluated by Dávidová — Dávid, 1981. Our studies continue mainly in the investigations of Beuss et al., 1965; Heier — Adams, 1964; Ljachovič, 1972; Solodov et al., 1980; Stavrov et al., 1978; and Tauson, 1977. The classification of rocks and their grouping into sets was based on the mesonorm methods (Mielke — White).

Sets of rocks and their tabular and graphical representation

The evaluation of alkali contents in the granitoid samples from the whole West Carpathians is more difficult than their evaluation for a set of samples taken from one mountain range — the Malé Karpaty. In the Malé Karpaty region it was possible (Cambel et al., 1981) to solve detailed problems which required a larger number of samples from one area or one rock type.

This paper informs of the alkali contents in the granitoids of the entire West Carpathians, divided into classification groups on the basis of the differentiation degree and the following criteria:

a) the mineral (modal) composition of samples, determined on the basis of planimetric analyses (areas ca. 7 × 7 cm) and the classification accepted by the IUGS Subcommission (1973);

b) the mesonormative recalculation, as proposed by Mielke and Winkler (1979). The mesonormative recalculation was applied and correlated with the modal classification of the set of ZK samples by Vilinovič and Petrík (1981);

c) regional points of view, viz. classification of the samples according to individual mountain ranges, groups of mountain ranges or major geological regional units.

The mountain groups defined on geological-tectonic grounds are four:

A. The West Slovakian group of granitoid massifs:
Malé Karpaty (MK), Inovec (I), Suchý (S), Malá Magura (M);

B. North Slovakian group of granitoid massifs:
Malá Fatra (MF), Vysoké Tatry (VT), Branisko (B);

C. Central Slovakian group of granitoid massifs:
Žiar (Ž), Tribeč (T), Nízke Tatry (NT), Veľká Fatra (VF);

D. The Veporide region — (Veporide granitoids):
The Veporide group very likely also comprises post-orogenic (Permian) or Neoidic rocks these are dealt with separately, because, judging from geochemical criteria, part of them differs somewhat from the Variscan

granitoids. Their Permian or Neoidic age has been indicated by radiometric K/Ar and Rb/Sr methods.

E. The region of the Spišsko-gemerské rudohorie Mts. — Gemeride granitoids:

These rocks clearly differ in petrochemistry and geochemistry from the Variscan granitoids of the Tatro-Veporides and therefore we regard them as a separate formation of the West Carpathian granitoids. As the group of five rock samples we have analysed did not show any substantial difference in the alkali content, we do not divide them into Permian and Jurassic series, as did Kantor — Rybár (1979) and Kovach — Svinger — Grecula (1979).

The mathematic-statistical treatment of larger sets of samples was mainly directed to the determination of arithmetic and geometrical means and standard deviation. The correlation matrix of the whole set allows for a correlation of the element contents and rock minerals. The histograms and correlation graphs in which samples are labelled according to their classification and regional assignment provide an important geochemical characterization of the rocks. The individual sets of rocks occupy characteristic places in the histograms and specific fields in the correlation graphs. All these data provide the basis for the interpretation of the genesis, and the geological and petrological relationships and differences between the rocks.

The basic data for the interpretational purposes are summarized in the following tables:

1. Table of basic analytical data arranged according to the modal composition of the rocks (Table 1).

2. Table of mean contents of elements in the individual granitoid groups, arranged on the basis of different classifications and classification principles (e.g. modal, mesonormal, degree of differentiation).

3. Table of analytical means arranged according to individual mountain ranges, or mountain groups and the rock types within idividual mountain ranges. In the Veporide region, for example, the following granitoid types are treated separately: Hrončok, Rochovce — Rimavice type, granite of Chyžné, Budiná, Čierny Balog leucotype, Podtajchová and Vydrovo granite — type Sinec, Turčok, and other rocks, in particular from the Kohút zone of the Veporides. Of particular importance for the correlation of the Veporide granitoids are the Sihla type and the Vepor or Ipel' type.

Chemical analyses of the granitoids

Although the aim of the study is the evaluation of the contents of elements of the alkaline group Li, Rb and Cs, we have tabulated also the contents of other elements that were analysed by Ing. E. Walzel (silicate analysis) and RNDr. J. Medveď, CSc. (Sr, Ba, spectrochemically). The analyses of Li, Rb and Cs elements were performed by Ing. E. Martiny, CSc. by the following procedure:

After the decomposition of samples by hydrofluoric and chlorous acids, the Li, Rb, Cs and Zn contents were determined from the nitrate solution using the atomic

Table 1

Basic data on the alkali contents in the granitoids of the West Carpathians

No	Mts	Reg	Mes	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
1/1														
8	MK	A	aG	3.45	2.97	0.21	34	131	4	60	330	263	2.5	2.18
16	SGR	D	mG	2.13	3.62	0.23	10	47	1	18	620	453	13.2	2.61
27	V	D	sG	9.92	2.52	0.22	12	94	5	68	316	417	3.4	1.32
39	VT	B	mG	3.17	3.04	0.24	26	71	1	440	780	446	10.9	0.16
41	T	C	aG	3.38	3.20	0.18	10	82	3	132	720	412	8.8	0.62
42	T	C	mG	3.25	2.13	0.17	17	118	5	209	760	275	6.4	0.56
44	VF	C	sG	4.15	2.34	1.45	16	108	4	132	480	384	4.4	0.82
55	B	B	aG	4.42	2.49	0.31	10	102	4	—	—	433	—	—
63	I	A	aG	3.24	4.41	0.18	7	95	2	59	630	341	6.6	1.61
66	V	D	aG	3.67	2.52	0.36	20	102	2	269	1170	360	11.5	0.38
68	NT	C	aG	3.67	2.41	0.16	8	99	2	—	—	371	—	—
69	V	D	aG	3.81	3.31	0.30	6	226	2	12	65	169	0.3	18.37
91	NT	C	aG	4.65	2.74	0.18	18	105	1	—	—	443	—	—
100	T	C	mG	1.29	3.89	0.18	9	38	1	350	420	339	11.1	0.11
122	V	D	aG	4.00	3.09	0.12	8	280	3	17	239	143	0.9	16.67
125	NT	C	sG	3.11	2.65	0.22	11	104	4	174	1200	301	11.5	0.60
1/2														
9	V	D	GD	2.72	2.58	0.49	15	58	2	450	1040	469	17.9	0.13
15	I	A	GD	2.76	2.91	0.24	46	92	4	170	660	300	7.2	0.54
23	VT	B	GD	3.02	2.91	0.29	23	72	2	440	440	419	6.1	0.16
43	VF	C	mG	3.02	3.04	0.16	24	78	3	151	540	390	7.0	0.51
45	VF	C	mG	2.72	2.52	0.49	15	82	5	450	1040	332	12.7	0.18
54	MK	A	mG	3.37	2.63	2.13	116	98	7	145	440	344	4.5	0.68
59	S	A	mG	2.72	3.47	0.13	10	161	5	182	47	169	0.3	0.88
65	MK	A	aG	2.95	3.97	0.16	25	114	3	71	239	259	2.1	1.61
85	V	D	mG	2.16	3.52	0.34	13	49	2	234	540	441	11.0	0.21
116	MF	B	GD	2.56	3.87	0.44	30	55	4	575	1200	465	21.8	0.10

Continuation of Tab. 1

No	Mts	Reg	Mes	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
2/1														
2	V	D	sG	3.22	2.97	0.55	26	114	3	350	680	282	6.0	0.33
6	V	D	mG	3.05	3.12	0.07	3	83	3	91	330	367	4.0	0.91
17	I	A	mG	2.29	3.29	0.28	24	57	3	141	1620	402	28.4	0.40
19	V	D	mG	3.82	2.20	0.25	32	157	6	174	910	243	5.8	0.90
26	V	D	sG	3.67	2.48	0.27	35	200	13	129	380	184	1.9	1.55
53	MK	A	mG	3.24	2.77	0.40	66	124	3	245	680	261	5.5	0.51
60	MK	A	mG	3.89	2.56	0.33	43	106	4	—	—	367	—	—
64	I	A	aG	3.05	3.52	0.37	28	67	2	145	2000	455	29.9	0.46
77	V	D	mG	4.28	2.47	0.16	20	146	2	170	1290	293	8.8	0.86
87	V	D	mG	3.50	2.78	0.49	13	94	—	—	—	372	—	—
90	VF	C	mG	2.99	2.64	0.18	33	105	2	—	—	285	—	—
95	V	D	aG	3.09	2.73	0.46	21	95	2	350	890	325	9.4	0.27
2/2														
4	NT	C	GD	3.07	2.97	0.33	5	121	4	480	400	254	3.3	0.25
18	I	A	mG	2.87	2.70	0.33	52	104	4	166	620	276	6.0	0.63
22	VT	B	GD	2.71	3.06	0.42	21	62	3	480	500	437	8.1	0.13
24	NT	C	GD	3.27	2.82	0.46	71	145	6	350	355	226	2.5	0.41
30	VT	B	GD	2.14	2.97	0.51	22	62	4	—	1040	343	16.7	—
47	VT	B	GD	1.61	2.77	0.47	19	32	4	470	870	310	16.7	0.11
48	MK	A	GD	2.61	3.26	1.15	43	99	3	316	710	264	7.2	0.31
50	MK	A	GD	2.55	3.01	0.26	89	85	3	288	760	300	8.9	0.30
51	MK	A	sG	2.45	3.42	0.65	62	88	2	—	—	278	—	—
67	V	D	mG	3.11	2.60	0.40	20	95	2	490	890	327	9.4	0.19
70	VT	B	T	1.88	2.79	0.66	17	49	—	440	1260	384	25.7	0.11
71	VT	B	GD	2.66	2.67	0.37	22	55	2	490	1350	484	24.5	0.11
72	V	D	GD	2.49	2.39	0.72	32	69	3	440	1660	361	24.1	0.16
76	V	D	mG	3.72	2.71	0.39	16	105	2	245	1200	354	11.4	0.43
93	Ž	C	mG	2.49	2.64	0.19	36	69	—	—	—	361	—	—
94	MK	A	mG	2.66	3.15	0.26	117	118	7	—	—	225	—	—
96	VT	B	mG	2.39	2.80	0.60	22	83	2	525	1480	290	17.9	0.16
111	VT	B	mG	2.73	3.10	0.51	33	69	2	302	690	396	10.0	0.23
126	V	D	—	—	—	—	94	126	5	—	—	—	—	—

