GEOLOGICA CARPATHICA, 45, 4, BRATISLAVA, AUGUST 1994
225 - 238

THE GENESIS OF FELDSPARS FROM PEGMATITES OF THE POVAŽSKÝ INOVEC MTS.

ŠTEFÁNIA DÁVIDOVÁ

Department of Mineralogy and Petrology, Faculty of Sciences, Comenius University, Mlynská Dolina, 842 15 Bratislava, Slovak Republic

(Manusript received May 19, 1993; accepted in revised form October 5, 1993)

Abstract: The detailed characteristics of the feldspar from the pegmatites of the Považský Inovec Mts. enabled the construction of a temperature-genetic graph of the formation of pegmatites. K-feldspars are micro- to macroperthites with a wide range structural arrangement of Al-Si in the tetrahedrical position of the K-phase. The Na-phase has an exsolution, exsolution-segregation to autometasomatic character. On the basis of the content of Rb, Cs, Ba, Sr, more differentiated pegmatites can be distinguished from less differentiated. The coexistence of feldspar minerals begins at 625 °C in the feldspar-quartz-mica zone. Exsolution to 410 °C and the process of structural arrangement occur at the same time in the subsolid state. In some areas, Na autometasomatism is brought into the processes of exsolution, during which the albite zone originates in the temperature interval from 316 to 297 °C.

Key words: feldspars in pegmatites, structural arrangement, chemical composition, trace elements, temperature-genetic graph.

Introduction

In the crystalline rocks of the Považský Inovec Mts., pegmatite swarms are developed mostly in 3 areas in the granitoid massifs, and in their immediate surroundings (Fig. 1), and: **1** - in the area of Hrabový Hill (samples 27, 36 - 39), Železnica Valley (1 - 7), Slivničná Valley (8 - 12, 26) and Soľnisko (28, 35), **2** - in the Bojnianská area (14 - 21) and Hradná Valley, where we can trace them best in the old quarries (22, 23, 26), **3** - in the area of Skalničný (31, 32), Strieborničný Potok (29, 30, 34) and in the line of pits at the elevation point of Zlatý Hill in the slopes of Striebornica (33) described by Uher & Broska (1989). The pegmatites are spatially and genetically bound to the Hercynian monazite orogenic granitoids (Broska & Uher 1991) chiefly in areas of occurrence of paragneiss. Only a small part of the pegmatites occurs in the actual metamorphosed facies of the crystalline complex in two-mica paragneiss and migmatites of complex tectogennic development (Korikovsky & Putiš 1986), not far from the contact with the granitoid rocks.

Seven paragenetic mineral zones (Klinčuchová 1989), 5 of them primary, were identified in the pegmatites of the Považský Inovec Mts. These are, zone **1** - aplite, **2** - feldspar- quartz-mica, which is the most wide-spread and simple pegmatites are formed only in them (samples 1, 2, 5, 8, 10, 11, 14, 17, 19, 21, 24, 29, 30, 31, 32, 34), **3** - graphic, **4** - block K-feldspar, and **5** - block quartz, which occurs in the more extensive pegmatite bodies (samples 3, 4, 7, 12, 15, 18, 22, 23, 25, 26, 27, 28, 36, 37, 38), **6** - quartz-muscovite, and **7** - albite belong to autometasomatic zones. The quartz-muscovite zone is more extensive than the albite, sometimes occurring in the form of fan-shaped muscovite, which consists of oriented growths of quartz and muscovite (Dávidová 1970). However more frequently, muscovite forms large arranged flakes in quartz. So far the albite zone was found in the Striebornica area (sample 33) (Uher & Broska 1989) and probably occurs in the area of Hrabový Hill and Soľnisko.

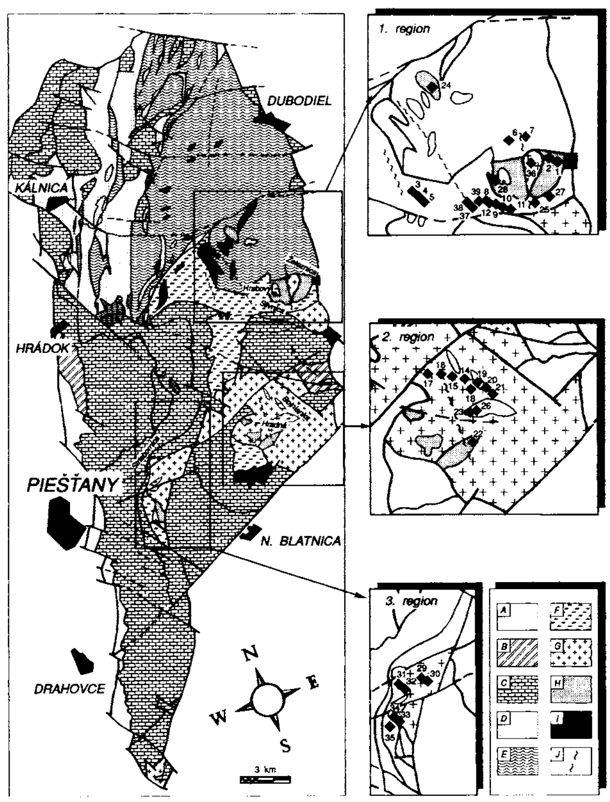

Fig. 1. Location of pegmatite samples on the geological map according to Putiš (in Maheľ 1986). **A** - Neogene and Quaternary, **B** - Central-Carpathian Paleogene, **C** - mantle and nappe units, D-I Tatricum, **D** - Permian and Upper Carboniferous, **E** - migmatized gneiss, banded migmatites, mica schists to phyllonites, **F** - para-gneisses to schist gneisses, **G** - two-mica granites, granodiorites and leucotonalites, **H** - aplite-pegmatite granites, **I** - amphibolites, **J** - mylonite zones.

