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THE GRADE OF ORDER OF POTASSIUM FELDSPARS OF PEGMATITES IN THE TATRIDES

(Fig. 1—10).

Abstract: The objective of the work is the study of the structural state of potassium feldspars of pegmatites in the Tatrides and its interpretation to genetic conditions. The structural state as grade of order of potassium feldspars has been found out from optical and X-ray data. It has been established that for determination of the potassium feldspar modification several methods should be selected. The majority of potassium feldspars of pegmatites from the Tatrides have been determined as perthitic maximum microline, intermediate microlines and only a small amount as orthoclase pertite. The grade of order of potassium feldspars increases from the margin of pegmatite bodies towards the centre and independently on the colour of potassium feldspars. Direct dependence has been found between triclinity and the size of crystals. The lowest degree of triclinity display feldspars from porphyroblasts, indicating different conditions of their formation.

Резюме: Целью работы является изучение структурного состояния калиевых полевых шпатов пегматитов татрид и его интерпретация в связи с генетическими условиями. Структурное состояние в качестве степени упорядочения калиевых полевых шпатов определялось помощью оптических и рэнтгенометрических данных. Установлено, что для определения модификации калиевого полевого шпата надо применять больше методов. Большинство калиевых полевых шпатов из пегматитов татрид установлены как пертитовые максимальные микроклины, переходные микроклины и только ничтожное количество отнесено к ортоклаз пертиту. Степень упорядочения калиевых полевых шпатов поднимается от каймы пегматитов в центр и независимо от цвета калиевых полевых шпатов. Между триклинностью и размером кристаллов установлена прямая зависимость.

Ideal formulas for feldspars are MT_4O_8 or DT_4O_8 where M represents an univalent element and D a bivalent element. In positions M may occur K, Na, more rarely Rb, Cs and in positions D Ca, more rarely Ba, Sr, Pb. At high temperatures Na and K may occur in positions M in various proportions. The same is valid also for representation of Ca and Na but not for representation of Ca and K. T positions are occupied by Si or Al, which may be variously distributed in tetrahedron skeletons. According to the character of distribution ordered and unordered states are forming.

Already T. F. W. Barth (1934) supposed that polymorphic modifications of K-feldspar are evoked by distribution of Si and Al in positions T. This supposition was confirmed by later studies (W. F. Cole et al., 1949; S. W. Bailey, W. H. Taylor, 1955 and other authors). Completely unordered feldspars have monoclinic symmetry and are triclinic-ordered. Monoclinic and triclinic symmetry are only marginal states of structure, between which there are various transitions caused by distribution of atoms in T positions and the

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presence of domains of various structural states. The modes of order are different in $AlSi_3$ and Al_2Si_2 groups.

In monoclinic alkalic feldspars are 2 positions T of atoms T_1 and T_2 and in triclinic ones are 4 positions T of atoms-T_1O, T_1m, T_2O, T_2m.

According to T. F. W. Barth (1969) potassium feldspars have 3 extreme variants regarding to distribution Al/Si: 1. Al/Si distribution is completely unordered and in ratio 1:3 Al:Si will be 25 Al and 75 Si in positions T_1 and T_2 in monoclinic system. Comparing with triclinic feldspars with four positions T, Al occupies each 25. To this state corresponds the formula $K(AlSi)_4O_8$, 2. Si occupies positions T_2O and T_2m. In positions T_1O and T_1m is Al statistically distributed up to 50. The formula for such a feldspar is $K(AlSi)_2Si_2O_8$, 3. One of four positions T, i. e. T_1O is occupied by Al and the others by Si. This is a completely ordered distribution with the formula $KAlSi_3O_8$.

Alkalic feldspars formed at high temperatures are not only disordered but also form solid solution. With sinking temperature substitutional disordered structure becomes unstable and the solid solution passes into stable state but to one ordered phase or mechanical mixture of two phases with own order. According to H. D. Megaw (1962) it depends only on the circumstance whether equal atoms have the tendency to occur side by side or prefer other atoms.

The change of symmetry from monoclinic to triclinic in alkalic feldspars is characterized by arrangement of structural domains. A typical product of changes is the intime domain structure, in which the domains are connected according to the albite and pericline law. If twining is balanced, the feldspars are optically monoclinic, if not, the optical properties are triclinic. Therefore it is possible that optically monoclinic feldspar is determined as X-ray triclinic. F. Laves (1952) mentioned 3 types of monoclinic feldspars after the fact, whether optical and X-ray data point to monoclinic symmetry or X-ray data point to triclinic symmetry, which may be shown by various intensity of diffusion of reflections of some surfaces. For this reason J. V. Smith (1974) suggests to specify symmetry according to the applied method.

In the work presented the subject of study are potassium feldspars of pegmatites from the Tatrides and some porphyroblasts from the surrounding rocks. On the basis of microscopic analysis from 650 samples 110 were chosen for a more detailed study of the structural state. The studied potassium feldspars of pegmatites are from various zones of relatively slightly differentiated pegmatites from the Malé Karpaty, Low Tatra, Western Tatra, Veľká Fatra, Malá Fatra, Malá Magura, Žiar, Branisko and Čierna Hora. The majority of potassium feldspar samples are from the zone of block microcline and quartz-feldspar-mica zone, a lesser amount from the graphic and aplite zone of pegmatites. The porhyroblasts are from various types of granitoids and migmatite gneisses to migmatites from the vicinity of pegmatites. Designation of samples in the tables and graphs is in accordance with the localization mentioned in the work by Š. Dávidová (1977).

The investigated potassium feldspars belong to various types of perthites. Mostly spread are net, fibrous and banded macroperthites, less frequent are spotted perthites. From genetic viewpoint segregation perthites predominate over unmixing, segregational metasomatic, and recrystallization perthites.

Optical properties

Optical properties of potassium feldspars are depending roughly on three main factors: a) chemical composition, b) structural state, c) submicroscopic twinning. All these factors have not equal influence on optical constants. To the optical constants providing most information on the structural state belong the angle of optical axes, position of plane of optical axes, extinction angle $N\alpha\Lambda(010)$ on surface (001), $N\gamma\Lambda\perp(010)$- or $N\beta\Lambda\perp(010)$ in section (001) and birefrigence „b" $-\alpha$ where „b" is index of refraction of optical direction, which oscillates most parallel with crystal axis b.

