GEOLOGICKÝ ZBORNÍK — GEOLOGICA CARPATICA 32, 1, BRATISLAVA, MARCH 1981 Pp. 35—54

Š. DÁVIDOVÁ,* A. DÁVID**

DISTRIBUTION OF SOME TRACE ELEMENTS IN FELDSPARS FROM PEGMATITES OF THE TATRIDES

(Tabs. 1—6, Figs. 1—9)

Abstract: The work deals with the content, distribution and relation between Li, Rb, Cc, Tl, Ba, Sr, Pb, Mn, Fe and Ga in 137 feldspars of Tatride pegmatites. The contents of trace elements are compared with data from literature. By the method of statistical analysis the parameters for the whole group of trace elements or for the subgroups, selected according to genetic — topographic marks, have been found. For dinstiguishing of potassium feldspars in subgroups elements with decreasing significance from Ba, Sr and Rb were established as most suitable. We separated two associations of elements bound to plagioclase — Ga, Mn, Li, Sr and potassium phase — Ba, Cs, Tl, Rb of potassium feldspar. Correlations, dispersion and variations as well as the contents of the mentioned trace elements contributed to completing of the crystallization environment of feldspars from Tatride pegmatites, which is characterized by low content of trace elements — Li, Cs, Tl, Rb and high content of Ba, Sr, Fe.

Резюме: Работа занимается содержанием, распределением и отношениями между Li, Rb, Cs, Tl, Ba, Sr, Pb, Mn, Fe и Ga в 137 полевых шпатах пегматитов татрид. Содержания следовых элементов сравнены с данными литературы. Методом статистического анализа определили параметры для целой группы следовых элементов или для субгрупп, отобранных по генетическо-топографическим знакам. Определили, что для различения калийных полевых шпатов в субгруппах самыми подходящими являются элементы с понижающимся значением от Ba, Sr до Rb. Выделили 2 ассоциации элементов связанных на плагиоклазовую — Ga, Mn, Li, Sr и калиевую фазу — Ba, Cs, Tl, Rb калийных полевых шпатов. Корреляции, рассеяние и вариации, как и содержания приведенных выше следовых элементов содействовали дорисованию кристаллизационной среды полевых шпатов пегматитов татрид, которая характеризована низким содержанием следовых элементов — Li, Cs, Tl, Rb и высоким содержанием Ba, Sr, Fe.

Introduction

The contents of trace elements in minerals are an indicator of geological processes. Their investigaton is of greatest importance in the so called transitional minerals, i.e. such ones, which are forming under various genetic conditions. To these minerals in pegmatites and granites also feldspars belong. Feldspars originate in a wider interval of temperatures and pressures. The high-temperature varieties will be enriched in isomorphous admixtures of elements, which, although not corresponding strictly to iso-

* RNDr. Štefánia Dávidová, CSc., Department of Mineralogy and Crystallography of the Faculty of Natural Sciences of the Comenius University, Gottwaldovo nám. 19, 886 02 Bratislava,

** RNDr. Arnold Dávid, CSc., Department of Numerical Mathematics of the Faculty of Natural Sciences, Comenius University, Mlynská dolina, 801 00 Bratislava.

morphous conditions in magnitude of ion radius, strengthen the structure of feldspars. The high pressure hinders isomorphous entrance of great univalent ions to positions of cations and makes possible entrance of bivalent ones with higher coordination, resulting in formation of phases with smaller parameters of crystal structure. Of particularly great importance in isomorphous replacement are pressure and temperature in magmatic systems, where equilibrium occurs not only between the crystalline and liquid phase, but also gaseous. A further important factor of isomorphism is concentration of trace elements, which increases in many elements with advancement of crystallization and further, crystallochemical factors and pT conditions. The purpose of such pursuing of trace elements in feldspars is not only geochemical characterization, but mainly helps to solve their genesis and to trace changes of pT conditions during crystallization.

The group of the investigated trace elements was selected in accordance with data from literature and possibilities of laboratories. The purpose was to obtain as much as possible information about physical—chemical conditions of origin of feldspars. Elements were mainly selected, which can replace isomorphously K, Na, Ca cations, the contents of which were known from partial chemical analyses. The following lements were selected: Mn, Pb, Ga, Fe, Sr, Ba, Tl, Li, Rb, Cs. When also isomorphism of Mn and Fe in feldspar structure is weak, these elements were included in the group, mainly in order to trace their influence on colour.

The content of the mentioned trace elements was determined in 110 samples of potassium feldspars and 17 plagioclase samples. The feldspars were separated from various pegmatite zones and from the contact of pegmatites with surrounding rocks where potassium feldspars formed porphyroblasts in granitoid or metamorphosed rocks of the Tatride zone of the West Carpathians. On the basis of preceding works (Š. Dávidová, 1978a) 3 types of pegmatites were distinguished in the area under study. From the view-point of the mode of occurrence of mineral complexes pegmatites belong to common, partly garnet and rarely muscovite pegmatites according to A. E. Fersman (1940). According to the content of feldspar minerals they belong to simple microcline — plagioclase pegmatites. According to classification of K. A. Vlasov (1952, 1961), to the I. paragenetic — graphic type. Their differentiation is weak.

We range potassium feldspars of composition within the range $Or_{83}Ab_{16}An_1$ to $Or_{38}Ab_{56}An_6$ with prevalence of Or_{64} to Or_{76}, forming one of the principal minerals of the first two pegmatite types of the Tatrides, on the basis of optical and X—ray observations by Š. Dávidová (1978b), to 3 structure types, which are connected with gradual transitions. The overwhelming majority of potassium feldspars is maximum microcline with Δ_r 1,00 to 0,80, the less part belongs to intermediary potassium feldspars with Δ_r 0,80 to 0,20 and only an insignificant amount was determined as orthoclase with Δ_r 0,20 to 1,10. According to chemical compositon, the degree of unmixing and optical properties there are perthites, prevailingly macroperthites, less microperthites, which belong to the series of low albite — maximum microcline, a less amount to the the series low albite — orthoclase perthite. On the basis of optical data and partial chemical analyses the plagioclase were determined prevailingly as low albite — oligoclase with 3 to 21 % An com-