Fig. 2. Film to short spindle perthites of exsolutional origin (f) with irregularly patchy perthites (n). Block zone pegmatites. Quarry in Hradná Valley sample 23b. Microphoto magnification 130x, crossed nicols.

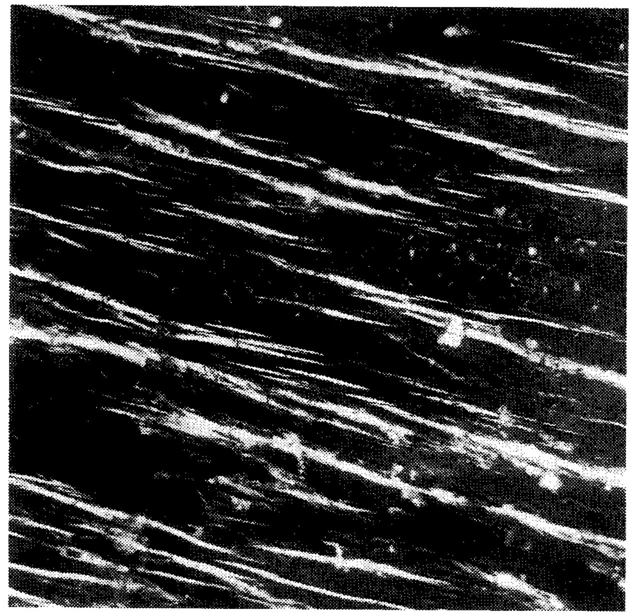

Fig. 3. Fibrous perthites in K-feldspar from the feldspar- quartz-mica zone. Bojnianka Valley sample 15bi. Microphoto magnification 65x, crossed nicols.

In the pegmatites, feldspars are represented by K-feldspars and plagioclases, although K-feldspar prevails over plagioclase, as in pegmatites of other ranges (Dávidová 1970, 1978). Plagioclases such as albites prevail over K-feldspars only in the Striebornica area.

Methods

After microscopic studies of about 80 samples of pegmatites, collected from the outcrop, representative samples were chosen for determination of their structural state (18), and content of cations and trace elements in the feldspar. The separation of K-feldspars and plagioclases from the crushed samples was carried out according to the character of the sample, either only under a wide-field stereomicroscope, or gravimetrically in bromoform, with experimentally determined density. Among the K-feldspar so obtained, an average sample with a content of domains with a varied structural order of Si-Al, and with a content of perthitic growths of plagioclases. Powder X-ray results were prepared on the DRON-3 instrument under constant conditions. E. Šamajová prepared the results at the Geology Institute of the Natural Science Faculty of the Comenius University in Bratislava. The diffraction results were indexed according to Borg & Smith (1969). Cations and trace elements were analysed by the ICP-OES method on the tg KONTRON spectrometer, with induction bound plasma (Ca, Ga, Si, Ba) and AAS (Mn, Fe, Pb, Na, K, Li, Rb, Cs). The chemical composition of feldspar phases in perthites, as well as some homogeneous feldspars, were obtained on X-ray microanalyser JEOL JCXA-733 Superprobe at the D. Štúr Geological Institute at an accelerating voltage of 25 kV and an average beam of 10 μm.

Potassium feldspar

The K-feldspars are mostly grey micro- to macro-perthites, often with a gradual transition to dark grey or white, or occasionally rose colour (sample 19, 22).

Microstructures: In K-feldspars, microstructures form a wide range, which is represented by various types of perthites, or varying origin. The most widespread are segregated and segregated-metasomatic, while exsolution and metasomatic perthites in the sense of the classification of Rudenko (1954).

Film perthites and fine spindle shape perthites belong among the clearly exsolution perthites. They are thinly spread in the aplite and quartz-mica zones. In the graphic and block zones, K-feldspar also occurs rarely, but always together with other types of perthites (Fig. 2). Unmixed small lamellae of Na-phases with film-perthites do not exceed a thickness of 0.007 and a length of 0.1 mm. They always occur only in the non-twinned domains of K-phase potassium feldspar. Most film perthite are oriented approximately according to the plane ($\bar{6}02$), determined on the universal table.

Exsolution-segregated and segregated perthites include spindle-shaped and fibrous perthites (Fig. 3). They are distributed mainly in the graphic zone and the zone of block K-feldspar. They often gradually proceed into braid perthites. The size of perthitic growths varies from 0.007 to 0.1 mm and their length reaches up to 1 mm. Contact with K-phase is frequently irregular among spindle shaped perthites. The course of perthite growths of Na-phase among spindle shape perthites is less united and on average follows levels (110), ($1\bar{1}0$) and (100).