In the potassium feldspars studied the following optical data were measured: 1. $N\alpha\Lambda(010)$, 2. $2V\alpha$, 3. $N\gamma\Lambda\perp(010)$ and 4. position of the plane of optical axes.

1. The angle $N\alpha\Lambda(010)$ was determined on plane stage in the surface (001) on fissile fragments of crystals as an average of 40 measurements.

2. The position of optical axes and the angle of optical axes were determined on 5-axes Fjodorov's stage in orthoscopic or conoscopic way. Determination of the angle of optical axes was carried out in thin sections specially ground according to plane (100) so that determination of angle 2V should be from the exit of two optical axes. The number of measurements in the individual samples varied from 5 to 10. The attained preciseness does not exceed $\pm 3°$ also with application of the conoscopic method.

3. Angle $N\gamma\Lambda\perp(010)$ was read from graphs on Vulf's net, which were constructed in determination of the above mentioned relations on Fjodorov's stage. The attained preciseness varies around $\pm 4°$. The error may be greater if polysynthetic twinnings according to the albite and pericline law are present.

Results of measurements

The measured optical characteristics are mentioned in Table 1. In the first column are quoted the angles of oblique extinction on plane (001) as angle $N\alpha'$ to fissile fissures according to plane (010). The values measured vary from 0 to 18°. Measurements on surface (001) are lying in zone (010) and therefore feldspars with monoclinic symmetry have the mentioned angle of oblique extinction equal to 0 and feldspars with triclinic symmetry reach various values according to several authors. According to A. Hall (1966) in untwinned potassium feldspars the angle of oblique extinction on plane (001) varies from 0 to 16°, according to 0. F. Tuttle (1952) from 4 to 19° and according to A. N. Winchell-H. Winchell (1951) from 0 to 15°. In Table are mentioned the average values from 40 measurements. The data designated with cross included measurements with zero value of the angle of oblique extinction. A survey of distribution of the values of the angle of oblique extinction is given in the histogram of relative frequency in Fig. 1. It is evident from the data that in the feldspars observed the angle of oblique extinction most often varies within the range of 8 to 16°, roughly corresponding to medium ordered to triclinic potassium feldspars. There are only very few monoclinic potassium feldspars determined on the basis of the angle of oblique extinction in pegmatites of the Tatrides although zero values were measured for many intermediate potassium feldspars in determination of the extinction angle. It would be necessary to

Table 1
Optical characteristics and modification of potassium feldspars from Tatride pegmatites

Continuation 1.

Sample	N α △ (010)	2V α	S_{tr}	N γ △ ⊥ (010)	$\triangle_o$	$\triangle_r$	Or	modification	
								after. opt. data	after $\triangle_r$
MK-24/2		82	0,95			0,86	72	micro-cline	max. microcl.
MK-76/2						0,90	67		max. microcl.
MK-78/2						0,90	74		max. microcl.
MK-86/2	17	82	0,95	17	0,94	0,95	74	micro-cline	max. microcl.
MK-96/2b		82	0,95	18	1,00	0,95	72	micro-cline	max. microcl.
MK-96/2s	15	82	0,95	17	0,94	0,90	72		max. microcl.
MK-163/2						1,00	73		max. microcl.
MK-17/3b	14	84	1,00	16	0,89	0,97	73		max. microcl.
MK-17/3s	15	82	0,95	15	0,83	0,93	74		max. microcl.
MK-60/3						0,85	76		max. microcl.
MK-63/3						0,93	72		max. microcl.
MK-67/3						1,00	68		max. microcl.
MK-6/4	18	80	0,90	16	0,89	0,90	74	micro-cline	max. microcl.
MK-20/4		80	0,90			0,98	69	micro-cline	max. microcl.
MK-28/4	16	86	1,05	18	1,00	0,85	74	micro-cline	max. microcl.
MK-10/5						0,91	70		max. microcl.
NT-1	12	78	0,85	14	0,78	0,76	77	micro-cline	max. microcl.
NT-8	14ˣ	76	0,80			0,79	55	micro-cline	max. microcl.
NT-9	9⁺	68	0,60			RD	76	ortho-clase	RD K-feld-spar

Table 1. Continuation 2.

Sample	$N\alpha \triangle$ (010)	$2V\alpha$	S_{tr}	$N\gamma \triangle \perp (010)$	Δ_o	Δ_r	Or	modification	
								after. opt. data	after Δ_r
NT-13	9^{+}	70	0,65			0,69	63	ortho-clase	RD K-feld-spar
NT-15	8^{+}	76	0,80			0	47	ortho-clase	ortho-clase
NT-27						0,80	66		max. microcl.
NT-31	9^{+}	70	0,65	12	0,67	0,34	82	ortho-clase	RD ortho-clase
NT-32	4^{x}			0,0	0,0	0,0	66	ortho-clase	ortho-clase
NT-34	16	80				0,93	72	micro-cline	max. microcl.
NT-37	15	81	0,93	16	0,89	0,86	71	micro-cline	max. microcl.
NT-40	12	80	0,90	12	0,67	0,76	78	micro-cline	max. microcl.
NT-45	8^{+}	78	0,85	8	0,44	ORD	62	ortho-clase	RD ortho-clase
NT-52	12^{+}	78	0,85			0,59*	54	ortho-clase	RD micro-cline
NT-54	10^{+}	74	0,75			0,66	72	ortho-clase	RD micro-cline
NT-57		78	0,85	12	0,67	0,0	68	ortho-clase	ortho-clase
NT-58	11^{+}					0,91	69		max. microcl.
NT-59	10^{+}	72	0,70	9	0,50	0,41	78	ortho-clase	RD ortho-clase
NT-66	12	85	1,03			0,80	46	micro-cline	max. microcl.
NT-67	12	78 58	0,85 0,35	14 0	0,78 0,0	0,64	81	micro-cline ortho-clase	RD micro-cline
NT-73	15^{+}	76	0,80			0,91	83	micro-cline	max. microcl.
NT-80						ORD	39		RD ortho-clase

Table 1. Continuation 3.