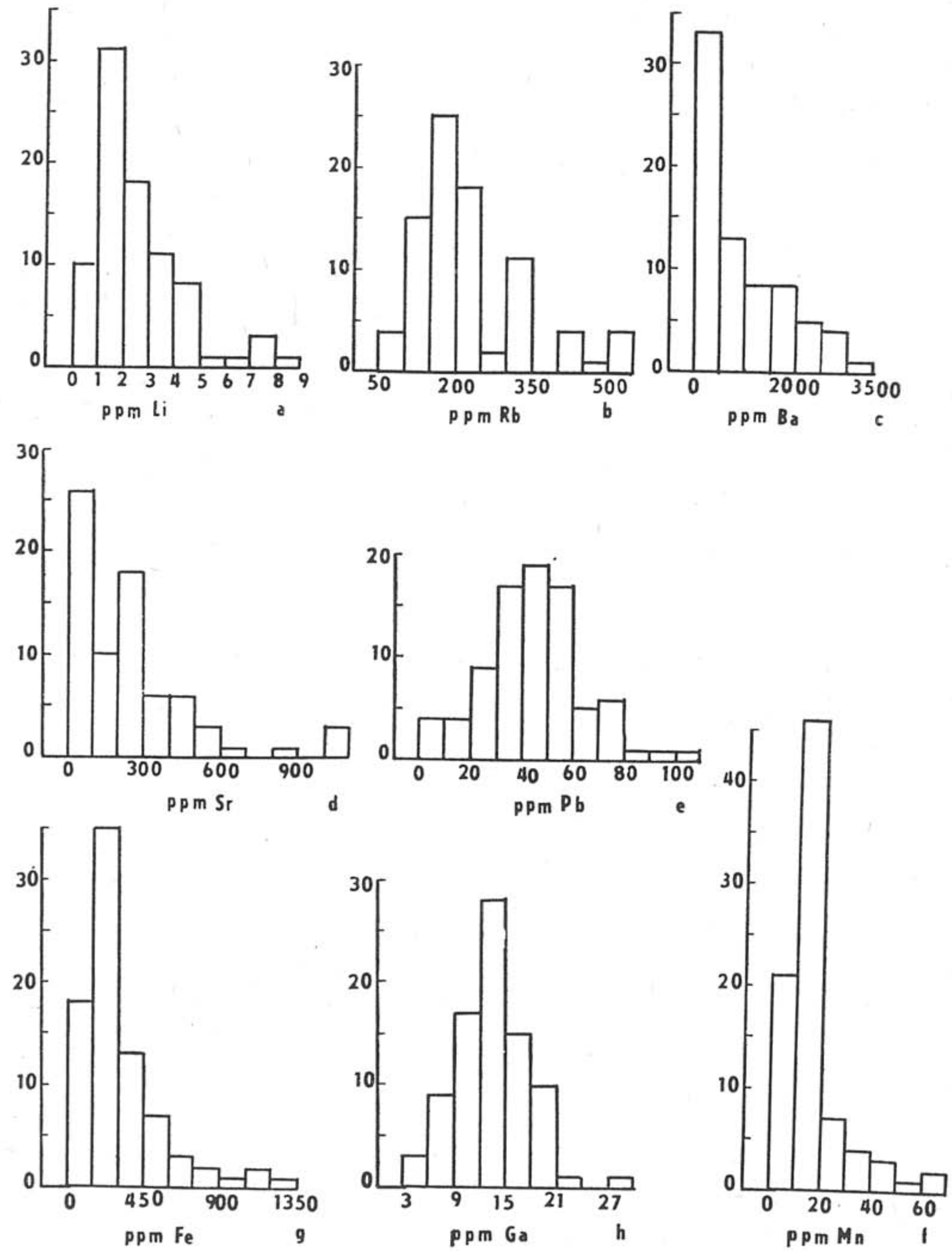


Fig. 1. Distribution diagram of trace element contents in K—feldspars of Tatride pegmatites.

ponents, only two samples from the Malá Fatra Mts. have 41—43 % An components. More detailed information about the location, character of feldspars, their ranging into pegmatite zones as well also the description of surrounding rocks is in the work by Š. D á v i d o v á (1976, 1978 a).

Methods

The contents of trace elements were determined spectrochemically at the Geological Institute of Natural Science Faculty of the Comenius University in Bratislava under leading of Prof. Ing. E. P l š k o Dr.Sc. and at the Dionýz Štúr Institute of Geology in Bratislava. The contents of Mn, Pb, Ga, Fe, Ba, Sr, Tl on spectrograph ISP — 51. The samples were buffered with addition of KCl. As comparative elements served: Zn for light-volatile and Eu for medium-volatile elements. Blackening of spectral lines measured on quick-photometer was converted to the values of intensities, using calibration curves of emulsion. Li, Rb and Cc were determined at the Dionýz Štúr Institute of Geology in Bratislava according to the method worked out by RNDr. K u p č o, CSc. The samples were buffered with NaCl and determination was taking place in infrared region. The exactness of the determination is 5—10 % except Cs. The lower detection limit of Mn — 10, Pb — 10, Ga — 3, Fe — 100, Ba — 30, Sr—10, Tl — 10, Li — 1, Rb — 10, Cs — 10 g.t^{-1}.

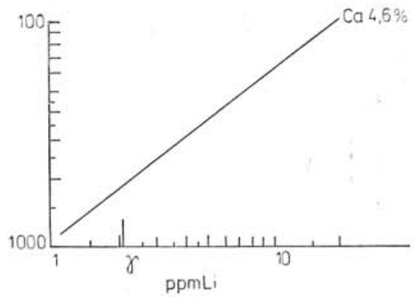


Fig. 2. Regression lines of elements to Li in K—feldspars of Tatride pegmatites.

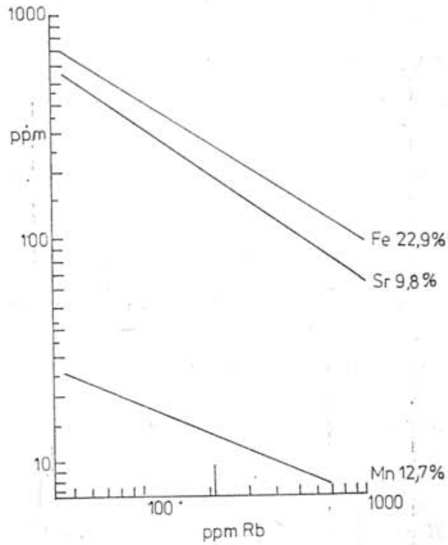


Fig. 3. Regression lines of elements to Rb in K—feldspars of Tatride pegmatites.

Mutual quantitative relation between the above mentioned trace elements in potassium feldspars was examined by statistical analysis. The statistical parameters were obtained for the whole group of samples or for sub-groups, which have been selected according the following criterii: a) geographical situation of the locality, thus mountain ranges; b) colour of potassium feldspar, c) zones of pegmatites, from which K—feldspars were obtained. For statistical evaluation 84 samples were taken, in which the content of orthoclase component did not sink under 60 %. From the statistical evaluation the elements Cs and Tl were excluded because they were determined in a small amount of samples only. In order not to have loss of information about the investigated group and subgroups, grouping of values of trace elements into intervals was avoided. The fundamental group and sub-groups were treated by methods used for a small number of samples. When also the process was more painstaking, the results are more precise and more trustworthy. The method of calculations was chosen according the works by I. S. Komarov (1972), V. Sattran — B. Soukup (19773) and K. Űberla (1974).

Before the calculation of statistical quantities was approached, the character of distribution of trace elements was determined partly informatively from the course of distribution histograms (Fig. 1a—h) and on the other hand was tested graphically by probability paper. It was established that the trace elements in K—feldspars are of lognormal distribution. Therefore, besides statistical parameters calculated from the values of the element contents, parameters of their decadic logarithms were calculated. This way normal division of the group was achieved and tests could be applied, which require normal division. From the content of the elements for the whole group and sub--groups were calculated fundamental statistical parameters, which are mentioned in Tabs. 1 to 4.

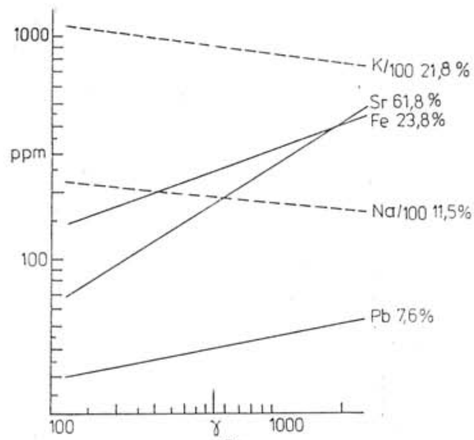


Fig. 4. Regression lines of elements to Ba in K—feldspars of Tatride pegmatites.

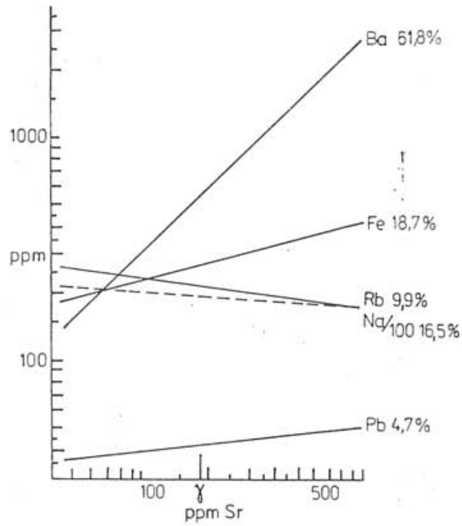


Fig. 5. Regression lines of elements to Sr in K—feldspars of Tatride pegmatites.