Spindle shaped perthites sometimes gradually proceed into braid, which can usually be considered as segregated-metasomatic (autometasomatic) perthites. Braided perthites (Fig. 4)

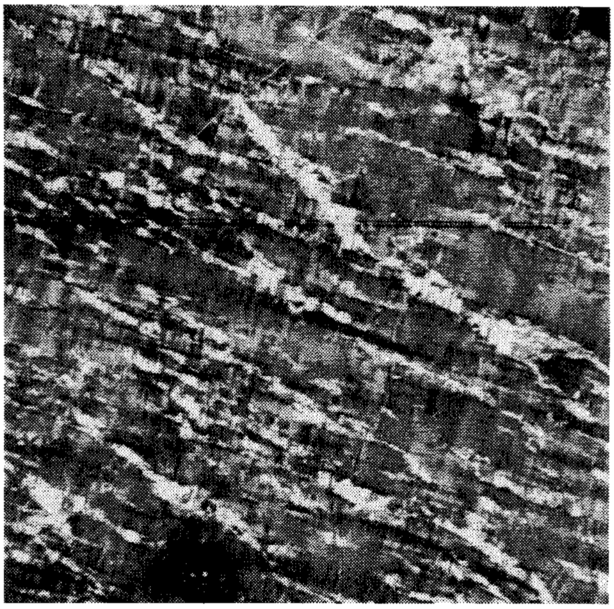

Fig. 4. Spindle-shaped to braided perthites with albite twinning. In the K-phase at the contact with the perthites, we observe the beginning of microcline cross-hatching. Block zone, Hrabový Hill sample 36. Microphoto magnification 35x, crossed nicols.

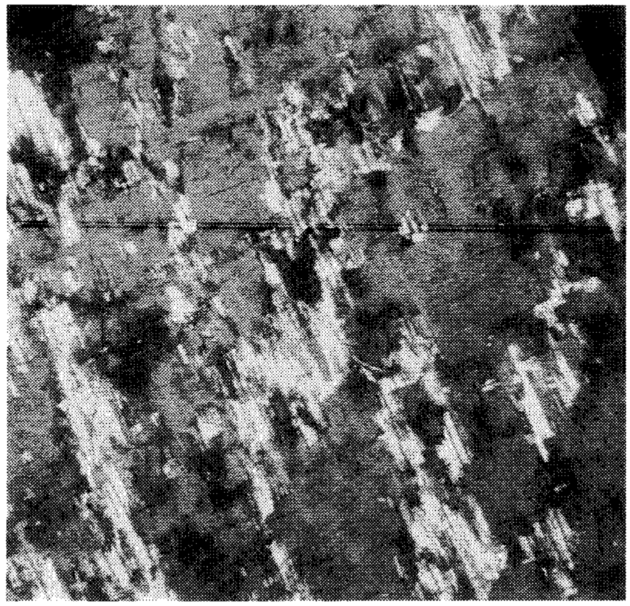

Fig. 5. Beginnings of chessboard albite in untwinned K-phase from block K-feldspar. Striebornica sample 33b. Microphoto magnification 35x, crossed nicols.

are mostly macroperthites, which we can observe with the naked eye. Their maximum thickness is up to 0.6 mm and the length may reach up to 20 mm.

The spatial orientation is consistent with the orientation of spindle-shaped perthites. The course of braiding is mostly uneven. Na-phase is frequently polysynthetically grown according to the albite or very occasionally the pericline law. In the case that K-phase is also twinned, the growth planes are parallel in both phases. They are spatially oriented vertically, or under a large angle to the course of the perthitic growths. The braiding growths of the Na-phase sometimes proceed from one grain of K-feldspar to another, while the accumulation of Na-phase often occurs on the edge of grains.

In some areas braided perthites gradually form chessboard albite (Fig. 5). Irregularly flawed Na-phases are maturely polysynthetically lamelled according to the albite law, while the course of the lamellae is often unfinished. Chemically they are pure albites with a 1 - 2 % An component. In the ternary graph, the compositions of feldspars are close to the peak of the Ab component (Fig. 9). The morphological properties of the braided perthites, as well as the high percentage of the albite component (max. 45 %) in grains of K-feldspars and the development of chessboard albite in the Striebornica area (samples 29, 33), Bojnianska Valley (sample 19), Hrabový Hill (36) show that these perthites did not originate only by the segregation of unmixed Na-phase in the framework of one grain, but the contribution of Na^+ probably in the form of metasomatosis also participated in their origin.

The structural order of K-phase is variable in different grains, but we can also trace differences in the framework of the grain. Under the microscope we observe various degrees of twinning, which is developed as polysynthetic growths according to the albite and pericline law, that is it creates a typical microcline cross-hatching. Marginal possibilities, that is, that a whole grain is without growths (Figs. 3, 5), or entirely cross-hatched (Fig. 6) are rare. Domains

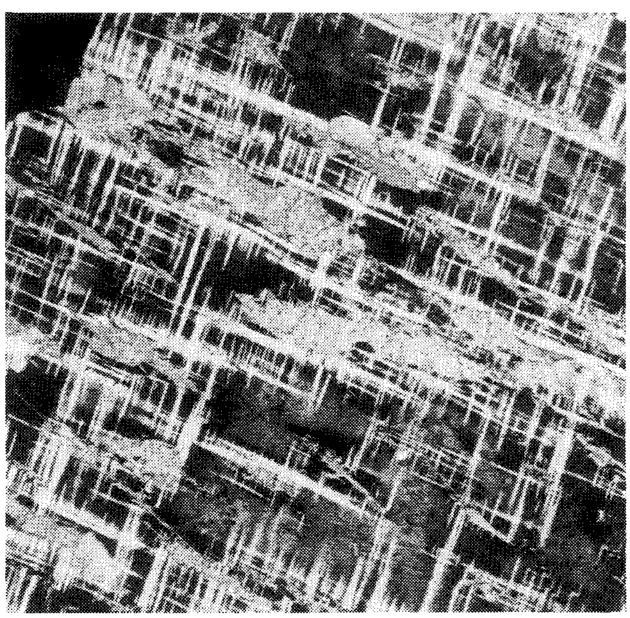

Fig. 6. Microcline cross-hatching of K-phase with irregular braided perthites. K-feldspar from the feldspar-quartz-mica zone. Skalničný Potok sample 32. Microphoto magnification 35x, crossed nicols.

with different degrees of twinning, associated with gradual change exist most frequently in grains. We observe domains with cross-hatching most frequently at the contact with inclusions, or with perthitic growths (Fig. 4), apart from film perthites. The position of grown domains testifies to secondary twining caused by pressure phenomena on the contact of two different environments, which could support the view that the cross-hatching is secondary (Laves 1955; Marfunin 1962; Smith 1974).