Continuation of Tab. 1

No	Mts	Reg	Mes	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
							3.1							
3	NT	C	GD	2.97	2.73	0.66	38	121	5	182	540	245	4.5	0.66
105	HUN	F	aG	4.03	2.46	0.39	62	198	—	141	316	204	1.6	1.40
106	HUN	F	aG	4.03	2.41	0.46	39	184	7	110	440	219	2.4	1.67
107	HUN	F	aG	4.42	2.19	0.33	14	134	—	42	251	330	1.9	3.19
109	HUN	F	mG	3.94	2.23	1.11	18	124	5	340	910	318	7.3	0.36
110	HUN	F	sG	3.84	2.26	0.72	26	123	10	430	1380	312	11.2	0.29
112	V	D	sG	3.49	2.34	0.66	29	129	3	540	1230	271	9.5	0.24
							3.2							
10	V	D	GD	2.69	2.74	0.68	26	72	4	440	1410	374	19.6	0.16
11	ČH	D	GD	2.37	3.04	1.04	24	72	4	370	1070	329	14.9	0.19
14	NT	C	GD	3.15	2.49	0.55	36	92	6	410	1260	342	13.7	0.22
21	MF	B	GD	2.85	3.06	0.33	17	68	2	430	420	417	6.1	0.16
25	NT	C	mG	2.52	2.91	0.94	91	100	8	430	720	253	7.2	0.23
29	V	D	mG	2.99	2.64	0.38	13	82	3	350	380	365	4.6	0.23
36	MF	B	sG	2.21	3.23	0.14	21	69	3	—	1350	320	19.6	—
38	MF	B	T	2.06	2.60	0.68	17	60	5	—	—	343	—	—
40	VT	B	T	1.54	3.12	0.48	20	46	4	600	350	335	7.6	0.08
52	MK	A	aG	1.87	3.52	0.40	33	49	2	510	830	382	16.9	0.10
56	V	D	GD	3.15	2.49	1.75	20	106	5	14	390	297	3.7	7.57
58	V	D	GD	2.52	2.97	0.59	47	110	5	400	340	229	3.1	0.28
62	Ž	C	mG	3.28	2.93	0.39	41	92	5	245	1070	357	11.6	0.38
73	V	D	GD	1.76	2.43	0.42	18	73	2	159	390	243	5.4	0.46
74	V	D	GD	2.95	3.19	0.54	44	88	3	370	400	337	4.6	0.24
79	V	D	mG	3.17	2.78	0.45	81	129	6	340	1100	246	8.5	0.38
80	VF	C	GD	2.18	3.38	0.87	49	78	4	490	1070	281	13.8	0.16
81	MF	B	T	1.53	2.58	0.75	16	49	3	420	1290	312	26.3	0.12
86	V	D	GD	1.74	3.07	1.09	18	62	—	370	540	281	8.7	0.17
89	B	B	T	1.81	2.41	1.80	15	78	3	—	—	241	—	—
92	NT	C	mG	3.87	2.63	0.45	48	114	3	—	—	339	—	—
97	MF	B	GD	2.29	3.39	0.75	29	80	3	740	870	286	10.9	0.11
98	MF	B	mG	2.37	3.06	0.91	26	71	2	890	980	334	13.8	0.08
99	MF	B	mG	2.52	3.22	0.77	23	78	2	650	955	325	12.3	0.12

Continuation of Tab. 1

No	Mts	Reg	Mes	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
103	S	A	mG	1.81	3.49	0.60	21	61	1	440	930	297	15.2	0.14
104	S	A	mG	2.37	2.46	0.48	16	52	2	350	740	460	14.4	0.15
117	NT	C	mG	2.64	3.41	0.90	70	100	4	560	1150	264	11.5	0.18
120	NT	C	GD	3.36	3.16	0.80	87	118	6	430	770	285	6.5	0.27
124	V	D	GD	2.32	3.16	0.74	25	85	3	510	1290	273	15.2	0.17
127	V	D	GD	2.25	3.41	1.16	30	85	3	480	1010	265	11.9	0.18
							4/1							
5	MK	A	GD	2.37	3.26	0.91	33	68	5	—	1150	349	16.9	—
49	MK	A	mG	3.49	0.13	0.46	20	173	2	15	390	202	2.3	11.93
84	V	D	aG	2.77	2.85	0.50	25	83	2	44	490	336	5.9	1.88
102	S	A	aG	4.23	2.66	0.27	12	109	2	83	350	388	3.2	1.31
113	MF	B	T	1.72	3.97	0.64	41	63	3	910	890	273	14.1	0.07
114	MF	B	GD	1.83	4.08	0.62	19	48	3	790	430	381	9.0	0.06
115	MF	B	GD	1.83	3.77	0.66	41	55	3	730	1040	333	18.9	0.08
118	V	D	T	1.83	3.32	1.00	25	50	3	830	1230	366	24.6	0.06
							4/2							
1	NT	C	T	2.13	3.23	1.27	—	44	—	—	910	484	20.7	—
7	V	D	T	2.21	2.97	1.42	30	70	6	—	—	316	—	—
12	ČH	D	T	2.08	3.15	1.15	38	55	3	790	1820	378	33.1	0.07
20	VF	C	T	2.22	3.01	0.93	32	97	8	—	680	229	7.0	—
28	V	D	T	2.17	3.01	0.97	26	67	4	—	1290	324	19.3	—
37	MF	B	GD	1.37	3.59	0.67	17	37	2	—	670	370	18.5	—
46	VT	B	T	1.63	3.26	0.48	20	46	5	600	760	354	16.5	0.08
57	V	D	T	2.36	2.52	1.03	27	102	5	10	1480	231	14.5	10.20
75	V	D	T	1.70	3.15	1.23	—	—	—	650	1350	—	—	—
78	NT	C	GD	2.08	3.08	0.94	29	60	3	540	2090	346	34.8	0.11
82	V	D	T	1.76	2.49	1.20	21	53	3	620	1700	332	32.1	0.09
83	V	D	T	1.81	2.39	1.04	30	61	3	575	1660	297	27.2	0.11
88	V	D	T	1.36	2.54	1.25	25	53	3	—	—	259	—	—
121	V	D	T	2.40	3.77	1.48	35	70	3	910	1550	343	22.1	0.08

Continuation of Tab. 1

No	Mts	Reg	Mes	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
							E							
13	SGR	E		3.20	0.15	1.18	58	310	17	10	141	103	0.46	31.00
33	SGR	E		3.52	2.28	0.05	195	465	32	89	34	76	0.17	5.22
34	SGR	E		3.59	2.57	0.04	103	288	15	47	340	125	1.18	6.12
35	SGR	E		3.82	2.66	0.08	124	403	13	101	50	94	0.12	3.99
61	SGR	E		3,74	2.74	0.21	61	430	12	17	72	87	0.18	25.29

Explanations: No — number of sample; Mts. mountain range (region); MK — Malé Karpaty; I — Inovec; S — Suchý; M — Malá Magura (regional mountain group A); VT — Vysoké Tatry; MF — Malá Fatra; B — Branisko (reg. mountain group B); VF — Veľká Fatra; NT — Nízke Tatry; Ž — Žiar; T — Tríbeč (reg. mountain group C); V — Veporides; ČH — Čierna Hora (regional group D); SGR — Spišsko-gemerské rudohorie (reg. group E); HUN — Hungarian People Rep. (reg. group F); Reg — column of groups of mountains or regions.
A = West Slovakian region (mountain group); B = North Slovakian region (mountain group); C = Central Slovakian region (mountain group); D = Veporides (group of mountains belonging to the Veporide crystalline complex); E = region of the Spišsko-gemerské rudohorie Mts.; F = Hungary, region of the Velence and Mecsek Mts. In the interspaces division according to modal composition; symbols 1/1 to 4/2 in accord with the proposal of the IUGS Subcommission (1973).
1/1 — leucogranites, 1/2 — leucogranodiorites, 2/1 — muscovite-biotite granites, 2/2 — muscovite-biotite granodiorites, 3/1 — biotite granites, 3/2 — biotite granodiorites, 4/1 — leucotonalites, 4/2 — biotite tonalites "Mes". Classification after the mesonormative calculation (Mielke — Winkler, 1979). aG — alkaline granite, sG — syenogranite, mG — monzogranite, GD — granodiorite, T — tonalite.

absorption spectrometric method. Ionizing interferences in determination of Rb and Cs were eliminated by adding spectroscopically pure potassium chloride.

The instrument used for the determination of Li, Rb and Zn was the atomic absorption spectrophotometer Perkin-Elmer 303, with a graph recorder. Cs was determined using a Varian 1200 spectrophotometer (Geol. prieskum, Spišská Nová Ves). For atomization an acetylene-air flame was employed and a discharge lamp with a hollow cathode as a source of flame excitation (Li, Cs, Zn). To determine Rb a spectral discharge lamp with a filter was applied having the absorption edge of about 650 nm. The wavelengths used: Li — 670.8 nm, Rb — 780 nm, Cs — 852 nm and Zn — 213.7 nm. Calibration solutions for the determination of elements were prepared from spectrally pure chemicals of Johnson-Mathey Comp., or 99.999 % metallic Zn, Koch-Light.

The correctness of determination was checked using standard reference materials G—2 GSP—1 (USGS) and GM (ZGI). The accuracy of analyses was controlled by repeated measurements.

Table 1 provides basic data on the contents of the elements studied from all analysed granitoid samples of the West Carpathians. The elements are included in the so-called "ZK" set, dealt with in greater detail in C a m b e l et al., 1982. The data are arranged on the basis of modal classification in agreement with international principles established by the IUGS Subcommission (1973).

The granitoid groups in which the fluctuation of the contents of individual elements was studied have been arranged according to different criteria, as seen in Tables 1 and 2. The following conclusions could be drawn from the evaluation results:

In the groups divided on the basis of modal composition (Table 1) the potassium contents are discretely higher in granites (1/1, 2/1, 3/1 — ratios with number one in denominator) than in granodiorites (1/2, 2/2, 3/2 — ratios with number two in denominator). In contrast, sodium, which predominates over potassium in the normal granodiorite types, does not increase in amount substantially with the basicity of rocks, being relatively unchanged. Potassium content drops rapidly with the increasing basicity. Magnesium displays an opposite tendency, increasing systematically from granites through granodiorites towards tonalites.