The values of selectional coefficient of correlation were calculated from the logarithms of values. The coefficient of correlation serves as measure of linear dependence, on the contrary to Spearman's coefficient of correlation, currently used in geology, which is the measure of monotonous dependence. In Tab. 3 the values of selectional correlation coefficients r_{xy} are mentioned above the diagonal correlation matrix. The values below the diagonal are the upper and lower estimation of the correlation coefficient of the general group (ρ_{xy}). The correlation is statistically important at 95 % level, when between upper and lower estimation the number 0 does not lie.

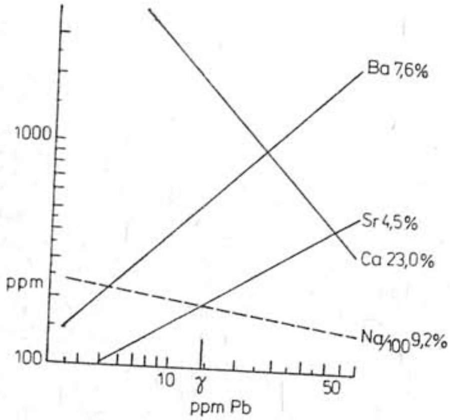
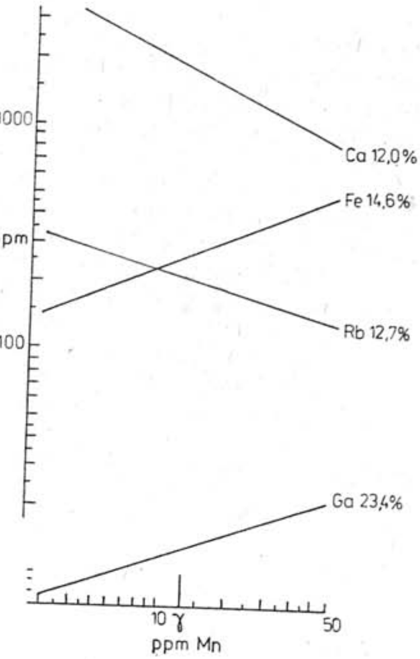


Fig. 6. Regression lines of elements to Pb in K—feldspars of Tatride pegmatites.

Fig. 7. Regression lines of elements to Mn in K—feldspars of Tatride pegmatites.



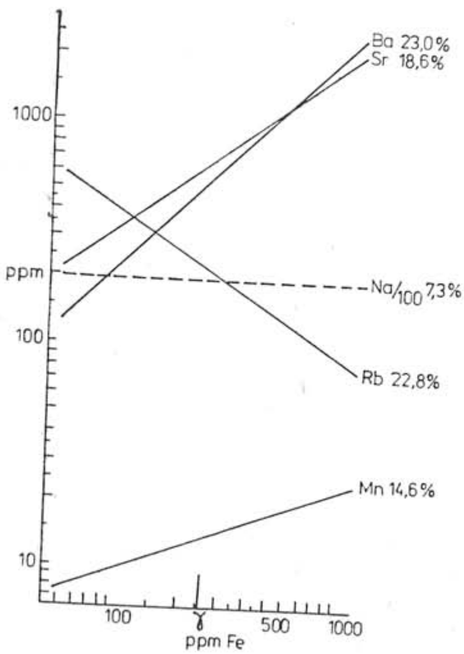


Fig. 8. Regression lines of elements to Fe in K—feldspars of Tatride pegmatites.

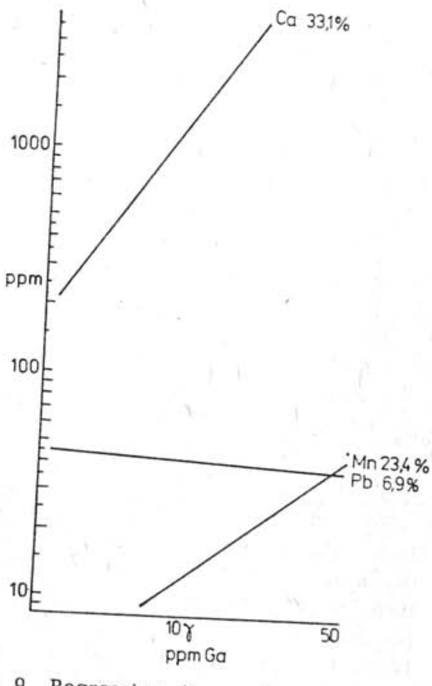


Fig. 9. Regression lines of elements to Ga in K—feldspars of Tatride pegmatites.

Table 1. Arithmetic mean of trace elements in sub-groups. MK — Malé Karpaty, NT — Low Tatra, ZT — Western Tatra, VF — Veľká Fatra, MM — Malá Magura, MF — Malá Fatra, B — Branisko, ČH — Čierna Hora, Ž — Žiar, ŽKS —feldspat quartz-micaceous zone

	n	Mn	Pb	Ga	Fe	Sr	Ba	Li	Rb	Ba:Rb
MK	15	15,707	47,800	15,053	321,80	462,51	1372,0	2,8000	270,00	5,08
NT	22	16,441	45,741	16,032	543,27	585,36	1864,5	2,5409	207,45	8,99
ZT	11	13,082	53,773	14,391	243,63	419,50	826,6	2,3091	178,18	4,64
VF	7	16,343	27,571	11,171	239,86	138,34	386,3	2,4000	201,43	1,91
MM	11	14,863	40,382	9,082	384,36	249,05	1042,5	1,4818	236,36	4,41
MF	10	17,140	47,710	11,100	345,60	313,40	1907	2,7300	184,00	10,36
B+ČH	4	24,825	40,250	12,200	518,50	397,50	2302,5	1,5000	265,00	8,69
Ž	4	32,475	25,375	12,700	445,25	93,625	783,3	3,0250	187,50	4,17
Sum	84	16,901	43,948	13,399	389,01	395,67	1382,1	2,4024	217,07	6,37
White	33	18,021	45,796	14,015	475,94	406,32	1560,1	2,5697	211,64	7,37
Grey	21	16,738	44,124	12,590	328,48	408,83	1397,2	1,9762	235,71	5,92
Pink	24	15,246	43,629	13,846	345,21	447,41	1409,6	2,6625	200,83	7,02
Blasts	10	15,742	50,000	11,475	573,43	571,93	2386,7	3,5000	184,29	12,95
Feldsp. quartz mic. zone	38	17,755	40,550	13,418	432,05	372,00	1396,2	2,5450	220,37	6,36
Graph. zone	10	21,183	41,060	12,533	285,17	150,72	419,00	1,7000	235,00	1,78
Block. zone	26	15,165	49,161	15,335	345,56	540,57	1557,3	2,1830	220,43	7,06

Table 2. Standard deviation

	n	Mn	Pb	Ga	Fe	Sr	Ba	Li	Rb
MK	15	12,375	24,715	3,2352	372,48	596,06	1842,6	1,8439	106,17
NT	22	10,550	22,760	5,3842	963,81	605,91	1941,9	1,5502	118,84
ZT	11	9,226	22,386	3,3542	129,53	543,15	1578,9	0,8154	56,71
VF	7	11,446	12,051	2,1899	90,40	174,58	566,25	0,9933	52,42
MM	11	11,298	11,943	3,5335	193,86	248,91	783,6	0,3790	135,96
MF	10	18,988	9,192	2,3678	276,89	143,78	965,9	1,7938	62,93
B + Č	4	27,727	8,057	2,5974	518,76	208,12	1571,5	0,4163	142,48
Ž	4	19,476	10,577	3,4728	213,57	79,18	679,0	2,6588	61,85
Sum	84	13,683	15,933	4,4356	546,13	475,661	1557,9	1,4673	103,32
White	33	18,254	21,807	4,255	819,73	430,06	1554,6	1,459	110,04
Grey	23	9,708	15,397	4,898	258,73	491,40	1521,4	1,369	104,25
Pink	24	7,956	23,262	4,154	345,14	560,34	1585,8	1,728	80,32
Blasts.	10	8,992	15,243	4,605	925,24	646,35	1686,1	2,354	80,59
Feldsp. quartz. mic. zone	38	15,922	21,323	4,670	168,07	430,66	1467,4	1,901	105,75
Craph. zone	10	11,913	19,881	4,188	233,08	171,54	894,0	0,779	95,45
Block. zone	26	11,115	20,014	3,488	380,70	583,54	1742,8	1,398	104,34