Table 1: Cell dimensions of feldspars and structural characteristics of K-feldspars from the pegmatites of Považský Inovec Mts.

												modification according to:		
												Afonina et al.	Smith	Goldsmith
	Colour	Δr^*	AlT_{1o}	AlT_{1m}	$AlT_{2o}=AlT_{2m}$	a (nm)	b (nm)	c (nm)	α^o	β^o	γ^o	1979	1974	1954
K-feldspars feldspar-quartz-mica zone														
6c	grey	0.81	0.8775	0.0475	0.0375	0.8586(6)	1.2967(3)	0.7213(1)	90.47	115.88	88.13	MM	MM	MM
15bi	white	0.38	0.6350	0.2250	0.0700							IM		IO
15s	grey	0.81	0.9100	0.0800	0.0050							MM		MM
22b	grey	0.22	0.6950	0.2450	0.0300	0.8571(14)	1.2941(6)	0.7206(6)	90.00	116.05	90.00	IM	IM	IM
31b	white	0.76	0.8476	0.0640	0.0440	0.8611(0)	1.2960(1)	0.7207(1)	90.16	115.20	88.01	MM		IM
32s	grey	0.55	0.7476	0.1790	0.0370	0.8554(1)	1.2972(1)	0.7218(0)	90.58	116.13	88.01	IM	LM	IO
Plagioclases feldspar-quartz-mica zone														
6d	white					0.8127(6)	1.2766(3)	0.7141(1)	94.14	116.59	87.90			
23a	white					0.8145(1)	1.2836(1)	0.7131(0)	93.49	116.26	89.02			
31b	white					0.8149(0)	1.2798(0)	0.7155(4)	94.22	116.38	87.42			
K-feldspars block microcline zone														
19	pink	0.88	0.9403	0.0030	0.0150	0.8570(0)	1.2957(0)	0.7217(0)	90.22	115.32	87.29	MM	MM	MM
22d	pink	0.80	0.9000	0.0800	0.0100	0.8602(2)	1.2962(9)	0.7222(3)	90.53	115.88	88.11	MM	MM	MM
23b	grey	0.92	0.9739	0.0260	0.0000	0.8574(1)	1.2971(1)	0.7226(0)	90.33	115.57	87.49	MM	LM	MM
28a	grey	0.00	0.4590	0.4590	0.0410	0.8576(2)	1.2965(1)	0.7213(2)	90.00	116.01	90.00	O	IM	O
33b	white	0.00	0.4490	0.4490	0.0520	0.8565(2)	1.2957(1)	0.7205(1)	90.00	115.38	90.00	O	HM	O
36	grey	0.00	0.4700	0.4700	0.0300	0.8582(1)	1.2970(0)	0.7216(1)	90.00	116.02	90.00	O	IM	O
36e	grey	0.80	0.8625	0.0625	0.0375	0.8568(12)	1.2970(5)	0.7214(2)	90.89	116.02	87.76	MM	MM	MM
Albites albite zone														
33c	white					0.8141(1)	1.2787(1)	0.7157(1)	94.15	116.36	87.44			
33d	white					0.8137(1)	1.2782(1)	0.7160(0)	94.27	116.63	87.21			

$r^* = 12.5\,(d_{131} - d_{1\bar{3}1})$, $AlT_{1o} = \frac{1 + \Delta z + 2\Delta ra}{4}$, $\Delta z = 1.47\,(9.38 - \delta\, 2\Theta_{\bar{2}04-060})$, $\Delta ra = 1.264 \cdot \delta\, 2\Theta_{131-1\bar{3}1}$, $AlT_{1m} = 1 + \Delta z - 2\,ra$, $AlT_{2o} = AlT_{2m} = \frac{1 - \Delta z}{4}$;

bi - white, s - grey, K-feldspar from the one sample; a, b, c, d, e, f - feldspars from different zones of one pegmatite body from one locality.

Table 2: Chemical composition of feldspars from the pegmatites of Považský Inovec Mts. determined by X-ray microanalyser expressed in mol % feldspar component.

?Aplite zone						Feldspar-quartz-mica zone								
K-feldspars			Albites			Plagioclases				Perthite K-feldspars				
										K-phase			Na-phase	
Sample No.	33a	33a	33a	33a	33a	10	10	23a	23a	22b	22b	22b	22b	22b
Or	98.02	98.68	0.75	0.58	0.51	1.54	1.68	2.75	2.95	88.39	88.75	93.99	0.76	1.55
Ab	1.98	1.32	97.76	98.43	97.44	94.35	93.50	76.28	75.34	11.42	11.23	5.87	98.16	97.46
An	0.00	0.00	1.49	0.99	0.05	4.11	4.82	20.97	21.71	0.19	0.02	0.15	1.08	0.99
K-feldspar block zone												Albite zone		
Perthite K-feldspars												K-feldspars		
K-phase						Na-phase			Film perthites					
Sample No.	22d	22d	22d	22d	33b	22d	33b	33b	22d	22d	22d	33c	33c	33d
Or	90.89	93.89	92.98	94.42	92.98	0.49	0.52	0.76	87.77	88.76	89.01	98.04	98.52	98.59
Ab	8.79	5.70	6.28	4.51	7.02	98.18	98.40	97.43	11.58	10.89	10.37	1.96	1.48	1.41
An	0.32	0.41	1.04	1.07	0.00	1.33	1.08	1.81	0.65	0.35	0.62	0.00	0.00	0.00
Albite zone														
K-feldspars			Albites											
Sample No.	33e	33f	33h	33c	33c	33c	33d			33e	33h			
							x*	min.	max.		x°	min.	max.	
Or	98.73	95.47	98.50	0.51	0.75	1.03	0.74	0.51	1.01	0.94	0.86	0.01	2.98	
Ab	1.27	4.44	1.50	98.21	98.24	97.94	98.33	93.90	98.50	98.22	96.31	93.91	97.17	
An	0.00	0.09	0.00	1.28	1.04	1.03	0.93	0.75	0.49	0.84	2.83	2.31	2.98	