In the groups arranged according to the mesonorm, the potassium content decreases systematically from alkaline granitoids towards tonalites; sodium content remains at the same level or decreases slightly in monzogranites and syenogranites. Magnesium rises systematically (decreasing slightly in the monzogranite group).

The largest K contents and the lowest Na and Mg contents have been found in the granitoids of the Spišsko-gemerské rudohorie Mts., and in the granitoids of the Velence and Meczek Mts. in Hungary (for detailed information see C a m b e l et al., in print). The samples from Hungary were obtained through the kindness of Dr. B. J a n t s k y, and are studied in cooperation with the Geochemical Research Institute of the Hungarian Acad. Sci., Budapest.

Detailed investigations issue from the works of J a n t s k y (1979, 1980) and B u d a (1969, 1973). The Hungarian granitoids, especially their accessory minerals are studied by G b e l s k ý and H a t á r, 1982. The mountain ranges of the Tatro-Veporides and the groups of the Core mountains consist of granitoids with similar contents of K, Na and Mg. Only the North Slovakian granitoid complex (VT—MF+B) forms a group having the lowest mean K content (2.28), the highest mean Na content (3.11) and relatively high Mg (0.58). These facts also affect the contents of trace elements in the rocks of this mountain group.

Table 2a

Basic statistical evaluation of alkali contents in the West Carpathian granitoids. (a — modal classification)

		K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
	n	115	115	115	116	115	108	116	101	114		
	A	2.78	2.92	0.59	30.9	91.8	3.60	356	857	325		
	S	0.78	0.52	0.40	22.3	39.7	1.88	229	442	72		
	G	2.66	2.83	0.47	24.9	84.8	3.20	232	725	316		
1/1	n	16	16	16	16	16	16	13	13	16	13	13
	A	3.46	2.96	0.29	13.8	113	2.75	149	595	347	7.04	3.54
	S	0.83	0.62	0.31	7.7	61	1.44	136	338	95	4.44	6.26
	G	3.33	2.91	0.24	12.2	101	2.36	89	482	331	3.37	1.12
1/2	n	10	10	10	10	10	10	10	10	10	10	10
	A	2.80	3.14	0.49	31.7	86.1	3.70	287	619	359	9.06	0.50
	S	0.32	0.53	0.59	31.4	33.5	1.64	174	371	97	6.83	0.47
	G	2.78	3.10	0.33	24.0	81.0	3.40	238	472	345	5.86	0.34
2/1	n	12	12	12	12	12	11	9	9	12	9	9
	A	3.34	2.79	0.32	28.7	112	3.91	199	976	320	11.08	0.69
	S	0.52	0.38	0.14	15.8	40	3.24	95	561	76	10.50	0.41
	G	3.30	2.77	0.28	23.6	106	3.23	181	835	311	7.76	0.59
2/2	n	18	18	18	19	19	17	14	15	18	15	14
	A	2.64	2.88	0.48	41.7	87.2	3.41	392	919	326	12.8	0.25
	S	0.49	0.26	0.22	31.1	27.6	1.50	112	400	71	7.65	0.15
	G	2.59	2.87	0.44	32.1	83.1	3.14	374	834	319	10.50	0.22
3/1	n	7	7	7	7	7	5	7	7	7	7	7
	A	3.82	2.37	0.61	32.3	144	6.00	255	724	271	5.49	1.12
	S	0.46	0.18	0.26	16.1	32	2.65	184	452	50	3.88	1.07
	G	3.79	2.37	0.57	29.0	142	5.55	191	603	267	4.26	0.74
3/2	n	30	30	30	30	30	29	26	27	30	27	26
	A	2.47	2.97	0.73	34.1	80.6	3.66	438	855	314	11.4	0.48
	S	0.59	0.35	0.37	22.0	21.4	1.59	171	348	54	5.59	1.45
	G	2.41	2.94	0.64	28.9	78.0	3.33	378	775	309	10.00	0.22
4/1	n	8	8	8	8	8	8	7	8	8	8	7
	A	2.51	3.01	0.63	27.0	81.1	2.88	486	746	329	11.9	2.20
	S	0.93	1.27	0.24	10.5	42.2	0.99	414	369	62	8.04	4.35
	G	2.38	2.25	0.59	25.1	73.8	2.75	219	564	322	9.01	0.35
4/2	n	14	14	14	12	13	12	8	12	13	11	7
	A	1.95	3.01	1.08	31.7	62.7	4.00	587	1330	328	22.3	1.53
	S	0.34	0.41	0.27	16.9	19.1	1.71	264	476	68	8.65	3.82
	G	1.92	2.93	1.04	29.0	60.2	3.72	390	1242	322	20.54	0.17

According to Tables 1, 2 and in particular after the modal classification of granitoids, the behaviour of Li, Rb and Cs in the granite group (1/1, 2/1, 3/1) differs from that in the granodiorites (1/2, 2/2, 3/2). The content of Li decreases in granites and increases in granodiorites. The Rb and Cs contents increase

Table 2b

Basic statistical evaluation of alkali contents in the West Carpathian granitoids (b — mesonorm classification)

		K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
aG	n	18	18	18	18	18	16	15	15	18	15	15
	A	3.60	2.97	0.30	21.1	125	2.69	136	597	324	6.93	3.45
	S	0.70	0.60	0.12	14.4	60	1.40	139	490	95	7.88	5.78
	G	3.52	2.93	0.27	17.1	114	2.44	86	447	309		
sG	n	9	9	9	9	9	9	7	8	9	8	7
	A	3.34	2.69	0.54	26.4	114	5.22	260	877	305	8.44	0.74
	S	0.66	0.42	0.41	15.5	37	3.73	179	457	67	5.77	0.52
	G	3.28	2.66	0.42	23.1	110	4.35	207	757	298	5.75	0.58
mG	n	36	36	36	36	36	34	30	30	36	30	30
	A	2.94	2.81	0.47	34.4	95.4	3.38	311	307	327	9.77	0.84
	S	0.65	0.61	0.38	28.8	32.7	1.91	192	354	70	5.37	2.15
	G	2.85	2.62	0.37	25.6	89.8	2.88	239	701	319	8.53	0.37
GD	n	31	31	31	31	31	30	29	31	31	31	29
	A	2.55	3.00	0.66	33,8	81.3	3.67	414	872	327	12.20	0.50
	S	0.46	0.35	0.33	19.4	23.5	1.21	154	433	72	7.75	1.37
	G	2.51	2.98	0.59	29.2	78.3	3.47	360	771	320	9.36	0.22
T	n	19	19	19	17	18	16	12	15	18	14	11
	A	1.91	2,96	1.02	28.5	61.8	4.00	613	1215	322	20.8	1.01
	S	0.30	0.45	0.35	15.8	16.7	1.46	250	419	63	8.14	3.05
	G	1.88	2.93	0.96	25.8	60.0	3.80	457	1127	316		

in granites and granodiorites, but they decrease again in the tonalite group. In the rock groups arranged on the basis of the mesonormative classification, these trends are still more pronounced; in addition a small but systematic increase in Li and Mg with basicity and a slight decrease of these elements in the tonalite group are observed. In contrast, Rb decreases systematically (from 125 ppm in "aG" to 60 ppm in "T") and Cs increases haphazardly in "aG" and "sG" (from 2.69 to 4.35) and then decreases slightly and irregularly in the "mG", "GD" and "T" groups.

In regional classification (according to mountain ranges) only the North Slovakian group of Core mountains (VT, MF, B) is characterized by low Li, Rb and Cs contents. The granitoids of the Spišsko-Gemerské rudohorie Mts. have unusually low Li and high Rb and Cs contents. The analysis of five samples did not show any substantial difference between the Permian and Permian-Cretaceous Gemeride granitoids. The granitoid samples from Hungarian mountain ranges have similar but less high contents of these elements.

In general, the Tatro-Veporide granitoids display extraordinarily low contents, especially of Rb; they vary between 63 ppm (B) and 97 ppm (A,D) in the individual groups. This low Rb content and high barium and strontium contents may be regarded as a characteristic feature of the Variscan granitoids of the West Carpathians. The Ba content reaches 573 ppm in region A and 928 ppm

Table 2c

Basic statistical evaluation of alkali contents in the West Carpathian granitoids (c — regional units)

		K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
MK+ I+ S+M	n	21	21	21	21	21	21	17	18	21	18	17
	A	2.87	3.03	0.49	42.7	97.8	3.33	199	729	313	9.89	1.40
	S	0.61	0.82	0.45	31.8	33.2	1.62	140	477	78	8.71	2.78
	G	2.82	2.70	0.38	33.0	92.4	2.99	149	573	304	6.35	0.62
VT+ MF+ B	n	25	25	25	25	25	24	19	22	25	22	19
	A	2.28	3.11	0.58	22.7	63.2	2.96	575	892	361	15.1	0.12
	S	0.68	0.48	0.31	7.5	14.7	1.04	170	339	63	6.28	0.04
	G	2.19	3.08	0.51	21.6	61.6	2.77	552	823	356	13.80	0.11
VF+ NT+ Ž+T	n	24	24	24	23	24	22	17	19	24	19	17
	A	2.98	2.87	0.54	36.6	94.6	4.18	336	851	325	13.9	0.37
	S	0.73	0.39	0.38	27.0	25.1	1.92	151	415	68	17.0	0.22
	G	2.88	2.85	0.42	27.1	90.7	3.68	300	769	318	8.64	0.31
V+ ČH	n	40	40	40	40	40	38	36	37	39	33	32
	A	2.75	2.85	0.69	26.3	97.4	3.52	341	928	314	11.1	2.04
	S	0.76	0.39	0.42	17.3	48.8	2.03	243	493	74	8.18	4.60
	G	2.65	2.83	0.55	22.6	88.8	3.14	208	763	305	7.82	0.46
SGR	n	5	5	5	5	5	5	5	5	5	5	5
	A	3.57	2.08	0.31	108	379	18.8	52.8	127	97	0.42	14.3
	S	0.24	1.09	0.49	56	77	7.7	41.2	126	18	0.44	12.8
	G	3.57	1.45	0.13	98	373	17.7	37.3	90	96	0.29	10.00
HUN	n	5	5	5	5	5	5	5	5	5	5	5
	A	4.05	2.31	0.60	31.8	153	7.33	213	659	277	4.88	1.38
	S	0.22	0.12	0.32	19.4	36	2.52	164	478	60	4.23	1.18
	G	4.05	2.31	0.54	27.5	149	7.05	157	535	271	3.59	0.95

Explanations: n — number of samples in a set; A — arithmetic mean; S — standard deviation; G — geometrical mean. The first mean values relate to the whole set; the values are calculated without Gemeride granitoids. For other symbols see Table 1.

in region D; the Sr content ranges from 199 ppm in region A to 851 ppm in region B. These findings are of particular petrogenetic importance.