Table 3. Correlation matrix

S r_{xy}	Mn	Pb	Ga	Fe	Sr	Ba	Li	Rb	K	Na	Ca
Mn	1	.1511	.4834	.3817	—.0920	—.0978	.1253	—.3564	.0034	—.0311	—.3347
Pb	.38 —.08	1	—.2623	—.0202	.2162	.2753	.1286	—.0754	—.0404	—.3027	—.4797
Ga	.66 .31	.46 .00	1	—.0759	—0.023	—.1627	.0750	.0192	—.0217	—.0406	.5921
Fe	.57 .17	.23 —.25	.18 —.30	1	.4312	.4800	—.0347	—.4775	—.1057	—.2698	—.0168
Sr	.15 —.33	.45 .00	.23 —.24	.60 .22	1	.7862	.0950	—.3140	—.1250	—.4059	.1811
Ba	.15 —.33	.47 .05	.09 —.38	.64 .28	.86 .69	1	.0382	.1603	—.4664	—.3387	.0000
Li	.35 —.10	.36 —.10	.30 —.18	.22 —.26	.33 —.13	.28 —.20	1	.0133	—.1183	—.0135	.2151
Rb	—.12 —.55	.18 —.30	.26 —.21	—.33 —.63	—.10 —.52	.38 —.08	.25 —.21	1	.1853	—.1597	.2071
K	—.25 —.23	.20 —.27	.22 —.25	.16 —.32	.12 —.35	—.24 —.61	.15 —.33	.41 —.05	1	—.9510	.3539
Na	.25 —.23	—.05 —.50	.20 —.27	—.20 —.47	—.16 —.58	—.10 —.52	.25 —.24	.10 —.37	—.93 —.98	1	.6246
Ca	—.09 —.51	—.27 —.64	.75 .44	.24 —.24	.26 —.21	.24 —.23	.42 —.02	.42 —.02	.54 .13	.75 .48	1

Statistically important regressions are demonstrated graphically in Figs. 2 to 9. The parameters of regressive straight lines were calculated from the logarithms of values. In the graphs is illustrated the relation of one selected element to the other examined trace elements, as well as also the geometric mean(γ). As measure of suitability of two elements x, y was chosen the r^2_{xy} value, which in form of % at individual regressive straight lines shows the measure of explanation of linear regression. The limits of reliability of regression parameters were determined also by the method, which is mentioned by I. S. K o m a r o v (1972 on p. 171).

T a b l e 4. Variation coefficient

	n	Mn	Pb	Ga	Fe	Sr	Ba	Li	Rb
MK	15	78,8	51,7	21,5	115,7	128,9	133,0	65,9	39,3
NT	22	64,2	49,8	33,6	177,4	103,5	104,2	61,0	57,3
ZT	11	70,5	41,6	23,3	53,2	129,5	191,0	35,3	31,8
VF	7	70,0	43,7	19,6	37,7	126,2	146,6	41,4	26,0
MM	11	76,0	29,6	38,9	50,4	99,9	75,2	25,6	57,5
MF	10	110,8	19,3	21,3	80,1	45,9	50,7	65,7	34,2
B+Č	4	111,7	20,0	21,3	100,0	52,4	68,3	27,8	55,7
Ž	4	60,0	41,7	27,3	50,0	84,6	86,7	87,9	33,0
Sum	84	80,9	36,3	33,1	140,4	120,2	112,7	61,1	47,6

Distinguishing of sub-groups only on the basis of average values of element in both sub-groups is not sufficient, because selection of samples is a casual action and in treatment of the results the statistical regularities must be taken into consideration. For comparison of sub-groups therefore the F-test was applied, which requires normal distribution. So the whole test was carried out with decadic logarithm values. When it is valid that $\hat{E} > F$, we have at least 95 % probability that the given subgroups are different from each other in the content of trace elements in case of sufficient number of samples. When the test was counted at 99 % level, the elements in Tabs. 5 and 6 are underlined.

The mentioned statistical quantities were also calculated for plagioclases as one fundamental group. For the small number of samples the division into sub-groups was not carried out.

Discussion

Lithium in K-feldspars of Tatride pegmatites belongs to little dispersed elements similarly as Ga and Pb (Tabs. 2, 4). The Li content varies from the low detection limit 1 to 8 $g.t^{-1}$(NT—97) with average 2,4 $g.t^{-1}$. In plagioclases the Li content varies from 3 to 7 $g.t^{-1}$ with higher average value 4, 7 $g.t^{-1}$. The low content of Li in potassium feldspars is connected with crystallostructural properties of K—feldspars. The absence of position with hexagonal coordination and little ion radius of Li limit its entering the structure of K—feldspar. From it results that pure Li—feldspar is unstable (K. Rankama — T. G. Sahama, 1950). In spite of it also Li contents in K—feldspars were found out by many authors (T. F. Borovik Romanova — E. D. Kalita, 1958, K. I. Litovčenko 1963, V. V. Gordienko — I. E. Kamencev, 1967, D. O. Ontoev — A. I. Batova 1969, V. Arnaudov — B. Karadžova, 1970). According to K. S. Heier (1960) Li probably replaces Na. The literature data about Li content are different. The highest Li contents 140 to 390 $g.t^{-1}$ were established by T. F. Borovnik Roma-

Table 5. F-test results for distinguishing of element contents in individual mountain ranges

	NT	ZT	VF	MM	MF	B + ČH	Ž
MK	**Ca** K	Rb	**Na** **K** **Ca**	**K** **Ca** **Ga** Li	Ba **K** **Ca** Rb	**K** **Na** **Ca** Rb	Mn **K** **Ca**
NT		Ca	**Sr** **Ca** **K** **Na**	**Ga** Li **Ca**	Na Ga	Rb **Ca**	Mn Sr K
ZT			Sr **Ca**	Fe Rb **Ca** **Ga** **Li**	**Ba** **Ca**	Ba Na **Ca**	Mn Pb **Ca**
VF				K Li	**Sr** **Ba** **Ca**	Sr **Ba** Na	**Fe** **Ca**
MM					Li **Ca**		**K**
MF						Na Ca	**Pb** **Sr** Ba K
B + ČH							Sr

nova — E. D. Kalita (1958) in microcline perthite from pegmatites of Kola. On the contrary, S. R. Taylor — K. S. Heier (1958a) and K. S. Heier — S. R. Taylor (1959a, b) affirm that Li content in K—feldspars cannot exceed 1 $gt.^{-1}$. A relatively high medium value 197,3 $g.t^{-1}$ for K—feldspars of pergmatites is mentioned by V. V. Ljachovič (1972).

Unbonding of Li in the structure of investigated feldspars is pointed out by statistically unimaportant correlations of Li to other selected trace and major elements (Tab. 3). A very low degree of positive correlation ($r=0,2$) between Li and Ca con be called forth with higher content of plagioclase K—feldspar phase, to which Li is probably bound. Only one important Ca regression to Li (Fig. 2) was statistically established, dependence of which we can express $\% \; Ca = 0,12 \; Li^{0,47}$

With the study in sub-groups on the basis of F-test at 95 % level statistically important differences in Li content in K—feldspars were established according to the mountain ranges (Tab. 5) and zones (Tab. 6). With a higher Li content K—feldspars from the areas of the Malé Karpaty, Low Tatras, West Tatras, Veľká Fatra, Malá Fatra are different from the K—feldspars of the M. Magura, what can be, except the Malé Karpaty, explained by predominance of the 2nd and 3rd type of pegmatites in the areas under study.