Sample	N α △ (010)	2V α	S_{tr}	N γ △ ⊥ (010)	$\triangle_o$	$\triangle_r$	Or	modification after. opt. data	modification after $\triangle_r$
NT-91	13					0,70	76		RD micro-cline
NT-93		72	0,70				74	ortho-clase	
NT-97	6^+	64	0,50	6	0,33	RD	79	ortho-clase	RD K-feld-spar
NT-101	9^+	78	0,85			0,30	38	ortho-clase	RD ortho-clase
NT-108	6^+	64	0,50			0,85	76	ortho-clase	max. microcl.
NT-110	9^+						80	ortho-clase	
NT-111						0,75	80		max. microcl.
NT-114	0	68	0,60	2	0,28	0,0	81	ortho-clase	ortho-clase
NT-120	10^+	72	0,70	10	0,55	0,69	77	ortho-clase	RD micro-cline
ZT-1	16					0,95	74	micro-cline	max. microcl.
ZT-3	10	82	0,95	13	0,72	0,73	72	micro-cline	max. microcl.
ZT-6	10^+	72	0,70	10	0,55	0,65	77	ortho-clase	RD micro-cline
ZT-15	13					0,75	62	micro-cline	max. microcl.
ZT-16		74	0,76			0,0	44	ortho-clase	ortho-clase
ZT-20	13	88	1,10	18	1,00	1,00	66	micro-cline	max. microcl.
ZT-22	15					0,95	63	micro-cline	max. microcl.
ZT-41	15	80	0,90	16	0,89	0,85	52	micro-cline	max. microcl.
ZT-41p	10	76	0,80	14	0,78		63	micro-cline	
ZT-49				16	0,89	0,86	69		max. microcl.

Table 1. Continuation 4.

Sample	N α △ (010)	2V α	S_{tr}	N γ △ ⊥ (010)	$\triangle_o$	$\triangle_r$	Or	modification	
								after. opt. data	after $\triangle_r$
ZT-50	16	84	1,00	18	1,00	0,95	62	micro-cline	max. microcl.
ZT-52						0,85	68		max. microcl.
ZT-76				14	0,78	0,91			max. microcl.
VF-51		76	0,80	14	0,78	0,79	58	micro-cline	max. microcl.
VF-61a		84	1,00	16	0,89	0,88		micro-cline	max. microcl.
VF-61p	15	83	0,96	16	0,89	0,74	65	micro-cline	max. microcl.
VF-63		82	0,95	17	0,94	0,82	69	micro-cline	max. microcl.
VF-70	13⁺	86	1,05	15	0,83	0,86	68	micro-cline	max. microcl.
VF-75a	10	86	1,05	15	0,83	0,85	61	micro-cline	max. microcl.
VF-75p	16	84	1,00	16	0,89	0,85	72	micro-cline	max. microcl.
VF-82						0,85	61		max. microcl.
MM-19a	10⁺	88	1,10	14	0,78	0,86	76	micro-cline	max. microcl.
MM-19s						0,75	75		max. microcl.
MM-22	13⁺	72	0,70	13	0,72	0,66	80	ortho-clase	RD micro-cline
MM-27		82	0,95	18	1,00	0,76	75	micro-cline	max. microcl.
MM-33p	14	77	0,83	14	0,78	0,73	71	micro-cline	max. microcl.
MM-33b	10⁺	84	1,00			0,63	71	micro-cline	RD micro-cline
MM-53		80	0,90			0,73	67	micro-cline	max. microcl.
MM-61		84	1,00			0,83	75	micro-cline	max. microcl.

Table 1. Continuation 5.

Sample	N α $\triangle$ (010)	2V α	S_{tr}	N γ $\triangle$ $\perp$ (010)	$\triangle_o$	$\triangle_r$	Or	modification	
								after. opt. data	after $\triangle_r$
MM-64	10^{+}	84	1,00	12	0,67	0,61	72	micro-cline	RD micro-cline
MM-65		78	0,85			ORD	71	micro-cline	RD K-feld-spar
MM-66		72	0,70			0,83	69	ortho-clase	max. microcl.
MM-67		84	1,00			0,90	75	micro-cline	max. microcl.
Ž-2		78	0,85			0,72	68	micro-cline	max. microcl.
Ž-4				18	1,00	0,81	64		max. microcl.
Ž-5						0,88	64		max. microcl.
Ž-9		76	0,80			0,78	67	micro-cline	max. microcl.
Ž-13		70	0,65			RD	58	ortho-clase	RD K-feld-spar
Ž-18		72	0,70			0,51	65	ortho-clase	RD K-feld-spar
MF-3		82	0,95	16	0,89	0,88	70	micro-cline	max. microcl.
MF-5						0,38	42		RD ortho-clase
MF-21						0,88	68		max. microcl.
MF-22						ORD	42		RD ortho-clase
MF-23						0,88	74		max. microcl.
MF-25b		70	0,65			RD	64	ortho-clase	RD K-feld-spar
MF-25r		68	0,60	12	0,67	0,63	68	ortho-clase	RD micro-cline
MF-29		70	0,65			0,73	72	ortho-clase	max. microcl.

Table 1. Continuation 6.

Sample	N α △ (010)	2V α	S_{tr}	N γ △ ⊥ (010)	$△_o$	$△_r$	Or	modification after. opt. data	modification after $△_r$
MF-32		72	0,70			0,0	67	orthoclase	orthoclase
MF-36		76	0,80			0,0	65	microcline	orthoclase
MF-37		72	0,70			RDM	61	orthoclase	RD microcl.
MF-87		80	0,90	17	0,94	0,75	79	microcline	max. microcl.
B-1		84	1,00			RD	47	microcline	RD K-feldspar
B-5						0,80	61		max. microcl.
B-7		82	0,95			0,98	57	microcline	max. microcl.
B-8		86	1,05			ORD	44	microcline	RD orthoclase
B-11	12	82	0,95	14	0,78	0,86	72	microcline	max. microcl.
B-15		82	0,95			0,85	72	microcline	max. microcl.
ČH-20		74	0,75			0,86	65	orthoclase	max. microcl.
ČH-24	16	86	1,05	17	0,94	0,85	67	microcline	max. microcl.
ČH-30		80	0,90			0,86	80	microcline	max. microcl.
ČH-38		82	0,95			0,85	81	microcline	max. microcl.
DB	0	65	0,53	0,0	0,0	0,0		orthoclase	orthoclase
KV	0	57	0,33	0,0	0,0	0,0		orthoclase	orthoclase

carry out measurements of microscopic blocks within individual crystals or individual grains within one sample.