The Sr content increases systematically with the basicity of the rock to culminate in tonalites (149 ppm in leucogranitoids — 1/1 and 587 ppm in tonalites — 4/2). The mean Ba contents increase analogously, from 595 ppm in 1/1 to 1330 in 4/2. The contents of these elements are lower in granites than in granodiorites, as is seen from the Table of element contents compiled on the basis of modal classification.

On the regional basis, mean contents of Sr and Ba are exceptionally high in the North Slovakian group (VT, MF, B), i.e. 575 ppm for Sr and 892 ppm in Ba. The lowest contents of Sr (149 ppm) and Ba (729 ppm) have been found in the granitoids of the West Slovakian mountain group. The Ba contents correspond to a high degree with the behaviour of Sr contents, i.e. they concurrently decrease or increase. The granitoids of the Spišsko-gemerské ru-

Table 3

Correlation matrix of alkali contents and mineral composition of all rocks studied (without Gemeride granites)

	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Qz	Kf	Plg	Bi	Mu
K		—.41	—.36	——	+.55	+.25	—.62	—.37	——	+.28	+.75	—.70	—.45	+.32
Na			——	——	—.38	—.32	+.37	——	+.28	——	——	——	——	——
Mg				——	—.26	——	+.38	+.33	——	—.50	—.49	+.52	+.54	—.37
Li					+.54	+.72	——	——	—.51	——	——	——	——	+.32
Rb						+.79	—.50	—.49	—.75	+.36	+.49	—.58	—.32	+.42
Cs							—.28	—.32	—.61	——	——	—.35	——	+.38
Sr								+.51	+.32	—.32	—.56	+.59	+.38	—.43
Ba									+.40	—.42	—.39	+.45	+.40	—.28
K/Rb										——	——	+.24	——	——
Qz											——	—.50	—.65	+.40
Kf												—.87	—.49	+.32
Plg													+.45	—.46
Bi														—.45
Mu														

Explanations: Only significant correlation coefficients are given. Qz — quartz, Kf — potassium feldspar, Plg — plagioclase, Bi — biotite, M — muscovite.

Table 4

Mean contents of alkalies in individual granitoid groups from the Malé Karpaty Mts.

Rock type	K	Na	Mg	Li	Rb	Cs	Sr	Ba	K/Rb	Ba/Rb	Rb/Sr
The Bratislava massif											
sG (5)	3.37	2.52	0.19	20.2	110.2	1.4	105.6	480.2	320	4.7	1.24
mg (24)	2.99	2.45	0.33	27	94	1.4	181	920	322	10	0.56
GD (10)	2.63	2.71	0.54	27.2	82.5	1.4	261	1078	322	13	0.32
The Modra massif											
mG (2)	2.90	2.02	0.53	24	65	1.1	453	695	468	12.1	0.14
GD (11)	2.09	2.86	0.54	17.6	58.2	1.4	681.4	1126.4	363	19.7	0.09

Table taken from the paper of Cambel et al. (1981), modified.

dohorie Mts. have the lowest contents of Ba (127 ppm) and Sr (only 52 ppm), which are much lower than those established in the rocks of the Hungarian mountain ranges Velence and Meczek (213 ppm Sr and 659 ppm Ba, on the average). These specific features differentiating the latter granitoids from the Gemeride and Variscan West Carpathian granitoids suggest different genetic conditions of their origin.

Worth of mentioning is the K/Rb ratio, which is of petrological importance. This ratio is high in the individual mountain groups and in regional units as well; there are only small differences in the individual ranges and groups. Low K/Rb ratios have been determined only in the granitoids of the Spišsko-gemerské rudohorie Mts. and relatively low in those of the Hungarian mountains. The above conclusions appear still more distinctly from the study of histograms and correlations of the elements. The individual rock types have been studied separately because we think it very important to recognize their assignment to the petrogenetic types of the West Carpathian granitoids. A brief evaluation of the chemistry of the rock samples, in relation to the principal Tatro-Veporide and Gemeride granitoids leads to the following conclusions:

1. The sample of the Turčok granite (ZK—16) in no case belongs to the granitoids of the Spišsko-Gemerské rudohorie Mts. and even partly differs from the Veporide granitoids.

2. Leucogranite from the Vydrovo valley near Čierny Balog has little Sr, a low K/Rb ratio and high Rb (ZK — 122.69); it stands near to the Gemeride granites, similarly as that of Lieskovec (69). The České Brezovo (19) and Hrončok (26) granite samples have increased Rb and K contents, but higher Ba and Sr than those of Gemerides, and thus are closer to the Veporide type.

3. The granitoid rocks of Podkriváň (Veporides) and the sample from the neighbourhood of Čierny Balog (ZK—121) show element contents typical of the Tatro-Veporide granitoids.

4. Granitoids of Rochovce and the leucocratic rock of Budiná locality (Veporides) do not differ from other Tatro-Veporide granitoids. For localization and description of samples see C a m b e l, B. et al. (in print).

Table 3 (correlation matrix) presents correlation between the elements and the mineral content of the rock. The correlation matrix reveals to what extent the individual minerals influence the contents of elements in the rock.

Table 4 provides the possibility of comparing the contents of alkalies in the granitoids of the Malé Karpaty (Little Carpathian) Mts. and the other mountain ranges of the West Carpathians. The fundamental geochemical features of the granitoids in all these mountain ranges show only small differences, which are most marked in the granitoids of the Malé Karpaty Mts.

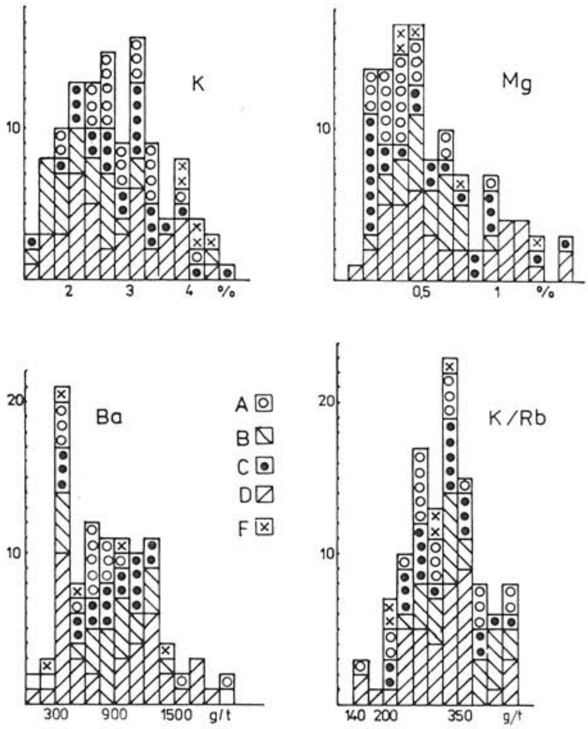


Fig. 1. Histograms of K, Mg, Ba contents and the K/Rb values in the set of samples, classified according to regional criteria.
A (West Slovakian group — MK, J, S + M); B (North Slovakian group — VT, MF, B); C (Central Slovakian group — NT, VF, T, Ž); D (Veporides — V); E (granitoids — Spišsko-gemerské rudohorie); F (Velence — Mecsek, MLR).

Interpretation of histograms and graphs

The distribution of elements in the granitoid rocks is shown objectively in histograms, in which the values reflect their frequency in the groups established according to the modal (IUGS 1973) or regional classification.

From the dispersion of the values of element contents it follows that the frequency distribution of the elements studied is relatively analogous in the granitoids of the Veporide and North Slovakian regions (VT, MF, B); the differences in the scatter of values in other mountain ranges are so small that, apart from the granitoids of the Spišsko-gemerské rudohorie and the Hungarian mountains, the frequency distribution does not differ essentially.

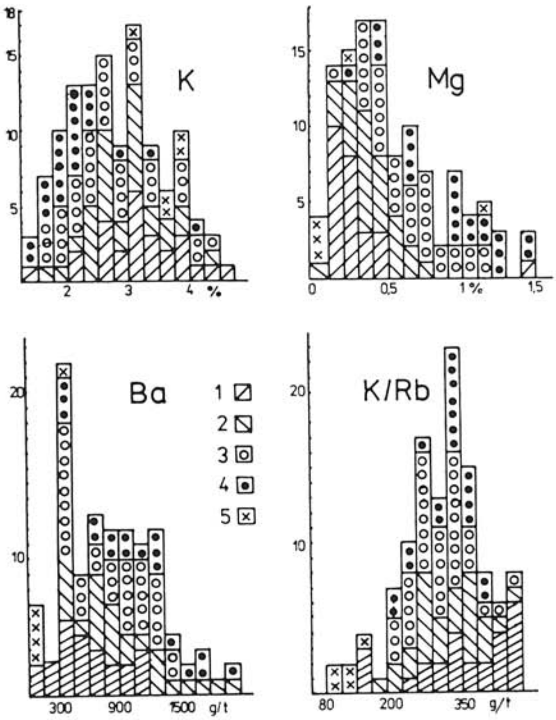


Fig. 2. Histograms of K, Mg, Ba contents and the K/Rb values in the set of samples, classified after the modal composition.
1 — leucocratic rocks; 2 — muscovite-biotite granitoids; 3 — biotite granitoids; 4 — tonalites; 5 — granitoids of the Spišsko-gemerské rudohorie (SGR).

The groups established on the basis of the modal IUGS classification occupy to a certain degree separate positions, as far as granites, granodiorites and tonalites are concerned, but in many cases the intervals of the individual groups overlap. Discretely different are the granitoids of the Spišsko-gemerské rudohorie.

A good survey of the distribution of the values of element contents are provided by the correlation graphs, which are also arranged according to the groups classified by regional, petrochemical (mesonorm) and modal (IUGS) criteria.