Table 6. F-test results for distinguishing of element contents in pegmatite zones and according to potassium-feldspar colour

	Feldspar-quartz micaceous zone	Graphic zone	Block zone
Blasts		*Ba*	Li Ca *Ga*
Feldspar-quartz micaceous zone		Sr *Ba*	Ca
Graphic zone			Ca

	Grey	Pink
White	Li	Fe
Grey		Fe

Statistically the difference between Li content in plagioclases and potassium feldspars was demonstrated, with the content of Li in plagioclases greater, what can be explained by probable isomorphism of Li after Na. Differences were not testified at 99 % level.

Rubidium. The amount of Rb in K—feldspars varies from 70 to 500 $g.t^{-1}$ (in 3 samples) with a small coefficient of variation (Tab. 4) and little dispersion (Tab. 2). The most frequent interval of content is 150 to 200 $g.t^{-1}$ (Fig. 1b). When we compare the average content 217 $g.t^{-1}$ with the mean content 5 485 $g.t^{-1}$, which V. V. Ljachovič (1972) mentions for potassium feldspars, it is very low. It is lower than the value 270 $g.t^{-1}$, which V. I. Kogan et al. (1971) established as the lowest for Rb content in potassium feldspars of micaceous pegmatites. On the whole, it has been established that the Rb content in K—feldspars of other pegmatite localities is much higher than in the Tatride belt. For example: W. Kowalewski — Z. Walenczak (1957) mention 3 100 to 6 000, N. A. Solodov (1959) 1 600 to 28 000, N. A. Solodov (1962) 1 530 to 5 500, R. S. Heier (1962) 200 to

1 600, B. M. Šmakin (1979) 220 to 5 540 $g.t^{-1}$. The maximum content of Rb 4 weight % is mentioned by J. V. Smith (1974). The Rb content rises in the process of crystallization of pegmatites and as it does not form own minerals, it accumulates in rock—forming minerals of highly differentiated pegmatites. Extreme values of Rb are in later magmatic to hydrothermal stages of mineral origin (V. I. Pavlišin — P. K. Vovk, 1971). In plagioclases of Tatride pegmatites the Rb content varies from 3 to 500 $g.t^{-1}$, with the average content value 20,5 $g.t^{-1}$ by 1 order lower than for K—feldspars only.

A moderate degree of negative correlation between Rb and Fe, Rb and Mn, Rb and Sr (Tab. 3) has been established. Analogously, also statistically important regressions of Fe, Mn and Sr to Rb have been established (Fig. 3), the following relations were derived: $Fe = 7\,936 . Rb^{-0,44}$; $Mn = 138 . Rb^{-0,44}$; $Sr = 7\,814 . Rb^{-0,69}$. No correlation between Rb and K has been found, although it is supposed, that Rb replaces isomorphous K. Replacement of K with Rb, however, occurs under conditions, which make extension of K—feldspar structure possible. When also dispersion of Rb in K—feldspars of Tatride pegmatites is small, some mountain ranges differ in Rb content (Tab. 5). These differences are, however, determined at 95 % level only.

Cesium. From 110 samples of potassium feldspars Cs was established only in 12 samples with the content from 2 to 10 $g.t^{-1}$. Entering of Cs into the K—feldspar structure is more difficult than of Li. An obstacle is 18 % difference in ion radii of Cs and K and low ionization potential. In spite of that are known high contents of Cs in K—feldspars of pegmatites from various localities. N. A. Solodov (1959b, 1962) found 50 to 2 580, M. M. Manujlova et al. (1966) 2 to 36, V. V. Gordienko — I. E. Kamentsev (1967) 4 000, B. M. Šmakin (1979) 4 to 748 $g.t^{-1}$, V. V. Ljachovič (1972) established the mean content of Cs in K—feldspars of pegmatites 431,5 $g.t^{-1}$. In plagioclases of pegmatites of the Tatrides Cs has been found in 3 samples only.

Thallium. In K—feldspars of Tatride pegmatites Tl was established in 39 samples. The majority of samples had Tl content lesser than the lower detection limit, i.e. 10 $g.-t^{-1}$. Maximum measured value is 19 $g.-t^{-1}$. Tl has a similar way of entering the structure of late crystallizing K—felrspars as Cs, because it has a tendency to form covalent bonds with oxygen. For K—feldspars of other localities of pegmatites are mentioned the following values: 3 — 140 K. S. Heier — S. R. Taylor (1959a, b), 9 — 99 S. R. Taylor et al. (1960), 12 — 61 T. F. Borovik — Romanova — A. F. Sosedko (1960), 4 — 17 I. G. Ganejev — N. P. Lechina (1962), 6 — 50 $g.t^{-1}$ N. G. Sretenskaja (1963, 1964).

The Tl content in plagioclases of Tatride pegmatites is in the interval from the lower detection limit to 51 $g.t^{-1}$. The average value 16,1 $g.t^{-1}$ is lower than for plagioclases of granites and much higher than for pegmatites. An essentially higher Tl content was established in most basic plagioclases (andesines).

Barium. Ba contente in investigated K—feldspars considerably varies from the lower detection limit 100 $g.t^{-1}$, which already is not reached at 14 samples, to the upper detection limit 3 000 $g.t^{-1}$, exceeding at 12 samples. Most numerous are values in 0 to 500 $g.t^{-1}$ interval (Fig. 1 c). Its dispersion is great

(Tab. 2, 4). The average content 1 382 $g.t^{-1}$ is essentially higher than 4 10 git^{-1} (Tab. 1), which V. V. Ljachovič (1972) mentions for K—feldspars of pegmatites. A great variation of values of Ba content, which is closely connected with genetic conditions of feldspar origin, is also found in literature. I. Oftedal (1959, 1961 a, b) mentions 500 to 5 000, W. Kowalski (1970), 220, B. M. Šmakin (1979) 20 to 8 800 $g.t^{-1}$. In the magmatic process Ba concentrates in minerals earlier than the remnant of differentiation originates. A mineral concentrator is K—feldspar. The Ba content in plagioclases is from traces to 560 $g.t^{-1}$ with an average 196 $g.t^{-1}$, which is only a somewhat lower value than the average content (215 $g.t^{-1}$), established by V. V. Ljachovič (1972) for plagioclases of granites. No regularities between Ba content in K—feldspars in dependence on pegmatites zones have been found.

A high degree of direct correlation between Ba and Sr (Tab. 3) points out simultaneous isomorphous entering of Ba and Sr into the structure of K—feldspar, where they replace potassium, isomorphism between Ba for K is more distinct and shown in the moderate degree of indirect correlation as between Sr and K, which is manifested with low degree of indirect correlation. A moderate degree of correlation is between Ba and Fe, Ba and K, Ba and Na and low between Ba and Pb. Statistically important are positive regressions of Pb, Tl, Sr to Ba and negative of K, Na to Ba, which we can express as follows:

$Pb = 19{,}82 \, . \, Ba^{0,11}$; $Fe = 58{,}55 \, . \, Ba^{0,24}$; $Sr = 3{,}26 \, . \, Ba^{0,64}$; $\% \, K = 14{,}68 \, . \, Ba^{-0,08}$; $\% \, Na = 2{,}73 \, . \, Ba^{-0,05}$.

They are graphically illustrated in Fig. 4. With equal measure in dependence on Ba, Fe and Pb enter K—feldspar. The regression staight lines of Na and K to Ba are almost parallel, what is modified with the moderate degree of indirect correlation between Ba — Na and Ba — K. As the results of F — test show, are in sub-groups differences at 99 % reliability level (Tabs 5, 6). Statistically plagioclases differ from K—feldspars in lower Ba content.