In the second column of Tab. 1. are placed the values of the angle of optical axes. All the measured values of the angle of optical axes are negative. They vary from 58 to 88°. The idea of frequency of angle 2V values is given in histogram, Fig. 2. The most frequent value of 2Vα is that of 79 to 82°. These data are partly different from the measurements mentioned by V. Mrmo (1955). The asymmetrical character of the histogram with the maximum at higher $2V\alpha$ angle values points to most potassium feldspars as belonging to triclinic symmetry also on the basis of $2V\alpha$ angle measurement. The angle $2V\alpha$ was the basis value for determination of the modification of potassium feldspars according to optical data. The limiting value for distinguishing of microcline and orthoclase was $2V = -76°$. taking into account the values $N\alpha\Lambda(010)$ and $N\gamma\Lambda\perp(010)$.

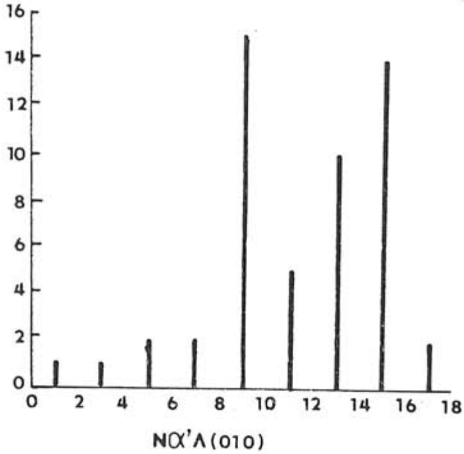


Fig. 1. Histogram of relative frequency of angle Nα'1 (010) in potassium feldspars of Tatride pegmatites.

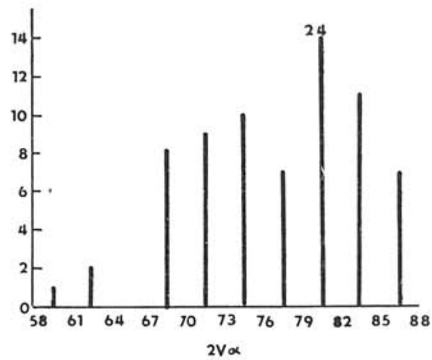


Fig. 2. Histogram of relative frequency of angle of optical axes of potassium feldspars from Tatride pegmatites.

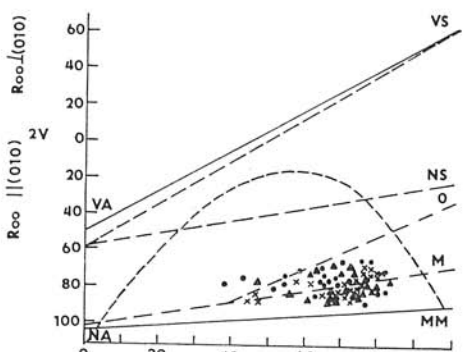


Fig. 3. Projection points of values of potassium feldspars from Tatride pegmatites in the diagram of dependence of 2V and chemical composition according to J. V. S m i t h (1974), p. 380. 1 — grey, 2 — white, 3 — pink potassium feldspars. NA — low albite, VA — high albite, VS — high sanidine, NS — low sanidine, O — orthoclase, M — microcline, MN — maximum microcline. Long dashed lines separate 4 series of alkalic feldspars. The dashed curve delimits the field of perthites.

The angle of optical axes together with chemical composition was used for total characterization of potassium feldspars according to the diagram compiled by O. F. T u t t l e (1952) represented in Fig. 3 and completed by J. V. S m i t h (1974).

Chemical composition of potassium feldspars was calculated from partial chemical analyses by which contents of Na_2O, K_2O and CaO were determined by the method described by J. Polakovič – J. Polakovičová (1966). In some samples the CaO content was determined by atomic absorption. The analyses were carried out by Ing. Polakovičová and Ing. Streško from the Geological Institute of the Natural Science Faculty of the Comenius University.

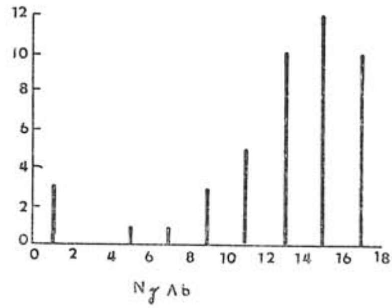
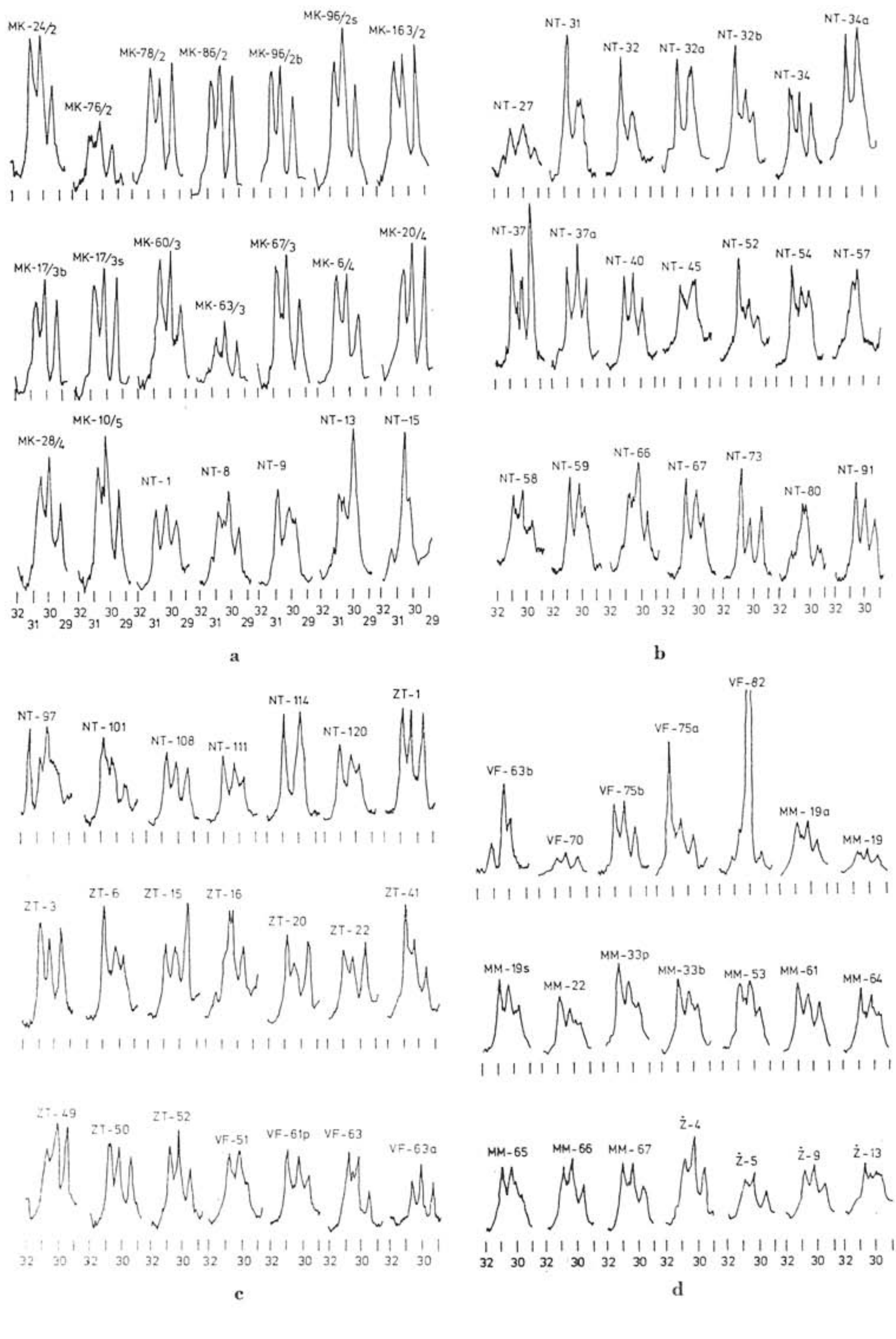