In the K:Na correlation graph (Fig. 7) the values of K/Na ratios are ranged according to the mountain groups. It shows that the North Slovakian (VT, MF, B) and Veporide /V/ granitoids have the lowest content of K and a widely varying Na content.

The highest K contents have been determined in the granitoids of the Spišsko-Gemerské rudohorie and the Hungarian mountains, occupying a separate position in the graph; they are also characterized by the low Na contents (2—2.8 %). All analysed samples from the West Carpathians (Tatrides and Ve-

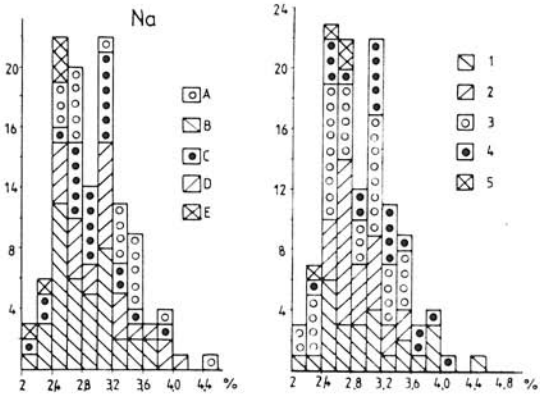


Fig. 3. Histograms of Na contents based on regional and modal classifications (for explanation see Figs. 1, 2).

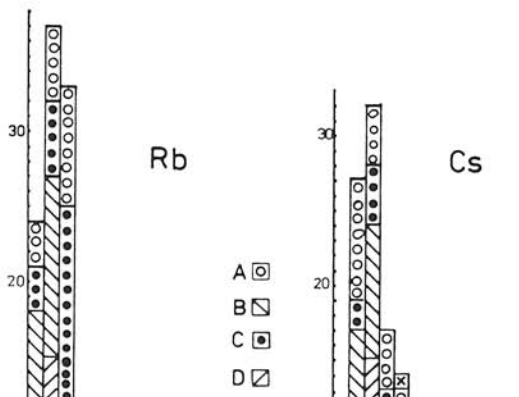


Fig. 4. Histograms of Cs and Rb contents in the set of samples based on regional criteria. For explanation see Fig. 2.

porides) constitute a common field showing a slight negative correlation, in which the projections of the K/Na points from the individual groups are interspersed.

In the K/Na graph (No. 8) compiled on the basis of mesonorm criterion (Mielke — Winkler, 1978) the interspersion of point projections is not so conspicuous. The lowermost layer is occupied by tonalites, higher up is a common field of the maximum occurrence of monzogranite and granodiorite, and the top layer is occupied by alkaline granites and syenogranites. A negative correlation trend is evident.

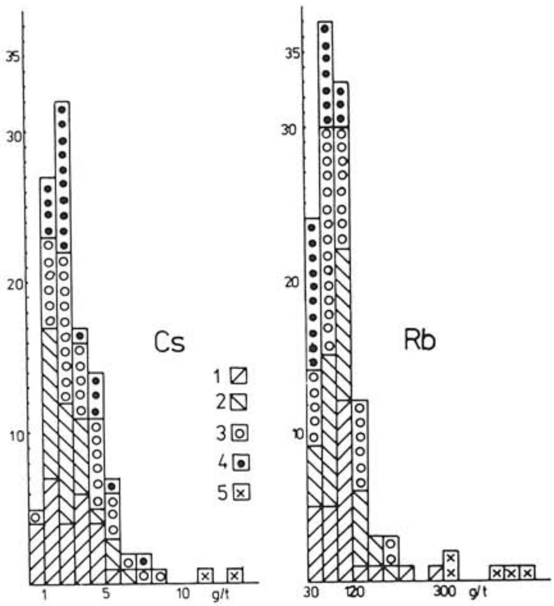


Fig. 5. Histograms of Cs and Rb contents in the set of samples, classified according to modal composition. For explanation see Fig. 2.

Of particular interest are the correlation graphs of the Rb:K ratios, evaluated according to the regional criterion (No.9), modal classification (No.10) and mesonormative classification (No.11). The graph of the K/Rb: Rb ratio is also illustrative.

From Fig. 9 it follows that the North Slovakian (VT, MF, B) granitoids occupy a field characterized by low K and Rb contents. The granitoids of Hungarian mountain ranges have higher contents of K and Rb, and the Gemeride granitoids have so high Rb contents that they do not lie on the straight line of positive Rb/K correlation of the West Carpathian and Hungarian granitoids. The leucocratic vein differentiates from the various regions of the West Carpathians are depicted by a special hachure. In contrast to the primary rock types, the straight line of the Rb/K correlation of these rocks has a high positive trend.

Fig. 10 shows that the scatter of the Rb/K ratio values increases from tonalites to acid granitoid differentiates, and in the transitional field the Rb/K values of granites (light-coloured hachure) and granodiorites (dark hachure) intermingle. For comparison, the Rb/K ratio is also presented in the graph compiled on the basis of mesonorm classification (Fig. 11). This graph makes it possible to delimit the fields of the projections of the ratio values for all basic classification types characterized according to mesonormative criterion. The graph 11 also reveals how much the fields of monzogranite, granodiorite and other rock types overlap. It is accounted for by an insufficient, faint dif-

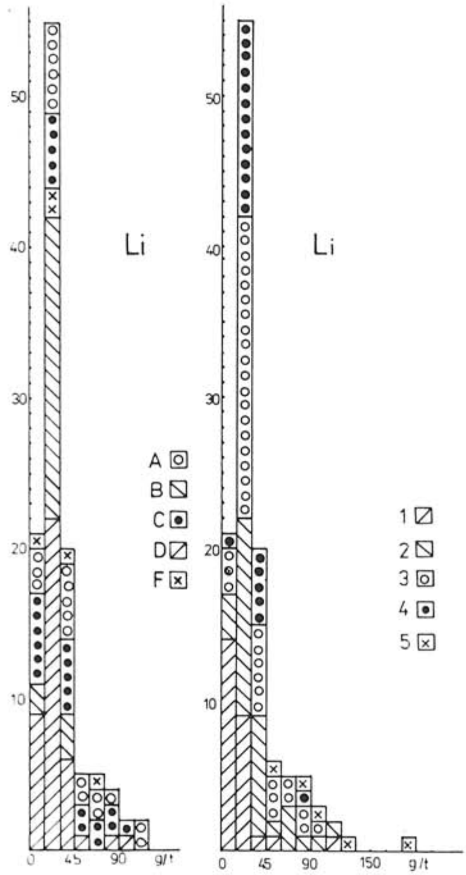


Fig. 6. Histograms of Li contents in the of samples classified according to regional (6 a) and modal (6 b) criteria. For explanation see Figs. 1, 2.)

ferentation of the palingenic magma from which the principal types of Variscan granitoids of the West Carpathians had developed. We can also regard it as evidence for analogous genesis of the Variscan granitoids that were formed by anatexis of rocks of similar lithology.

The scatter of values increases from the basic to leucocratic types, which can be interpreted in terms of differentiation and successive hypabyssal intrusions.

The graph of Rb: K/Rb ratio (Fig. 12) delimits the region of North Slovakian Core mountains as a prominent specific field (high K/Rb values and low Rb contents). The negative correlation of this ratio is pronounced.

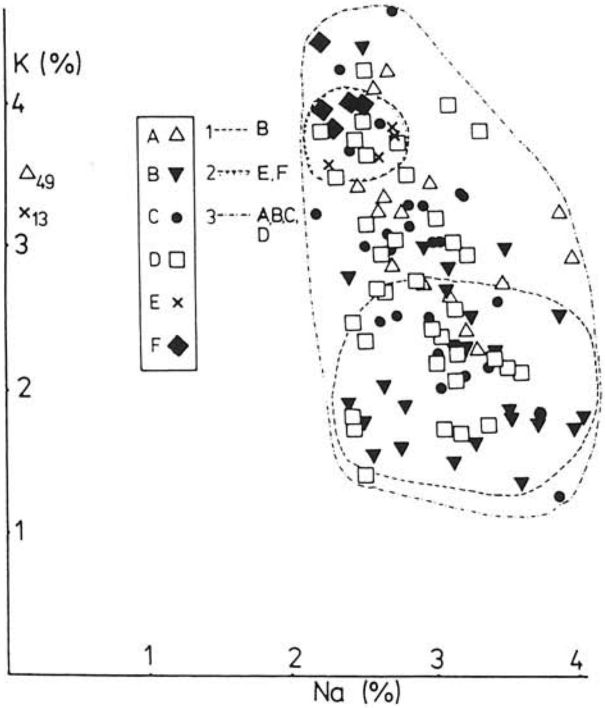


Fig. 7. Correlation graph of K:Na ratio.
The West Slovakian group: A — Malé Karpaty (MK), Inovec (I), Suchý (S) and Malá Magura (M). The North Slovakian group: B — Vysoké Tatry (VT), Malá Fatra (MF), Branisko (B). The Central Slovakian group: C — Veľká Fatra (VF), Nízke Tatry (NT), Žiar (Ž), Tribeč (T); D — granitoids the Veporides (V)., Čierna Hora (ČH); E — granitoids of the Spišsko-gemerské rudohorie (SGR); F — granitoids from Hungary (MLR).

According to the correlation graph Li/Rb (Fig. 13), there is no direct positive or negative relationship between these two elements in the Variscan granitoids of the West Carpathians. Only the samples of the granitoids from Hungary suggest a positive relationship; on the other hand, the projections of points of the Li/Rb ratio from the individual mountain ranges are concentrated in specific fields characteristic of certain regions. The North Slovakian region "B" and a greater part of samples from the Veporides constitute a common field of low Li and Rb values.