* - 16 analysis of cleavelandite in average; ° - 10 analysis of sacchroidal albites in average. The same sample numbers coincide to different thin sections and grains, the values are the average of 3 measurements.

Table 3: Microelement contents and feldspar components from the feldspar pegmatites of Považský Inovec Mts.

	Li*	Rb*	Cs*	Sr^+	Ba^+	Ga^+	Mn*	Fe*	Pb*	K*	Na*	Ca^+	Or	Ab	An
	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	ppm	wt. %	%	%			
Feldspar-quartz-mica zone, K-feldspars															
$6c^{\circ}$	0.91	223.7	<3	60.2	178	8.9	7.44	169.5	34.38	9.16	2.23	0.14	69.993	28.965	1.043
$7bi^{\circ}$	1.51	234.1	3.68	31.1	362	12.5	8.34	445.5	25.23	8.29	2.72	0.25	63.007	35.141	1.852
$7s^{\circ}$	1.35	277.3	11.50	35.8	269	12.3	12.17	299.4	42.54	9.94	1.35	0.154	73.778	25.167	1.114
10°	3.94	266.0	7.17	164	1620	13.1	14.24	318.0	60.45	11.33	1.78	0.12	78.286	20.906	0.808
12°	1.74	241.9	<3	373	11800	8.5	8.50	382.8	96.18	10.56	1.84	0.14	76.388	22.627	0.987
$15bi^{-}$	1.63	205.7	3.85	71.6	498	15.4	8.04	134.3	71.76	10.46	1.62	0.11	78.523	20.672	0.805
$15s^{-}$	1.43	86.5	<3	510	10400	8.85	7.04	253.6	42.76	7.35	3.27	0.14	56.344	42.610	1.046
17^{-}	2.45	236.4	10.30	192	1500	11.5	12.68	401.5	74.56	11.50	1.40	0.21	81.650	16.896	1.453
$22bi^{-}$	5.97	593.0	6.41	66	357	11.3	9.54	171.4	157.23	10.66	1.74	0.08	77.835	21.596	0.596
$22s^{-}$	3.80	121.2	<3	203	1990	9.70	13.94	199.0	60.44	6.33	3.35	0.72	49.740	44.745	5.515
$23a^{-}$	2.68	319.6	9.30	120.8	1825	11.52	11.21	291.4	60.77	8.81	1.31	0.25	78.100	19.740	2.160
27°	2.80	276.8	18.10	17.9	69.9	10.9	11.41	339.3	40.40	9.45	2.12	1.146	71.613	27.308	1.078
$30^{)}$	4.00	252.7	7.02	72.7	545	12.0	20.39	348.5	46.93	8.87	2.81	0.59	62.380	33.580	4.040
$31b^{)}$	2.02	297.6	8.34	69.4	455	13.3	11.71	286.6	51.33	11.23	1.76	0.12	78.320	20.865	0.816
$32bi^{)}$	2.51	257.2	9.50	59.7	294	9.20	11.15	308.6	55.12	11.33	1.85	0.12	77.647	21.551	0.802
$32s^{)}$	3.16	261.8	15.80	77.0	406	9.67	9.60	249.6	62.62	11.52	1.80	0.13	78.333	20.805	0.862
$33s^{)}$	4.91	1258.8	39.50	32.5	122	12.1	14.13	339.2	57.89	6.19	1.45	0.04	71.201	28.351	0.448
$35e^{\circ}$	1.38	342.1	10.90	18.2	166.0	16.7	10.24	308.0	53.27	10.90	1.94	0.11	76.198	23.053	0.750
$\bar{x}$	2.68	319.6	9.30	120.8	1825.4	11.52	11.21	291.4	60.77	9.71	2.06	0.19			
Plagioclases															
$6d^{\circ}$	1.93	15.3	<3	62.7	44.0	16.8	17.43	307.2	15.15	0.65	6.89	0.51	5.059	91.148	3.793
21^{-}	4.08	27.20	4.50	278	530	15.80	38.72	65.8	27.06	1.71	5.82	1.51	13.078	75.664	11.258