Strontium. The amount of Sr varies in a relatively wide extent from 12,3 (sample VF = 75p) to 1 000 $g.t^{-1}$, 10 samples have a content over the upper detection limit. The average value is 395,7 and most frequent class from 0 to 100 and from 200 to 300 $g.t^{-1}$ (Fig. 1d). When also the extreme magmatic differentiation leads to low content of Sr, in the literature we find different data about the Sr content in K—feldspars of pegmatites. B. M. Šmakin — E. S. Kostjukova (1969) establihed 7 — 710, V. V. Ljachovič (1972) 80 to 190, B. B. Šmakin (1979) 16 to 620 $g.t^{-1}$. The Sr content in plagioclases of Tatride pegmatites varies in a wide interval from 42 to above the upper detection limit (1000 $g.t^{-1}$). The average content 406 $g.t^{-1}$ is only insignificantly higher than at potassium feldspars of Tatride pegmatites, but more than twice as great as the average value for plagioclases of pegmatites, which V. V. Ljachovič (1972) mentions. High contents of Sr more than 1000 $g.t^{-1}$ were found at two samples from the Little Fatra (MF—7, MF—8), which correspond to andesine.

Sr dispersion in K—feldspars of Tatride pegmatites is great (Tabs. 2, 4). A high degree of direct correlation (Tab. 3) between Sr and Ba points to

correlation of these two elements similarly as found by J. M. Rhodes (1969) for feldspars in granitoid rocks. Interesting is a moderate degree of direct correlation between Sr and Fe and indirect between Sr and Na, Sr and Rb. The correlation relation between Sr and Na points to Sr being bound to the plagioclase phase, which forms perthite intergrowths in K—feldspar. From regressive relations are statistically important 3 positive regressions Ba, Fe, Pb to Sr and 2 negative Na and Rb to Sr (Fig. 5). We can express this as follows : Ba = 3,55 . $Sr^{0,96}$; Fe = 64,00 . $Sr^{0,26}$; Pb = 22,60 . $Sr^{0,11}$; % Na = 2,93 . $Sr^{-0,08}$; Rb = 444,5 . $Sr^{-0,14}$.
No relations were established between Sr and Ca. Sr after Ba appears as one of the most important trace elements for distinguishing in sub-groups (Tabs. 5, 6) and in many cases forms with Ba a distinguishing couple.

Lead. The Pb content in potassium feldspars of pegmatites varies from 10 to 110 $g.t^{-1}$ (MK — 10/5) with average content 44 $g.t^{-1}$, what represents a relatively low value in comparison with data in literature. K. H. Wedepohl (1956) — 100; K. S. Heier — S. R. Taylor (1959a) — 11 to 290; B. R. Doe et. al. (1965) — 80 to 500; I. Oftedal (1967) — 10 to 500; J. V. Smith (1974) — 2 to 600 $g.t^{-1}$. The distribution of lead has almost a normal course with the most abundant class in the interval 40 to 50 $g.t^{-1}$ (Fig. 1 e). In plagioclases was found the content of lead in the interval from < 10 to 55 $g.t^{-1}$ with average 17 $g.t^{-1}$, what is a lower content than the mean content 26,2 $g.t^{-1}$ and 40,5 $g.t^{-1}$, which is mentioned for plagioclases of pegmatites of pegmatites and granites by V. V. Ljachovič (1972). Lead in K—feldspars of Tatride pegmatites is a weakly dispersed element (Tab. 2) with low variation coefficient (Tab. 4). The correlation relations (Tab. 3) between Pb and other studied elements are very weak. A moderate degree of indirect correlation for Pb and Ca and Pb and Na has been established, what can point out Pb entering the plagioclase phase, which is represented by perthite intergrowths in K—feldpars. Isomorphous replacement of Pb with K and Pb with Ca is equal according to the majority of mentioned authors, when also a higher isomorphism between Pb and K is generally supposed because of a lower ratio of ion radii. The low degree of direct correlation was established between Pb and Ba, Pb and Sr. 2 positive and 2 negative regressions were established by statistic calculations, expressed as follows: Sr = 39,01 . $Pb^{0,43}$; % Ca = 3,47 . $Pb^{-0,82}$; Ba = 47,16 . $Pb^{0,67}$; % Na = 2,98 . $Pb^{-0,11}$. Their course is illustrated in Fig. 6.

By F-test it has been established that Pb is not a suitable element for distinguishing in selected sub-groups. With a higher Pb content the plagioclases are different from K—feldspars of the Tatride pegmatites.

Manganese. Is a little frequent trace element in K—feldspars for weak isomorphous substantiation. Its content varies from the lower detection limit, within the range < 10 to 71 $g.t^{-1}$ with an average value 17 $g.t^{-1}$ (Tab. 1). The diagram (Fig. 1f) of distribution points to asymmetric distribution of Mn content with highly exceeding class 10 to 20 $g.t^{-1}$, to which also the average value (16,0 $g.t^{-1}$) falls. The mentioned values are lower than in K—feldspars of pegmatites established by R. A. Higazy (1953) and S. R. Taylor et al. (1960), but they agree well with the data of I. Oftedal (1969), who mentioned 15 to 60 $g.t^{-1}$ for microclines of southern Norway. In the observed plagioclases Mn content varies from 11 to 72 $g t^{-1}$ with an average of 29 g.t^{-1}. Up to lately it was supposed that Mn in plagioclases is bound to heterogeneous admixtures only. The study of luminiscence has found that a part of Mn is bound isomorphously.

The Mn content was correlated with colour. No important differences were found statistically, also when the average content of Mn for white K—feldspars is 18.g.t^{-1}, for grey 17 g.t^{-1} and pink 15 g.t^{-1}. The high variation coefficient (Tab. 4) and high value of standard deviation (Tab. 2) for the areas of the Branisko, Čierna Hora and Malá Fatra Mts. could indicate contamination. Mn does not show any more distinct correlations to other studied elements. A moderate degree of positive correlation was found between Mn and Ga, Mn and Fe, and a negative between Mn and Rb, Mn and Ca. The latter corerlation advises substitution relations between Mn and Ca, shown also in the higher Mn content in plagioclases of Tatride pegmatites than in K—feldspars. A positive correlation of Mn and Fe can point to the presence of impurities of dark minerals in form of inclusions. Four statistically important regressions are illustrated in Fig. 7 and their relations can be expressed; Ga = 5,88 . $Mn^{0,31}$; Fe = 90,91 . $Mn^{0,41}$; Rb = 440 35 . $Mn^{-0,20}$; % Ca = 0,68 . $Mn^{-0,51}$. Mn appears not as an important trace element for distinguishing in sub-groups, only potassium feldspars of pegmatites from the Žiar Mts. display a statistically important higher Mn content in contrast to some core mountains. In the lower Mn content K—feldspars differ from plagioclases of Tatride pegmatites.

Iron. The Fe content in feldspars is largerly discussed in literature and there is no uniform view of its entering into structure. Fe belongs among highly scattered trace elements in K—feldspars of Tatride pegmatites. The interval of content is from < 100 to > 3000 g.t^{-1}. In the distribution diagram (Fig. 1 g) most frequent is the class 150 to 300 g.t^{-1}, to which the arithmetic mean does not fall (Tab. 1). In plagioclases of Tatride pegmatites Fe varies in a wide interval from <100 to 1740 g.t^{-1} (sample B—4) with average value 559 g.t^{-1}. Relatively high Fe—contents (500 — 2000 g.t^{-1}) have been found by I. Oftedal (1969) with very thoroughful separation in K—feldspars of pegmatites, although he mentions 20 — 400 g.t^{-1} for feldspars from pegmatites, considers only 20 — 30 g.t^{-1} Fe of it as isomorphous, the remaining as part of unmixed solid solutions. The Fe content in the observed feldspars is high when compared with the data of P. H. Ribbe — J. V. Smith (1966) and S. R. Taylor et al. (1960).