Graph no. 14 is based on the modal classification (IUGS—1973) of the groups. It shows distinctly that according to the Li/Rb ratio the Variscan granitoids of the West Carpathians are divisible into granites (lower part) and granodiorites (upper part). Blank squares in the upper part belong to leucotonalites. Tonalites occupy a particular field with low Rb contents, and leucogranitoids a field with low Li values. Samples with anomalous Rb or Li contents in graph no. 14 are numbered so that they can be evaluated separately. They proved to be mainly the granitoids of the Prašivá type from the Nízke Tatry (Low Tatra)

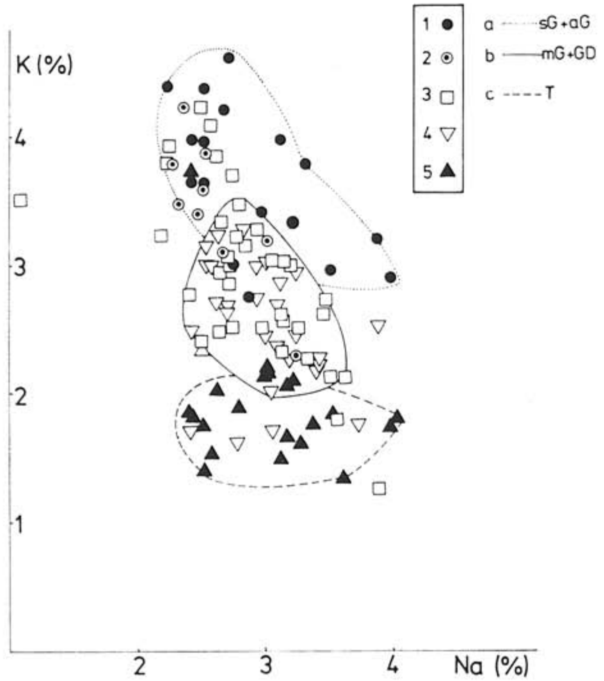
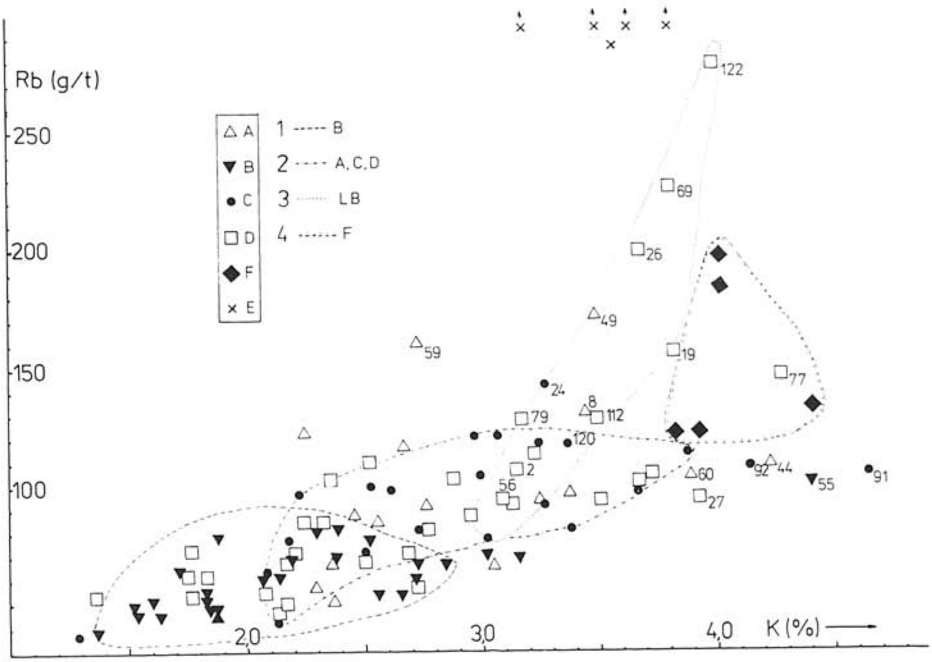


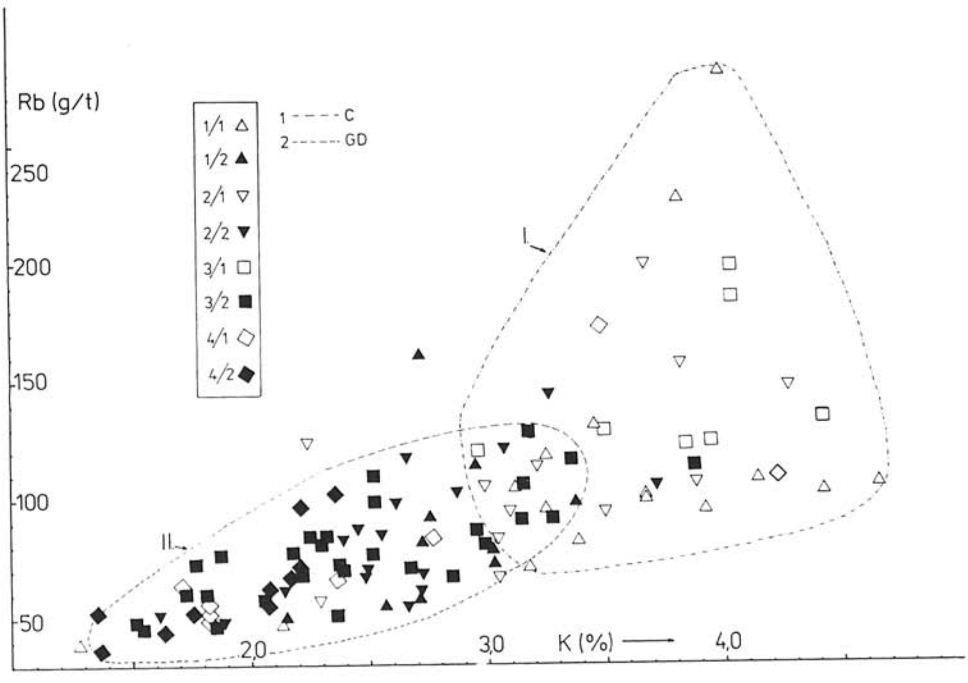
Fig. 8. Correlation K/Na graph of the West Carpathian granitoids, classified according to mesonorm.
1 = aG — alkaline granite, 2 = sG — syenogranite, 3 = mG — monzogranite, 4 = GD — granodiorite, 5 = T — tonalite, a = field sG + aG, b = field mG + GD, c = field T.

Mts. and some biotite-muscovite granitoids of the Malé Karpaty region (Devín quarry). Leucocratic rocks of the Veporides, however, lie below the line.

The graph of Sr/Rb ratio (Fig. 15) discretely differentiates the rock types. Tonalites and granodiorites occupy well delimited fields as do the alkaline granites (aG) and syenogranites (sG), but the Sr and Rb content values of monzogranites are widely scattered. The line of the projections of Sr/Rb points is of a asymptote character.

The correlation graph no. 16, based on regional classification, indicates a relatively separate position of the North Slovakian core mountains (VT, MF), and a broadly analogous Rb/Sr ratio in the granitoids of the Nízke Tatry (Low Tatra) in the Central Slovakian group and of the West Slovakian group. The rocks of the Veporides are dispersed over the whole graph area. The granites


Rb (g/t)
250
200
150
100
2,0
3,0
4,0
K (%)
A
B
C
D
F
E
1 B
2 A, C, D
3 LB
4 F
122
69
26
49
59
19
77
24
8
112
79
120
2
56
60
27
92
44
55
91


Rb (g/t)
250
200
150
100
50
2,0
3,0
4,0
K (%)
1/1
1/2
2/1
2/2
3/1
3/2
4/1
4/2
1 C
2 GD
I
II

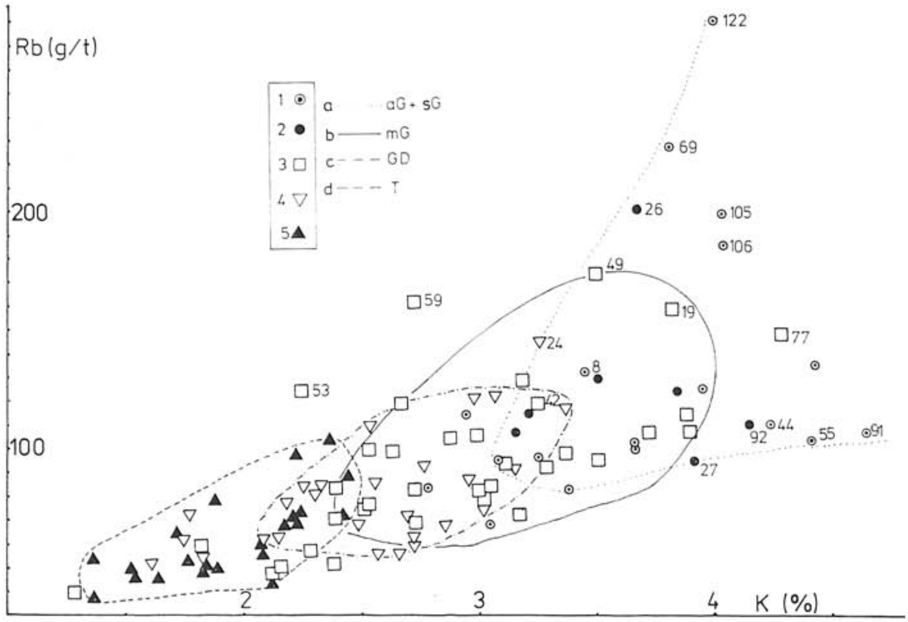


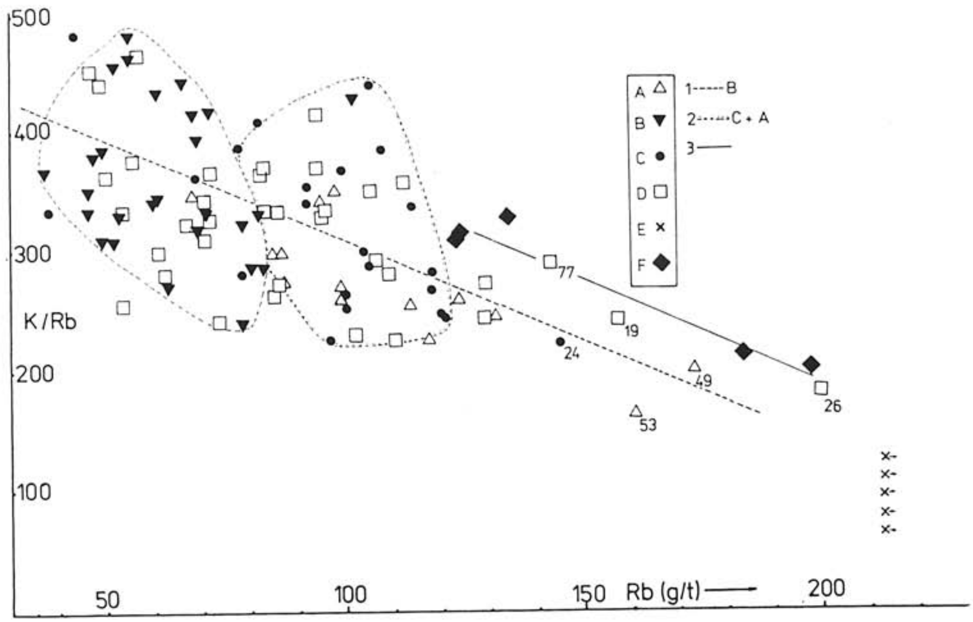
Fig. 9. Correlation graph of Rb: K ratio, compiled according to regional criteria. 1 — North Slovakian group (VT + MF), 2 — granitoids of other mountain ranges (A, C, D), 3 — field of dyke differentiates, 4 — field of Hungarian granitoids (MLR). Numbers with some projection points = numbers of samples.