Continuation of Tab. 3

	Li* ppm	Rb* ppm	Cs* ppm	Sr^+ ppm	Ba^+ ppm	Ga^+ ppm	Mn* ppm	Fe* ppm	Pb* ppm	K* wt.%	Na* %	Ca^+ %	Or	Ab	An
23a⁻	3.42	7.32	<3	620	290	14.5	32.86	510.8	32.86	0.57	6.07	3.69	3.934	71.218	24.848
24c°	2.26	16.7	13.70	745	304	15.2	34.64	269.0	24.86	0.72	5.57	4.64	4.894	64.360	30.746
36a°	1.78	7.07	6.06	142	54.5	12.2	56.15	364.4	27.06	0.62	5.96	1.98	4.889	79.891	15.220
$\bar{x}$	2.69	14.72	5.45	370	244.5	14.9	35.96	303.4	25.40	0.85	6.06	2.47			
Graphic zone K-feldspar															
35d°	1.84	257.7	12.20	39.2	534.0	11.0	5.55	273.4	34.95	8.52	1.97	0.086	71.265	28.048	0.687
Block K-feldspar zone K-feldspars															
19⁻	0.84	153.2	<3	130	1360	9.09	6.54	341.6	55.36	10.59	1.77	0.17	76.938	21.858	1.204
22d⁻	1.17	162.4	3.00	150	2060	8.80	17.27	245.5	80.43	10.06	1.94	0.23	74.069	24,280	1.651
23b⁻	1.44	141.8	<3	31.2	96.8	11.4	15.03	393.8	51.31	8.81	1.31	0.25	78.100	19.740	2.160
28a°	1.82	382.1	18.80	11.7	45.3	12.9	14.08	331.5	49.68	9.81	2.28	0.14	83.973	15.040	0.987
33b)	4.57	1316.4	42.70	27.7	176	14.2	8.92	226.0	29.60	11.85	1.45	0.09	82.278	17.113	0.609
33f°	6.63	1840.1	299.70	38.5	210	12.2	9.86	239.4	24.19	11.22	1.91	0.09	77.095	22.309	0.590
35°	1.89	356.4	12.20	19.0	87.9	18.9	9.95	305.4	46.05	10.63	2.13	0.13	73.936	25.183	0.881
36°	1.44	136.4	<3	205	1270	9.9	18.06	360.7	81.42	12.17	1.44	0.21	89.361	9.136	1.503
$\bar{x}$	2.46	561.1	47.6	76.6	663.3	12.2	12.46	305.5	52.26	10.64	1.78	0.16			
Albite zone Albites															
33d)	2.46	7.8	<3	7.1	8	12.3	10.49	146.3	12.42	0.35	7.10	0.19	2.777	95.754	1.469
33c)	1.99	20.1	7.20	9.8	28	11.6	18.72	49.0	9.08	0.53	7.37	0.29	3.973	93.908	2.119
$\bar{x}$°	1.88	272.2	9.50	88.7	1490.8	12.3	10.91	321.2	51.32	10.07	1.98	0.15	-	-	-
$\bar{x}$⁻	2.29	212.9	4.45	205.8	2149.4	10.42	10.34	262,0	81.87	9.79	2.10	0.22	-	-	-
$\bar{x}$)	3.97	783.5	60.40	59.7	315	11.81	12.25	285.4	46.82	10.32	1.86	0.17	-	-	-

$^+$ - ICP; * - AAS; ° - 1. area; ⁻ - 2. area;) - 3. area. Other explanations see Tab. 1.

Table 4: Phase equilibrium temperatures of feldspars in the pegmatites of Považský Inovec Mts.

?Aplite zone			Feldspar-quartz-mica zone				
Homogeneous feldspars			Homogeneous feldspars			Exsolution of perthites	
Sample No.	33a	33a	10	23a	23a	22b	22b
Ab alk	0.0198	0.0132	0.2090	0.1974	0.1974	0.1142	0.0587
Ab pl	0.9776	0.9843	0.9435	0.7628	0.7534	0.9816	0.9746
T_1°C	280.21	251.77	549.39	597.89	601.63	445.52	371.80
T_2°C	354.82	320.45	582.89	644.27	648.42	521.03	457.03
T_0°C	318	286	566	621	625	483	414

Block K-feldspar zone			Albites zone				
Exsolution of perthites			Homogeneous feldspars				
22d	22d	33b	33c	33c	33d	33e	33h
0.0879	0.0570	0.0702	0.0148	0.0196	0.0141	0.0127	0.0150
0.9818	0.9818	0.9840	0.9821	0.9824	0.9850	0.9822	0.9717
413.68	368.06	388.78	259.53	279.08	256.07	249.40	261.22
459.78	453.03	473.25	329.90	353.45	325.69	317.57	332.00
455	410	431	295	316	291	284	297

Explanations see Tabs. 1, 2. T_1 - according Stormer & Whitney (1977); T_2 - according Whitney & Stormer (1977); $T_0 - x = (T_1 + T_2)/2$.

The structural state of the K-feldspars was determined by powder X-ray results. First the structural state Δr^* was orientationally determined, according to Goldsmith & Laves (1954). The values of Δr^* 1.0 - 0.0 (Tab. 1 - see on the page 228) point to K-feldspar with tricline and monocline symmetry. Δra and Δz, according to Afonina et al. (1979), who used for calculation the distribution Al to the positions T_{1o}, T_{1m}, T_{2o}, T_{2m} (Tab. 1) and the determination of the modification of K-feldspar (Fig. 7). The cell dimensions (Tab. 1) calculated according to the EDCEL programme worked out by Ercit (1988) in the National Museum of Natural Sciences in Ottawa. Their reciprocal values were shown on a graph of the dependence of b* versus c* (Fig. 8). The position of the points on this graph for samples were placed in the areas of maximum, intermediate and high microcline, inasmuch