Fig. 4. Histogram of frequency of the angle $N\gamma \triangle \perp$ (010) in potassium feldspars of Tatride pegmatites.

The projection points of all the studied potassium feldspars, on the basis of 2V and chemical composition, fall into the field of perthites, separated by a dashed line from nonperthitic feldspars. The majority of points are concentrated in the series maximum microcline-low albite and microcline-low albite. Only a part of the samples falls to the series orthoclase cryptoperthite, totally agreeing with the data mentioned in Tab. 1. and later determinations on the basis of X-ray data. From the graph in Fig. 3 is evident, that placement into the individual series is not depending on the colour of feldspars, which in the crystalline region of the West Carpathians perhaps expresses the genetic type.

Submicroscopic twinning has only little influence on the 2V value. The content of cryptoperthite has also slight influence on the 2V value. According to A. S. Marfunin (1962) 2V raises by 5 to 7° when the content of cryptoperthite increases up to 40 % of Ab component. This little influence of other factors than order allows to apply 2V as criterion of the grade of order of potassium feldspars.' Triclinic order is expressed by the scale from 0 to 1 similarly as X-ray triclinity. The grade of order $S_{tr} = 0{,}025\ (2V-44)$ according to A. S. Marfunin (1962). The calculated values S_{tr} are mentioned in the third column of Tab. 1. In some samples S_{tr} values exceed the unit value although the later should represent samples with maximum triclinity. This deviation is evident from the extent of 2V determined on interpolation by A. S. Marfunin (1962) who chose the interval $2V = -44°$ to $-84°$. If we, however, consider that maximum microclines have 2V to $-88°$, so the constant has to be changed to 0,0228 in calculation of S_{tr}.

The grade of triclinity is also measured with deviation $N\gamma$ from $\perp$(010), which is zero in monoclinic feldspars and may attain the maximum value 18° in triclinic ones. The measured values of angle $N\gamma \Lambda \perp$(010) are in Tab. 1. in the fourth column. The measured values for potassium feldspars of Tatride pegmatites vary from 0° to 18°. Their frequency is expressed in graph Fig. 4. This histogram is of similar character as histogram 2V. The shape of histogram indicates that neither minimum nor maximum values predominate. Most frequent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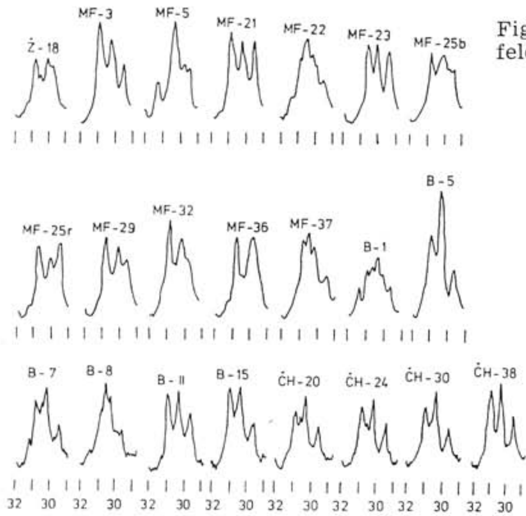

Fig. 5. Diffraction records of potassium feldspars from Tatride pegmatites in the area 29–32 2ϑ.

are the values between 14° and 16°. The measured values of angle $N\gamma\Lambda\perp(010)$ were the basis for calculation of optical triclinity Δ_o according to A. S. Marfunin (1962). The results are given in Tab. 1.

The order is not the only factor determining the value of optical triclinity. Optical triclinity depends also on submicroscopic twinning, which does not influence the 2V values. Therefore the value of optical and S_{tr} triclinity which are recalculated to one comparable base need not be equal.

The values of angles $N\gamma\Lambda\perp(010)$ in this table sometimes do not correspond to the values of potassium feldspars, modifications of which are mentioned in the last two columns of Table 1. In the nomenclature of feldspars on the basis of optical properties it was taken into account only marginally as it belongs to most precisely measured constants. Its unaccuracy results from two sources. On the one hand unaccuracy is caused by weak evidence of fissility along surface (010) in thin sections and it is often difficult to set up for measuring. On the other hand the constant was only obtained on the basis of one measurement and is not the average of several meauserements as e. g. $N\alpha'\Lambda(010)$. It was placed into Tab. 1. in order to point to the possibilities of application of the individual optical characteristics.