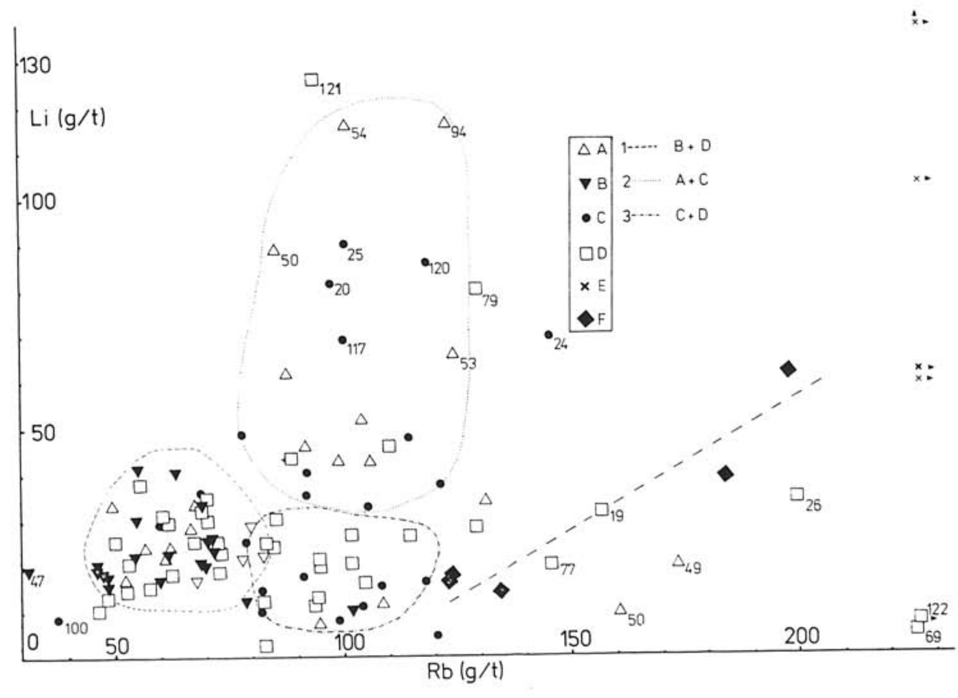
Fig. 10. Correlation graph of K:Rb ratio constructed on the basis of modal classification.
1/1 — leucogranite, 1/2 — leucogranodiorite, 2/1 — muscovite-biotite granite, 2/2 — muscovite-biotite granodiorite, 3/1 — biotite granite, 3/2 — biotite granodiorite, 4/1 — leucotonalite, 4/2 — biotite tonalite. 1 — field of granites, 2 — field of granodiorites and zonalites.

Fig. 11. Correlation graph of K:Rb ratio constructed on the basis of mesonormative classification of rocks.
a = field aG + sG — alkaline granite + syenogranite, b = field mG — monzogranite, c = granodiorite — GD, d = field T — tonalite. 1 = sG — syenogranite, 2 = aG — alkaline granite, 3 = mg — monzogranite, 4 = GD — granodiorite, 5 = T — tonalite.

of the Gemerides and part of the Hungarian granites show a separate distribution.

The correlation graph of Sr/Ba ratio (Fig. 17) compiled according to the modal classification shows that the Sr and Ba contents in granites are lower than in granodiorites, being the lowest in the granitoids of the Spišsko-gemerské rudohorie Mts. Granodiorites and tonalites display a broad range of contents, e.g. for barium it is 300 to 1300 ppm. The same also applies to leucotonalites. Graph no. 17 shows fields of the Gemeride granitoids and some other leucocratic rocks. A faint positive correlation between Sr and Ba is observable in both


K/Rb
Rb (g/t)
A △
B ▼
C ●
D □
E ×
F ◆
1------B
2.........C + A
3——


Li (g/t)
Rb (g/t)
△ A
▼ B
● C
□ D
× E
◆ F
1----- B + D
2 ...... A + C
3---- C + D

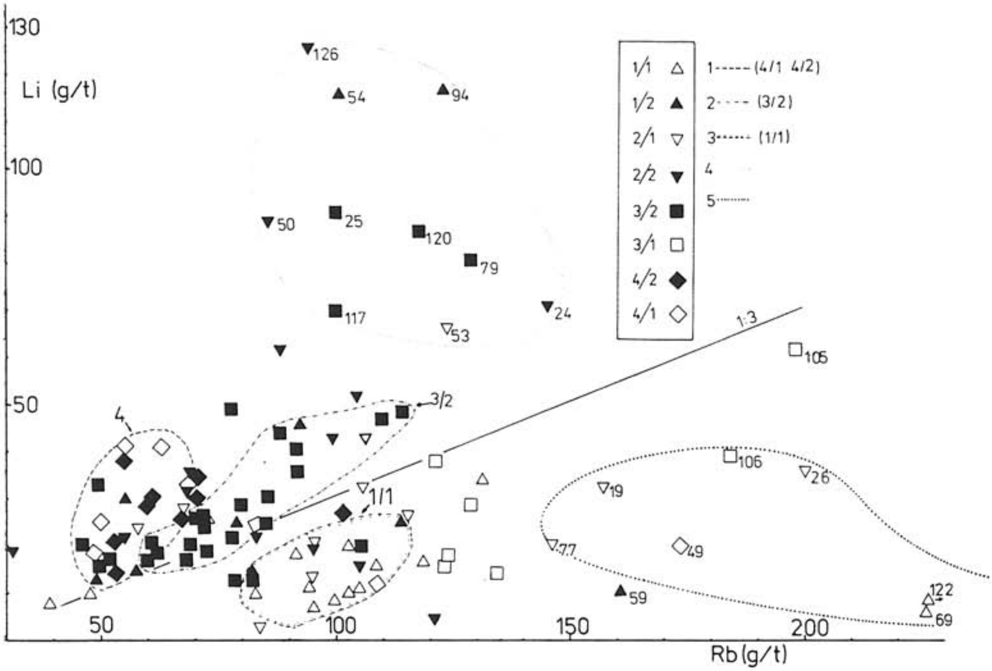


Fig. 12. Correlation graph of Rb: K/R ratio. Explanation as in Fig. 6. The granitoids of Hungary (MLR) lie on the upper straight line. The ratio values of the principal rock types of the West Carpathian Core mountains and of the Veporides are projected on the lower line. 1 = the region of VT, MF, B; 2 = C + A region.

Fig. 13. Correlation graph of Rb:Li ratio compiled from the sets ranged according to regional criteria. For explanation see Fig. 10. The values of Hungarian granitoids (MLR) are plotted on the straight line.

Fig. 14. Correlation graph of Rb:Li ratio constructed on the basis of modal classification. For explanation see Fig. 10. Straight line separates the projection points of granites (lower part) from granodiorites and tonalites (upper part). 1, 2, 3 — demarcation of fields in which several rock types are concentrated; 4 — leucocratic rocks of the Prašivá type from the Nízke Tatry Mts. and related rocks from the Malé Karpaty region; 5 — leucocratic rocks in the Veporide region.

the granite group and the granodiorite and tonalite group, and in the whole set of rocks as well.

From the graphs nos. 18 and 19 it follows that the Ba/Rb ratios are of less pronounced discrimination significance.

In graph no. 18 the projections of Ba/Rb points of the VT and MF rocks constitute a demarcated field. The rocks of the MK and NT form another separate group; the Gemeride granitoids and part of the granitoids of Hungary occupy another field. The Veporide rocks show the widest dispersion.

For the graph in Fig. 19 the mesonorm classification has been used. It shows that the Ba/Rb ratios only of tonalites and granodiorites (GD and T) have se-

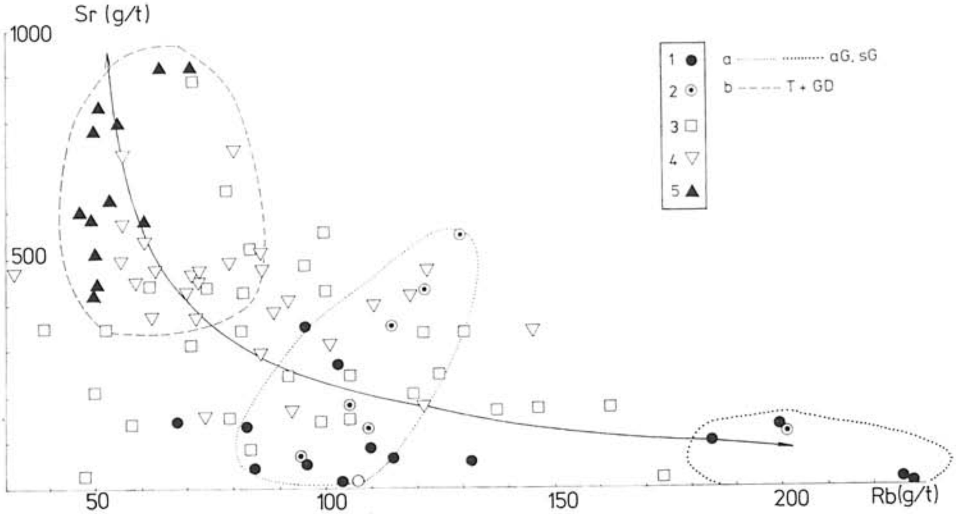


Fig. 15. Correlation graph of the Sr/Rb ratio — based on mesonormative classification. Explanation as in Fig. 11. a = alkaline syenogranites (aG + sG); b = tonalites + granodiorites (T + GD).