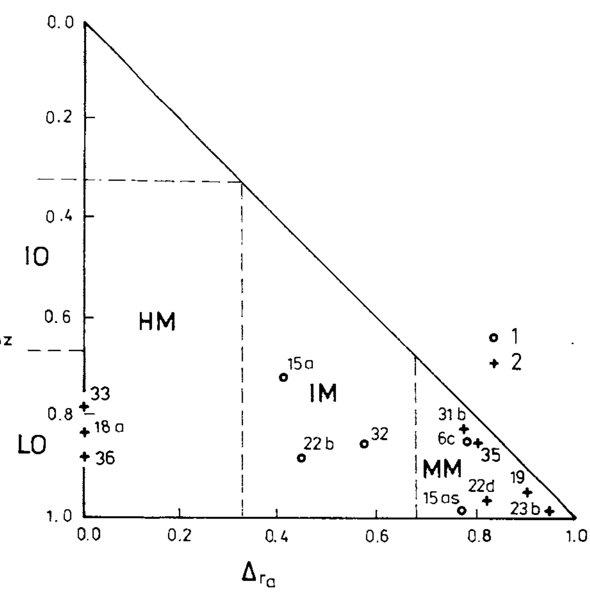

Fig. 7. Classification diagram Δz, Δra (Afonina et al. 1979) of the structural state of K-feldspars from the pegmatites of Považský Inovec Mts. **K**-feldspar, 1- from the feldspar-quartz- mica zone, 2- from the zone of block K-feldspar. **IO** - intermediate orthoclase, **LO** - low orthoclase, **HM** - high microcline, **IM** - intermediate microcline, **MM** - maximum microcline.

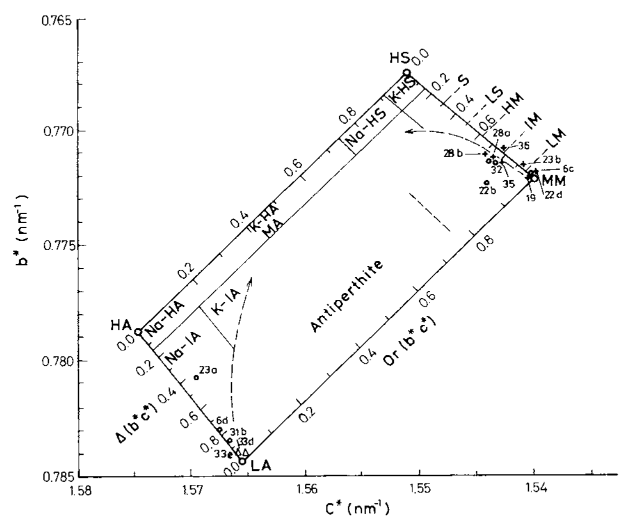

Fig. 8. Classification of K-feldspars from pegmatites of the Považský Inovec Mts. in the graph c* against b* according to Smith (1974). **HA** - high albite, **IA** - intermediate albite, **LA** - low albite, **MA** - monalbite, **HS** - high sanidine, **S** - sanidine, **LS** - low sanidine, **LM** - low microcline, others as in Fig. 9.

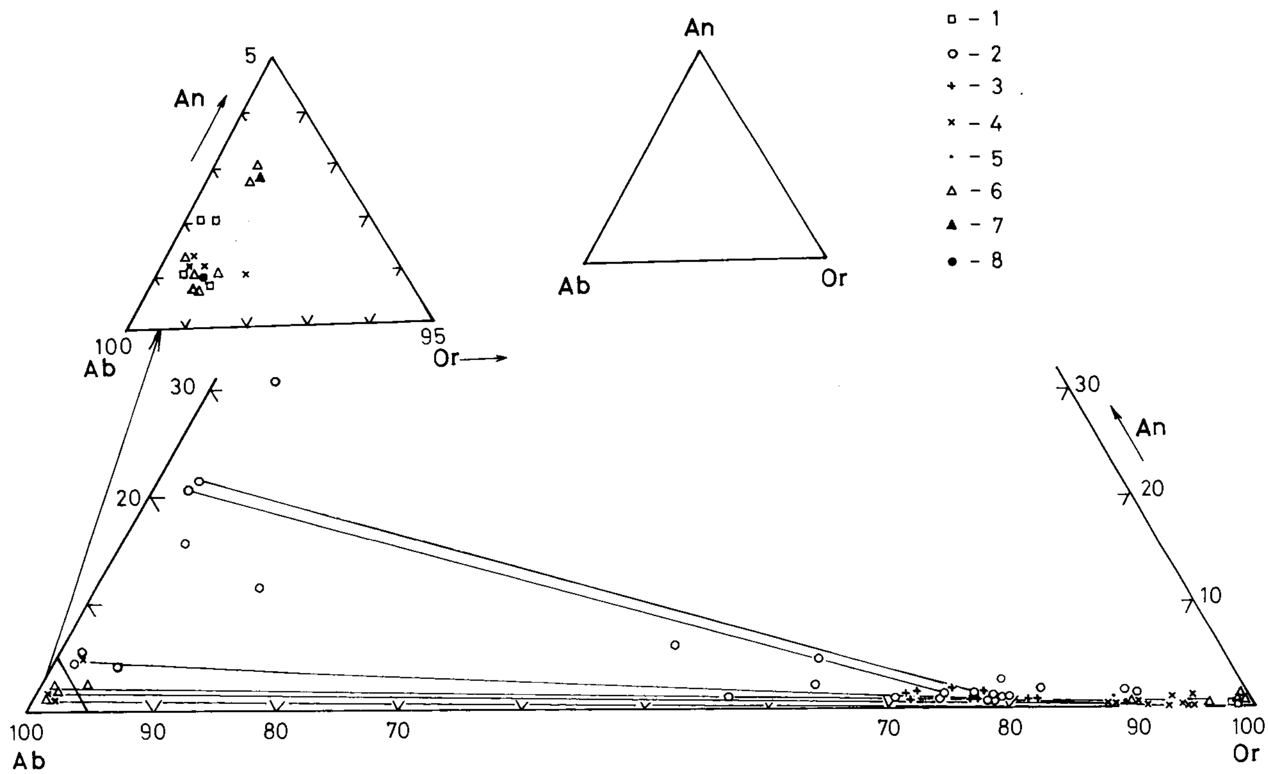

Fig. 9. Chemical composition of feldspars in a ternary diagram of the feldspar components. **1** - aplite (?) zone, **2** - feldspar-quartz-mica zone, **3** - block K-feldspar zone, **4** - Na- and K-phase perthites, **5** - film perthites, **6** - albite zone, **7** - saccharoidal albite (average of 10 analyses), **8** - cleavelandite (average of 16 analyses). Lines connect the coexisting phases of feldspars.