A moderate degree of positive correlation has been found between Ba, Sr, and Mn, negative with Rb and a low degree of negative correlation with Na (Tab. 3). Statistically important are positive regressions of Mn to Fe, Sr to Fe and Ba to Fe and negative of Rb to Fe, Na to Fe (Fig. 8), expressed as follows: Mn = 1,84 . $Fe^{0,35}$; Sr = 3,58 . $Fe^{0,71}$; Ba = 2,50 . $Fe^{0,97}$; Rb = 1541,0 . $Fe^{-0,36}$; % Na = 3,13 . $Fe^{-0,09}$. According to F test results Fe is suitable for distinguishing in sub-groups by colour only (Tab. 6). Pink feldspars, which contain more Fe than grey and white ones, probably contain Fe in form of unmixings.

Gallium. As trivalent element in the structure of feldspars it may replace Al. Synthetic NaGa Si_3O_8 feldspar is stable and occurs in ordered state (H. Pentinghaus, H. U. Bambauer — 1971). In K—feldspars of Tatride pegmatites Ga content varies within the limits 4,2 to 28,8 g.t^{-1} with an average value 13,4 $g.t^{-1}$. In plagioclases from 7,4 to 28,8 with a higher average values 16,21 $g.t^{-1}$ than in K—feldspars. According to Ga content the investigated potassium feldspars are closer to K—feldspars from granites, for which P. Kolbe, S. R. Taylor (1966) established Ga content 6 — to 30 $g.t^{-1}$. The weak Ga dispersion in K—feldspars of Tatride pegmatites (Tabs. 2, 4) appears in the regular distribution histogram (Fig. lh). Most frequent is the class 12 to 15 $g.t^{-1}$, which includes also the average value. Preferring of plagioclase phase to the phase of potassium feldspar is indicated by the significant degree of positive correlation between Ga and Ca (Tab. 3). The absence of correlation between Ga and Na can point to the presence of Na in solid solution of K—feldspars. Interesting is the moderate degree of positive correlation between Ga and Mn and Pb and Ga. From these relations also statistically important regressions result (Fig. 9), which we can express as follows: $Mn = 1{,}88 \cdot Ga^{0{,}76}$; $\%\ Ca = 0{,}004 \cdot Ga^{1{,}43}$; $Pb = 105{,}6 \cdot Ga^{-0{,}37}$. The almost parallel linear course of straight lines of Ca to Ga and Mn to Ga is modified by the moderate degree of correlation between Ga and Mn and Ga and Ca. Statistically a higher Ga content in K—feldspars from pegmatites of the Malé Karpaty, Low Tatra and Western Tatra than in K—feldspars of the Malá Magura and in feldspars of the block zone than in blasts has been found (Tabs. 5, 6).

Conclusions

The subject of the paper is the content, distribution and tracing of mutual relations between Li, Rb, Cs, Tl, Ba, Sr, Pb, Mn, Fe and Ga in 137 feldspars of Tatride pegmatites. The contents of the mentioned trace elements are compared with data from literature. With the method of statistical analysis parameters for the whole group of K—feldspars and plagioclases or for sub-groups of K—feldspars were obtained. The criterii for assignment into sub-groups were selected according to topographical — genetic aspects. Whole groups and sub-groups were treated by the methods applied for a small number of samples. Distinguishing of subgroups only on the basis of average values of the content of element is not sufficient and therefore F-test was applied.

Trace elements on the basis of the content, distribution, variation and mutual correlations we may range into two association according to their relation to phases of potassium feldspars:

a) It has been found that to the plagioclase phase, represented by perthite intergrowths in K—feldspars, Ga, Mn, Sr and Li are bound. This binding is also shown statistically in the proved higher Li, Ga, Mn contents in plagioclases of Tatride pegmatites.

b) To the potassium phase of K—feldspars are bound Ba, Sr, Fe and probably Rb, Cs and Tl. The relations are also supported by the fact that K—feldspars of Tatride pegmatites contain more Ba, Rb and Pb than plagioclases.

On the one hand simultaneous entering and high Ba, Sr and Fe contents and low contents of Cs, Tl, Rb, Li on the other hand in comparison with contents of K—feldspars at other pegmatite localities, indicate conditions.

which partly do not fit in the idea of pegmatite crystallization from differentiated, fluid — enriched residual melt. We conclude from the given facts that pT conditions, under which crystallization of pegmatites occurred, were determined by higher pressures, which correspond to depth of 5 — 8 km and a higher temperature, mainly at the second type of pegmatites, containing more Fe. Such an environment was probably accompanied by lacking fluid components.

Although we suppose that part of Rb could have been intercepted in biotite of granitoid rocks in earlier phases of crystallization, to which pegmatites are genetically bound, the contents of Rb, Cs, Tl and Li are low, what may indicate the origin of pegmatites bound to anatectic melt.

As elements most suitable for distinguishing of K—feldspars from Tatride pegmatites in sub-groups Ba, Sr, Rb and Li have been found although the latest two have little dispersion. The greatest differences were recorded between the individual mountain ranges. The highest Ba, sometimes Sr contents have been established in K—feldspars of pegmatites from the Malá Fatra, Branisko and Čierna Hora Mts., which belong to weakest differentiated pegmatites. Relatively higher Rb and Li contents are in more differentiated pegmatites of the Malé Karpaty Mts. The contents of Ba, Sr, Rb and Li are a criterion suitable for distinguishing of pegmatite differentiation.

Translated by J. Pevný

REFERENCES

ARNAUDOV, V. — KARADŽOVA, B., 1970: Razpredelenije na redkie alkalii v pegmatitite ot severozapdna Rila i njakoi pegmatiti ot Vlachina planina. Izv. Geol. Inst., Ser. Geochim. Mineral. Petrogr., (Sofia), 19, p. 81—91.

BOROVIK — ROMANOVA, T. F. — KALITA, E. D., 1958: O ceziovo-rubidievom mikroklín-pertite i razprostranenii v nem redkich sčeločnych metalov. Geochimija (Moskva), 2, p. 107—114.

BOROVIK — ROMANOVA, T. F. — SOSEDKO, A. F., 1960: O sootnošenii meždu soderžanijem tallija a rubidija v mineralach iz pegmatitovych žil Kolskogo poluostrova po dannym spektralnovo analyza. Geochimija (Moskva), 1960, 1, p. 31—36.

DÁVIDOVÁ, Š., 1976: Mineralógia a geochémia živcov pegmatitov tatríd. Habilitačná práca. Rukopis. Geofond, Bratislava, 339 p.

DÁVIDOVÁ, Š., 1978 a: Mineralógia a petrografia pegmatitov kryštalinika tatríd. Mineralia Slovaca, (Bratislava), 10, 2. p. 127—146.

DÁVIDOVÁ, Š., 1978 b: The Grade of order of potassum feldspars of pegmatites in the tatrides. Geol. zborn. — geol. carpath (Bratislava), 29, 2, p. 275—294.

DOE, B. R. — TILTON, G. R. — HOPSON, C. A., 1965: Lead isotopes in feldspars from selected granitic rocks associated with regional metamorphism. J. Geophys. Res. (London) 70, p. 1947—1968.

FERSMAN, A. E. 1940: Pegmatity. Moskva, 640 p.

GANEJEV, I. G. — LECHINA, N. P., 1962: Geoochimičeskaja charakteristika albitizirovanich granitov. Geochimija (Moskva) 2, p. 158—165.

GORDIENKO, V. V. — KAMENCEV, I. E., 1967: O prirode primesi rubidija v kalevom polevom špate. Geochem. (Moskva) 4, p. 478—481

HEIER, K. S., 1960: Petrology and geochemistry of high grade metamorphic and igneous rocks on Langoy Northern Norway. Norg. geol. Unders. (Oslo), No 207, p. 1—245.

HEIER, K. S., 1962: Trace elements in feldspars — A review. Nor. geool. Tidskr. (Osl), 42, 2, p. 415—454.