For comparison of the properties potassium feldspars from two known localities are summarized in Tab. 1., orthoclase from Lokeť near Karlove Vary (KV) and orthoclase from Dolné Bory (DB). In orthoclase KV the angle $2V = -57°$ was measured, agreeing well with the data received by E. Pivec (1973). The data of triclinity, however, disagree. For the Lokeť orthoclase E. Pivec (1973) quotes the value $\Delta_r = 0{,}57–0{,}74$. Our diffractographs did not display indications of triclinity and so this orthoclase served as standard of monoclinic orthoclase.

Determination of the grade of order on the basis of X-ray data

We know that polymorphic modifications of $KAlSi_3O_8$, which we also express by the structural state of potassium feldspars, are depending on Al/Si distribution in feldspar structures. Disordered feldspars have statistically distributed Al atoms in individual T positions. Ordered triclinic feldspars have maximum Al atoms placed in positions T_1O. It means, according to H. Kroll (1973), that Al is in tetrahedron chains parallel with (110) in disordered forms and Al is concentrated in tetrahedrons forming chains parallel with (110) in ordered forms. As the distance Al-O is greater than the distance Si-O in disordered modifications, distances in (110) are greater whereas in ordered modifications are greater distances in (110). This fact may be applied for determination of triclinity. These changes evoked by Al distribution in various positions T are shown in diffraction record mainly on positions of reflexions of planes (060). (204), (111) and (131), where not only shift of lines but also splitting occurs in the last two positions.

The most frequent way of determination of deviation from monoclinic symmetry on the basis of diffraction records is X-ray triclinity. The term triclinity (obliquity) Δ_r was introduced into literature by J. R. Goldsmith. F. Laves (1954a, b) and is calculated according to relation $\Delta_r = 12.5 \cdot (d_{131} - d_{1\bar{3}1})$.

The basis for calculation of Δ_r in-studied samples were diffraction records prepared from powder preparations of separated out potassium feldspars on X-ray goniometer.

Conditions: anticathode Cu, filter Ni, diaphragm 5 and 3, speed 1° per min.. time constant 8 and speed of paper shift 600 min. per hour. The sample was inserted into the holder of preparation in form of pressed powder without using binding agent. For determination of X-ray triclinity records in the sphere $2\vartheta = 18°-32°$ were made. Picture was taken 2x in some samples with standard $KBrO_3$. The records were made in direction of higher diffraction angles by RNDr. E. Šamajová. CSc. from the Geological Institute of the Natural Science Faculty of the Comenius University.

Results of triclinity measurements

Parts of diffraction records that were the basis for Δ_r calculation are in Fig. 5. where the peaks in the area of diffraction angles $2\vartheta = 29°$ to $32°$ are plotted. Already in the diffraction records we observe that the majority of potassium feldspar samples have a doubled peak (131), indicating triclinic symmetry.

The values of X-ray triclinity Δ_r are in Tab. 1. Δ_r in potassium feldspars of pegmatites from the Tatrides varies from 0 to 1.0 and we know that $\Delta_r = 0$ is for monoclinic feldspars and $\Delta_r = 1.0$ is for maximum triclinic feldspars. A survey of distribution of Δ_r values presents histogram in Fig. 6.

As the histogram shows, the most frequent triclinity value is within the range of 0.8 to 0.9, the second most frequent class are the values 0,7 to 0,8 and 0,9 to 1.0. Least is represented the class from 0,1 to 0,2.

As the values of X-ray, optical triclinity and S_{tr} are recalculated to a comparable base, we may them compare mutually. Comparison is given on histogram Fig. 7. The histogram of triclinity values frequency points to a common trend of the individual triclinity types. Most similar course display optical and X-ray triclinity. The lower frequency of optical triclinity in contrast to X-ray one is evoked by lower number of measurements. The frequency in class 0 to 0,1 optical and X-ray triclinity should be reversed but as it was already shown. measurements of angle $N\gamma \Lambda b$ are loaded with errors. Frequency of S_{tr} in the area of triclinic members is different from frequency of optical and X-ray triclinity. Histogram of S_{tr} values is of asymmetric course with most abundant frequency of values 0,9—1. The deviation in this class is caused by the circumstance that also values more than 1,0 were included in these frequencies, as a consequence of $2V\alpha$ angles larger than 84° measured in potassium feldspars of Tatride pegmatites. Establishing the formula for $\triangle_o$, A. S. Marfunin (1962) did not count with a value higher than 84° although $2V\alpha = 84$ to 88° is quoted for microclines currently in literature. Histogram of S_{tr} therefore shifted by 0,1 right. After the new recalculation is made, when a higher value 2V is taken into account, the course of the histogram of S_{tr} values will acquire an analogous course as the histogram of other two triclinity values.

The relations between the individual triclinity types were expressed by means of correlation coefficients and regression lines. The strongest positive correlation has been found between X-ray triclinity and the angle of oblique extinction on surface (001) with correlation coefficient r = 0,929. Strong positive correlation is between the angle $N\gamma \Lambda b$ and X-ray triclinity r = 0,879. Relatively strong is the correlation between the angle of oblique extinction on surface (001) and angles $2V\alpha r = 0{,}714$. Only medium correlation was calculated between the angle

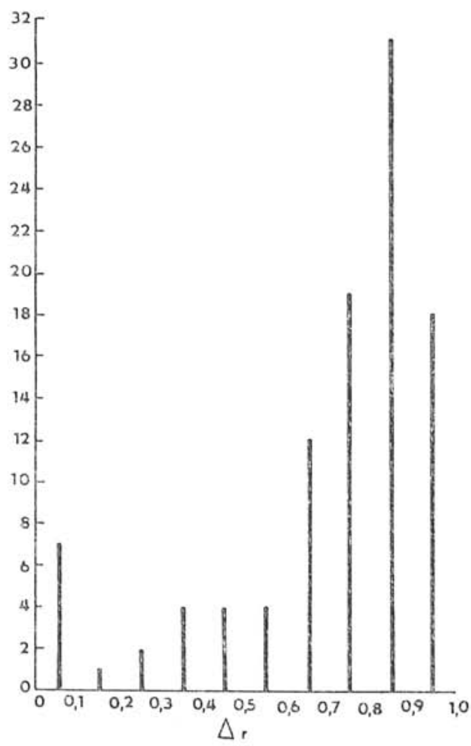

Fig. 6. Histogram of $\triangle_r$ frequency for potassium feldspars from Tatride pegmatites.