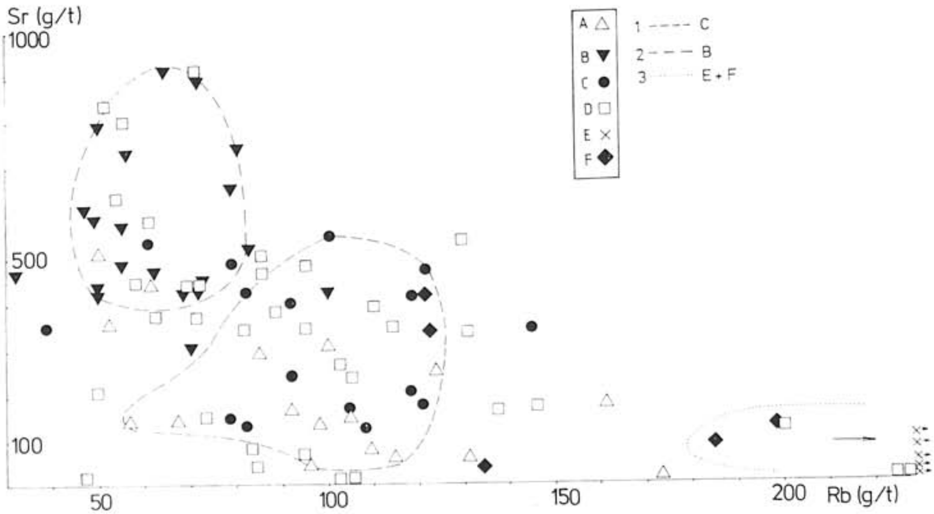


Fig. 16. Correlation graph of the Sr/Rb ratio — based on modal classification and regional criteria. 1 = West and Central Slovakian crystalline groups (A + C); 2 = North Slovakian group (VT, MF, B); 3 = SGR and MLR. For other explanation see Fig. 1.

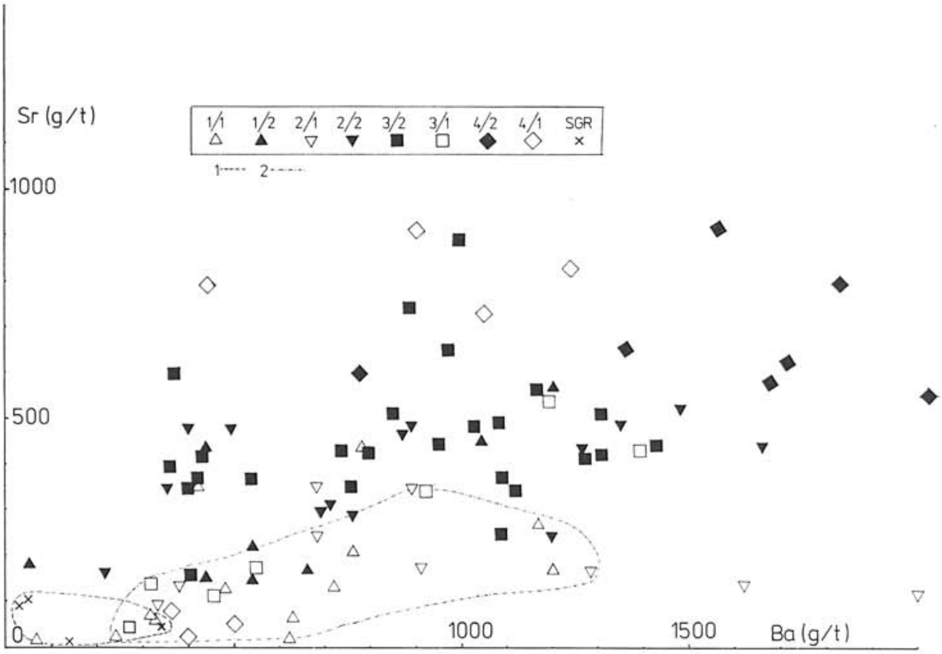


Fig. 17. Correlation graph of Sr/Ba ratio constructed on the basis of modal composition. For explanation see Figs. 2, 10. 1 = granitoids MLR and SGR; 2 = granitoids MLR and SGR and granites of the West Carpathians.

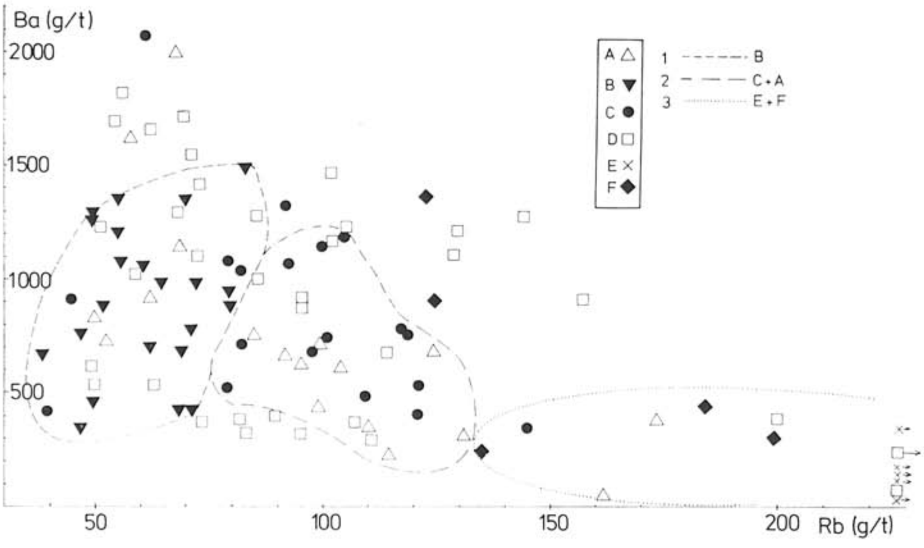


Fig. 18. Correlation Ba:Rb graph — set of rocks classified according to regional criteria. For explanation see Fig. 11.
1 = North and Central Slovakian groups (VT, MF, NT); 2 = West and Central Slovakian groups; 3 = SGR, MLR.

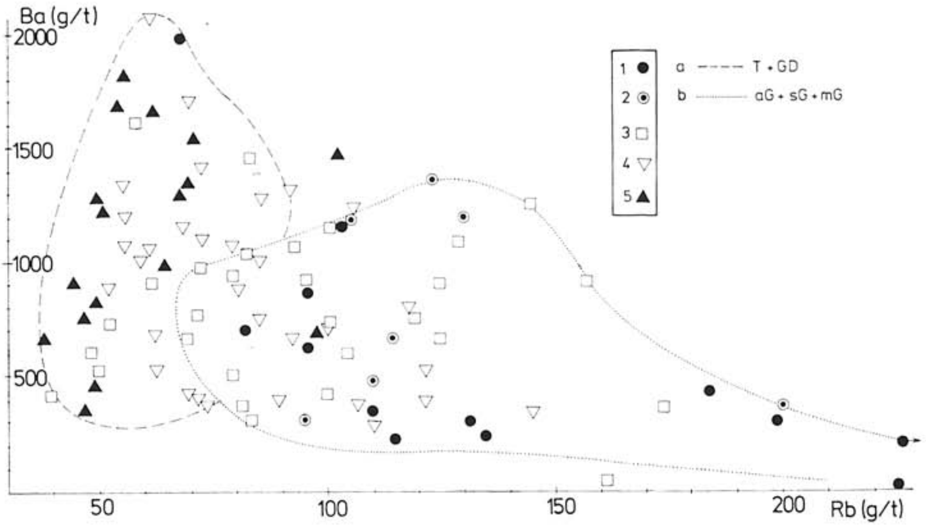


Fig. 19. Correlation graph of Ba:Rb ratios, based on mesonormative classification. For explanation see Fig. 11. a = tonalites (T) + granodiorites (GD); b = aG + sG + mG.

parate fields, the remaining rock types (aG, sG, mG) constitute a common field with a wide scatter of points, which terminates with the values of monzogranites and alkaline granites of the Spišsko-gemerské rudohorie, the Hungarian mountains, and some rock types of the Veporides.

In conclusion we draw attention to the considerable agreement of the arithmetic means of alkali contents from the Malé Karpaty Mts. (Table 4) and from other mountain ranges (Table 2). This accordance is the more important considering that another method to the analysis of alkalies (flame photommetry — IGFM, Kiev) was applied for the Malé Karpaty granitoids. The results have confirmed a geochemical-genetic relationship of these rocks with those of other West Carpathian mountain ranges.

Conclusion

The authors have evaluated the contents of alkalies in the granitoid rocks of the West Carpathians and five granitoid samples from the Velence and the Mecsek Mts. in Hungary (see the papers of Cambel et al., in print, and Gbelský et al., in print).

For the evaluation tabular, statistical and graphic (histograms and correlation graphs) methods have been used. The granitoid samples were classified from the regional, petrographical (modal) and petrochemical (mesonormative) points of view. Using this approach it was possible to characterize the granitoid types according to the alkali content with regard the above classifications. Although the differences in the alkali content in the West Carpathian granitoids are on the whole inexpressive, the two methods combined have revealed some geochemical features typical of the individual groups. The granitoids of the Spišsko-gemerské rudohorie and the granites of the Velence and Mecsek Mts. (Hungary) have a geochemical composition that differs evidently from that of the Variscan West Carpathian granitoids. As concerns the contents of alkalies, the latter are characterized by the predominance of sodium over potassium, a relatively low potassium content, and a comparatively inexpressive degree of differentiation between the principal granitoid types. The hypabyssal differentiates display the characteristic features of their parent rocks (deficiency in Rb, Cs, and increased Li in the granodiorite and tonalite types). Increased contents of Sr and Ba are also characteristic of the Variscan granitoids studied. The Rb/Sr, Ba/Sr and Ba/Rb ratios and the correlations of these elements, which were likewise examined, are of discrimination significance. The samples from the Hungarian mountain ranges differ from the West Carpathian samples in the contents of alkalies (are richer in K and poorer in Ba and Sr), but also from the granitoids of the Spišsko-gemerské rudohorie Mts., which have higher Rb and Cs and minimal contents of Ba and Sr.

The study of alkalies has corroborated the palingenic origin of the granitic magma and its formation from the sediments with a small amount of basic rocks of mantle derivation, probably tholeiitic in character.

The correlation of alkalies of the West Carpathian granitoids with their contents in the granitoids of the Malé Karpaty Mts. is suggestive of the geochemical-genetic consanguinity of these rocks.

Translated by H. Zárubová

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