HEIER, K. S. — TAYLOR, S. R., 1959 a: Distribution of Li, Na, K, Rb, Cs, Pm and Tl in southern Norwegian pre-Cambrian alkali Feldspars Geochim. Cosmochim. Acta (London), 15, p. 284—304.

HEIER, K. S. — TAYLOR, S. R., 1959 b: Distribution of Ca, Sr and Ba in southern Norwegian pre-Cambrian alkali feldspars. Geochim. Cosmochim. Acta (London), 17, p. 286—304.
HIGAZY, R. A., 1953: Observations on the distribution of trace elements in perthite pegmatites of the Black Hills, South Dakota. Amer. Mineralogist (Washington), 38, p. 172—190.
KOGAN, V. I. — NAZVANOVA, V. A. — SOLODOV, N. A., 1971: Rubidij i cezij. Nauka, Moskva, 82 p.
KOLBE, P. — TAYLOR, S. R., 1966: Major and trace element relationships in granodiorites and granites from Australia and South Africa. Contr. Mineral. Petrology (Berlin), 12, p. 202—222.
KOMAROV, I. S., 1972: Nakoplenije i obrabotka informacii pri inžinernogeologičeskich issledovanijach. Nedra, Moskva, 294 p.
KOWALSKI, W., 1970: Die Verteilung einiger Haupt und Spuren elemente in Feldspäten der Strzegom Pegmatite. Freiberg. Forsch. (Freiberg) 270, p. 133—150.
KOWALSKI, W. WALENCZAK, Z., 1957: Rubid v skaleniach pegmatitov sudeckich. Arch. Mineral. (Warszawa), v. 21, 2, p. 427—459.
LITOVČENKO, K., 1963: Rozpodil akcesornoyo litiju v mineralach pegmatitov zachidnoyo Priazovja. Trudy Inst. Geol. Akad. Nauk Ukr. SSR, ser. Petrogr., mineral., geochim. (Kiev), vyp. 20, p. 94—98.
LJACHOVIČ, V. V., 1972: Redkije elementy v porodoobrazujščich mineralach granitoidov. Nedra, Moskva, 199 p.
MANUJLOVA, M. M. — PETROV, L. L. — RYBAKOVA, M. M. — SOKOLOV, J. M. — ŠMAKIN, B. M., 1966: Zakonomernosti razpredelenija ščeločnych elementov i berilija v mineralach pegmatitov severo-bajkaľskogo pegmatitogo pojasa. Geochimija (Moskva), No 4, p. 410—422.
OFTEDAL, I. 1959: Distribution of Ba and Sr in microcline in sections across a granite band in gneiss. Nor. geol. Tiddskr. (Oslo), 39, p. 343—349.
OFTEDAL, I., 1961 a: Remarks of the variable contents of Ba and Sr in microcline from a single pegmatite body. Nor. geol. Tidskr. (Oslo), 41, p. 271—277.
OFTEDAL, I., 1961 b: Remarks on the variable contents of Ba and Sr in microcline from a single pegmatite body. Nor. geol. Tidskr. (Oslo), 41, p. 271—277.
OFTEDAL, I., 1967: Lead contents in microcline from some granites and pegmatites, Nor. geol. Tidskr. (Oslo), 47, 2, p. 191—198.
OFTEDAL, I., 1969: Note of the iron content of microcline. Nor. geol. Tidskr. (Oslo), 49, No 1, p. 87—88.
ONTOEV, D. O. — BATOVA, A. I., 1969: O razpredelenii ščeločnych metalov v polevych špatach postmagmatičeskych obrazovanij džidinskovo sudnogo polja. Zap. Vsesojuz. mineral. Obšč. (Leningrad), ser. 2, 98, 1, p. 18—28.
PAVLIŠIN, V. I. — VOVK, P. K., 1971: Redkije ščeločnyje elementy v mineralach kamernych pegmatitov. Mineral. Sbor. (Ľvov) 25, 1, p. 27—37.
PENTINGHAUS, H. — BAMBAUER, H. U., 1971: Der Einbau von Al (III) Ga^{+3} und Si^{+4} Ge^{+4} in synthetische Alkalifeldspäte. Fortschr. d. Mineral. (Stuttgart), 49, Beiheft 1, p. 37—38.
RANKAMA, K. — SAHAMA, T. G., 1950: Geochemistry. Univ. Chicago press.
RHODES, J. M., 1969: On the chemistry of potassium feldspars in granitic rocks. Chem. geol. (Amsterdam), 4, p. 373—392.
RIBBE, P. H. — SMITH, J. V., 1966: X—ray emission microanalysis of rock-forming minerals. IV. Plagioclasse feldspars. J. Geol. (Chicago), 74, p. 217—233.
SATTRAN, V. — SOUKUP, B., 1973: Použitie matematických metód v geolzgii. Knih. Ústř. Úst. geol. (Praha), sv. 45, 174 p.
SMITH, J. V., 1974: Feldspar Minerals I. II. Springer Verlag, Berlin, 690 p.
SOLODOV, N. A., 1959: K geochimii redkometaľnych granitnych pegmatitov. Geochimija (Moskva), 7, p. 628—637.
SOLODOV, N. A., 1962a: Zonalnost redkometalnych granitnych pegmatitov. Tr. in-ta Mineralog. Geochim. Kristalochim. red. elementov (Moskva), 8, p. 20—84.
SOLDOV, N. A., 1962b: Razpredelnije tallija v mineralach po moščinnosti zonaľnovo pegmatita. Geochimija (Moskva), 7, p. 635—637.
SRETENSKAJA, N. G., 1963: Ob uslovijach obrazovanija mikroklina pegmatitovych žil odnogo iz rajonov Kazachstana. Geochim. (Moskva), 7, p. 667—672.
SRETENSKAJA, N. G., 1964: Razpredelenije elementov — primesej v raznych gene-

raciach mikroklina iz pegmatitov Vostočnogo Kazachstana. D AN SSSR (Moskva), 154, 3, p. 621—623.
STAVROV, O. D., 1963: Osnovnyye čerty geochimii litija, rubidija, cezija v processe stanovlenija granitnych intruzivov i svjazanych s nimi pegmatitov. Geol. Mestor. red. element. (Moskva), 21, p. 3—140.
ŠMAKIN, B. M., 1979: Composition and structural state of K-feldspars from some U.S. pegmatites. Amer. Mineral. (Washington) V 64, p. 49—56.
ŠMAKIN, B. M. — KOSTJUKOVA, E. S., 1969: Geochimija barija i stroncija v muskovitovych pegmatitach Vostočnoj Sibiri i Indii. Geochimija (Moskva), 10, p. 11124—1237.
TAYLOR, S. R. — HEIER, K. S., 1958 a: Alkali elements in potash feldspar from the pre-Cambrian of southern Norway. Geochim, cosmochim, Acta (London), 13, p. 293—302.
TAYLOR, R. S. — HEIER, K. S. — SVERDRUP, T. L., 1960: Contribution to the mineralogy of Norway. Nor. geol. Tidskr. (Oslo), 40, p. 133—156.
ÜBERLA, K., 1974: Faktorová analýza. Slovenský preklad. Alfa, Bratislava, 334 p.
VLASOV, K. A., 1952: Teksturno-paragenetičeskaja klasifikacija granitnych pegmatitov. Izv. Akad. Nauk SSSR, Ser. Geol. (Moskva) 2, p. 30—56.
VLASOV, K. A., 1961: Principy klasifikacii granitnych pegmatitov a ich teksturno-paragenetičeskije tipy. Izv. Akad. Nauk SSSR, ser. Geol. (Moskva), 1, p. 8—29.
WEDEPOHL, K. M., 1956: Untersuchung zur Geochimie des Bleies. Geochim. cosmochim. Acta (London), 10, p. 69—148.

Review by B. CAMBEL

Manuscript received March 7, 1980