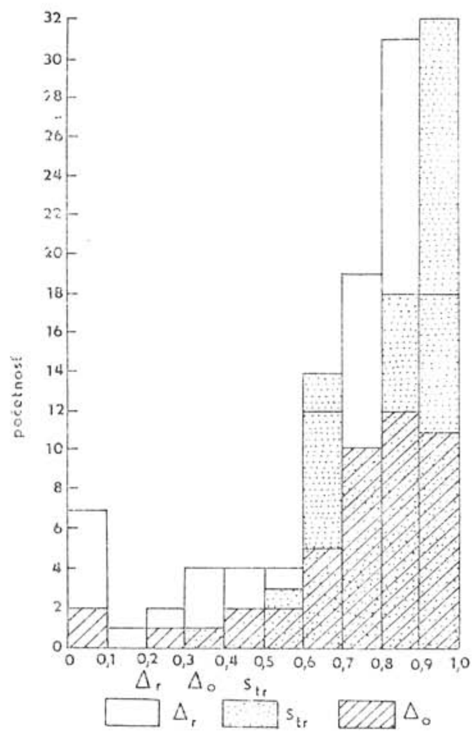

Fig. 7. Complex frequency histogram of optical, X-ray triclinity and S_{tr}.

of optical axes and X-ray triclinity, r = 0,531. Correlation relations between X-ray triclinity and optical constants are in Fig. 8. expressed by regression lines. $N\gamma\Lambda b = 1{,}734\triangle r + 2{,}981$ with 72,2 % regression reliability, $N\alpha'\Lambda(010) = 13{,}125\triangle_r + 2{,}650$ with 86,3 % reliability and $2V\alpha = 11{,}984\triangle_r + 69{,}924$ with 28,2 % reliability only. All these dependences point to the measured optical constants almost parallely increasing with higher X-ray triclinity.

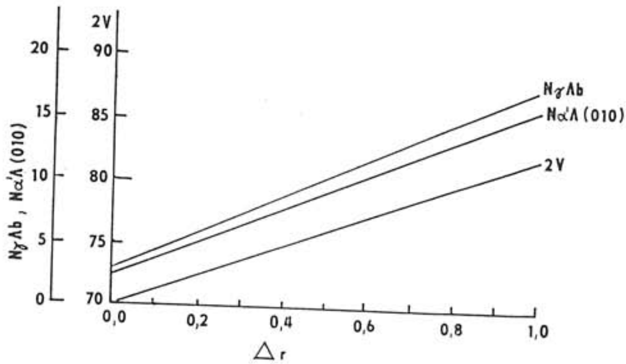

Fig. 8. Lines of regression between the optical constants and X-ray triclinity.

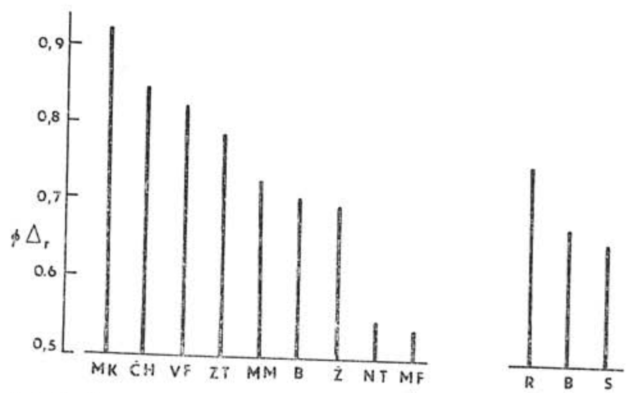

Fig. 9. Average triclinity values of potassium feldspars a) after mountain ranges, b) after colours.

The values of optical constants and X-ray triclinity were the basis for determination of modification of potassium feldspar as mentioned in Tab. 1. In the names the structural state is taken into regard. The column of names has two parts. On the left side are the names of potassium feldspars determined on the basis of optical data. As the main criterion for the names of potassium feldspar the value 2V and the value of the angle of oblique extinction on surface (001) were chosen. The right part of the column contains the names of potassium feldspars, in which X-ray triclinity is taken into regard. The names of potassium feldspars as maximum microcline are in accordance with the designation introduced by G. Guitart-R. R. Raguin-G. Sabatier (1960) for potassium feldspar with Δ_r from 1,00 to 0,80.

Other designations RD-orthoclase, RD-potassium feldspars and RD-microcline were used according to pentamerous series of designation of potassium feldspars, introduced by J. Touret (1967).

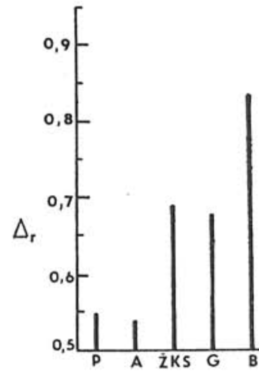

Fig. 10. Average values of X-ray triclinity in potassium feldspars of the individual zones of Tatride pegmatites. P — porphyroblasts, A — aplite and pegmatitoid zone, ŽKS — feldspar—quartz—mica zone, G — graphic zone, B — zone of block microcline.

The values of X-ray triclinity were used for characterization of potassium feldspars in the individual mountain ranges, pegmatite zones and in colours.

The average values Δ_r in feldspars from the individual mountain ranges are recorded in Fig. 9a. Highest triclinity have potassium feldspars from pegmatites of the Malé Karpaty and least pegmatites from the Malá Fatra. When comparing the obtained data with field observations of the character of pegmatite occurrences (Š. Dávidová, 1977) we see that highest triclinity display potassium feldspars from thickest pegmatite forms and lowest from least thick pegmatite forms. Most triclinic modifications with average triclinity $\Delta_r = 0{,}92$ display large crystals of potassium feldspars from thickest pegmatites of the Malé Karpaty Mts. Lowest order $\Delta_r = 0{,}54$ has been found in little thick pegmatite forms of the Malá Fatra. The second place as to the grade of order $\Delta_r = 0{,}83$ is taken up by potassium feldspars of the Veľká Fatra, the third by feldspars from pegmatites of the Western Tatra $\Delta_r = 0{,}79$, the fourth by feldspars from the Malá Magura $\Delta_r = 0{,}73$, the fifth by feldspars from pegmatites of the Branisko $\Delta_r = 0{,}71$, the sixth by feldspars from pegmatites of the Žiar Mts. An exception, according to Fig. 9a, are the Čierna Hora and Low Tatra. The low average value Δ_r for the Low Tatra is caused by the presence of several pegmatite types, of which some contain orthoclases, in this area.

Fig. 9b, tracing relation between triclinity and the colour of potassium feldspars, shows that the greatest average triclinity value display pink feldspars, a lesser one white and the least grey feldspars, the feldspars of all three colour have monoclinic members, with $\Delta_r = 0$ and maximum triclinic, with $\Delta_r = 1{,}00$. Statistically these differences in triclinity in dependence on the colour are insignificant.

An interesting result shows Fig. 10, in which the average of X-ray triclinity values of potassium feldspars from the individual pegmatite zones are plotted. From the margin of pegmatite towards its centre we observe increasing triclinity values. The minimum value $\triangle_r = 0{,}54$ display potassium feldspars from the marginal zone, including the aplite and pegmatitoid zones (A). Nearly an equal value $\triangle_r = 0{,}69$ and 0,68 have potassium feldspars of the feldspar-quartz-mica- and graphic zones. The maximum value $\triangle_r = 0{,}83$ show feldspars of the block microcline zone. A low triclinity value $\triangle_r = 0{,}55$ display porphyroblasts of potassium feldspars in the surrounding rocks, with none of these feldspars determined as maximum microcline.

Discussion

On the basis of optical constants and X-ray data modifications of potassium feldspars from pegmatite of the Tatrides have been established. In optical determination as basis served the angle of optical axes, which from optical constants most truly reflects the structural state. The other optical constants were taken into regard in determination of modification. According to optical properties from 83 examined potassium feldspars 30 were determined as orthoclase, from them 24 after the angle 2V and 6 after the angle of oblique extinction, $2V\alpha$ was more than 76°. The remaining 53 were determined as microcline.

Between the individual optical properties positive correlation has been found out. Strongest one is between the angle of oblique extinction on surface (001) and angle $2V\alpha$ with correlation coefficient $r = 0{,}714$ and regression line.

$N\alpha \Lambda(010) = 0{,}422 \,.\, 2V\alpha - 21{,}534$ with 51 % reliability.

On the basis of X-ray triclinity values, with elaborated broader scale of modifications of potassium feldspars (G. Guitard, R. Raguin, G. Sabatier, 1960; O. N. Christie, 1962; J. Touret, 1967) as in optical evolution, 70 potassium feldspars were determined as maximum microcline, 11 as intermediate RD-microclines, 8 as RD-potassium feldspars, 8 as intermediate RD-orthoclase and only 7 as orthoclases. From 30 optically determined orthoclases six were veryfied by X-ray data only. From the remaining 4 were determined as RD-orthoclases, 6 as RD-potassium feldspars, 7 as RD-microclines, 4 as maximum microclines and 3 have not been determined.

A high correlation between X-ray triclinity and optical constants has been found:

$r_{N\gamma\Lambda b}\triangle_r = 0{,}879$
$r_{N\alpha,\Lambda}(010), \triangle_r = 0{,}929$ and only medium one for 2V
$r_{2V\alpha}$,
with equations of regression lines.
$N\gamma\Lambda_b = 14{,}734 \,.\, \triangle_r + 2{,}981$ with 77,2 % reliability
$N\alpha' \Lambda(010) = 13{,}1 + 5 \,.\, \triangle_r + 2{,}650$ with 86,3 % reliability
$2V\alpha = 11{,}984 \,.\, \triangle_r + 69{,}924$ with 28,2 % reliability.

It results from the above mentioned that if a higher number of measurements of the angles of oblique extinction are carried out, so the statistical average of the results approximates more the X-ray data than the data obtained from 2V measurement. These facts may be clearly observed on histograms Fig. 4 and 7. The fact that 2V has not provided closer data to X-ray ones than the angle of extinction, may be due to lesser preciseness of 2V measurement, which can result from unprecise establishing of the position of extinction in perthitic and often twinned grains. Albite–pericline twinning of potassium phase of perthites, evident in "latticing", is not a criterion for distinguishing of potassium feldspar modifications. Obviously these results are valid for low-temperature potassium feldspars only.

Conclusion

Potassium feldspars of pegmatites from the Tatrides, on the basis of the above mentioned investigation, were ranged into 3 structural groups, which are linked by gradual transition. Most numerous is the group of maximum microclines. Less potassium feldspars belong among intermediate potassium feldspars and only a small percentage were determined as orthoclases, most of which are bound to pegmatites of the Low Tatra. On the basis of chemical composition and optical properties potassium feldspars from Tatride pegmatites are perthites, macro-and less microperthites, which belong to the series microcline – low albite and maximum microcline – low albite, only a small part (5) belongs to the series of orthoclase perthite, not depending on the colour of potassium feldspars.

The changes of the structural stage of potassium feldspars are controlled by many factors. The increase in triclinity, which is the measure of the structural state towards the centre of pegmatite bodies of the Tatrides, points to the possibility of rising effect of volatile components and sinking crystallization temperature in the development cycle of pegmatites. The low grade of order of porphyroblasts of the surrounding rocks of pegmatites where the possibility of rapid crystallization is little probable may be induced by higher temperature of origin than in formation of potassium feldspars of pegmatites.

The conditions of formation of potassium feldspars in pegmatites in the individual mountain ranges seem to have partly been different. Most fluidal components contained the environment of formation of pegmatites in the regions of the Malé Karpaty and Veľká Fatra where potassium feldspars display highest triclinity and least in the Žiar area, with least triclinity. A similar case is also the rate of temperature sinking. In general it may be stated that the environment in which pink potassium feldspars originated, was characterized by slower sinking of temperature and higher content of volatile components than in grey and white potassium feldspars although this relation is valid on an average only.

Translated by J. Pevný

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