as this classification does not include orthoclase, only a series of maximum microclines to high sanidines. The presence of domains with a different stage of structural order, the possible presence of submicroscopic twinning, as well as tension, which originate on the contact of K- and Na-phase resulted in part of the position points being placed outside the theoretical graph. Smith (1974), Černý & Chapman (1986), Vilinovičová (1989) and others also encountered similar phenomena.

In the pegmatites of Považský Inovec (Tab. 1), maximal microclines (MM) are most wide-spread, although their grains need not be cross-hatched (sample 22d) The group of intermediate microclines (IM) and low orthoclases (LO) is less numerous, and occurrences of high microclines in the sense of the classification of Afonina et al. (1979) and Smith (1979) are rare. Orthoclases were found in the area of Striebornica (sample 33b) Soľnisko and Hrabový Hill (28a, 36).

The chemical composition of feldspars: The overall chemical composition of the K-feldspars expressed in feldspar components has a wide range $Or_{99\text{-}50}$ $Ab_{45\text{-}1}$ $An_{6\text{-}0}$ (Fig. 9; Tabs. 2, 3 - see on the page 229 and 230, resp.). The chemically purest, with 93.90 - 98.50 % Or are small grains of K-feldspar, which coexist with albite in the albite zone. The high content of Or in K-feldspars of the aplite (?) zone 98.02 to 98.68 (Tab. 2) is interesting. In the feldspar-quartz-mica zone and the block microcline zone, the content of the albite component depends on the degree of autometasomatic and metasomatic changes. The content of the albite component in homogeneous K-feldspar, if we assume a temperature of origin from 625 to 566 °C, as was determined, according to Barth (1969), may vary from 27 to 37 %, and so some samples point to (auto)-metasomatic replacement.

Potassium phase among film perthites has a composition $Or_{87.77\text{-}89.01}$, among other perthites $Or_{88.39\text{-}94.42}$ (Tab. 2), which points either to incomplete exsolution and segregation, or to the presence of cryptoperthites. Taking into consideration the first possibility inasmuch as the content of the homogenized part of the Or component, found from the position of the reflex plane ($\bar{2}01$) according to the graph of Jones et al. (1969) varies from 88 to 95 %. The probability of incomplete exsolution also flows from the wide interval of Ab (6 %) in K-phase compared to the narrow interval (1 %) in the exsolution and separated Na-phase perthites (Tab. 2), which we observe in Fig. 9, where both phases of K-feldspars in other samples are connected by lines corresponding to exsolution phases.

Trace elements: Apart from the mineral typomorphism observed in the field, the contents of trace elements provide valuable results about the genesis, and especially about the degree of fractionation of a pegmatite melt, especially in K-feldspars (Tab. 3). From this point of view the contents of Rb, Cs, Li, Ba, Sr, Ga and Pb are the most valuable (Heier 1962; Gordienko 1971; Smith 1974; Černý 1982; Černý et al. 1985). On the basis of the degree of correlation, we can divide the contents of trace elements in the K-feldspars of the pegmatites of Považský Inovec into two groups.

The first group is formed by the elements Li, Rb and Cs, which between them indicate a high to significant degree of positive correlation: Rb-Cs, c = 0.81; Rb-Li, c = 0.76; Cs-Li, c = 0.59. A significant correlation was not found between these elements and the chief cations (K, Na), apart from a moderate degree of negative correlation between Rb-Ca, c = -0.32. Strongly positive correlations point to very similar conditions of entry of these elements into the K-feldspars. This especially applies to Rb and Cs,

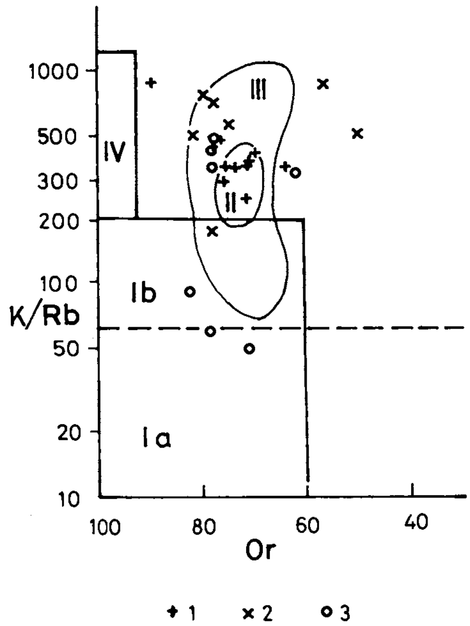

Fig. 10. The relationship between the K/Rb ratio and the composition of K-feldspars from the pegmatites of Považský Inovec. I-IV fields according to Smith (1974) for I-pegmatites, a - rare elements, b - other, the broken line shows the boundary between Ia - rare element productive pegmatites and Ib - unproductive according to Pavlišin and Vovk (1971). II - granites, III - syenites, IV - authigenic feldspars. K-feldspars 1 - Hrabový Hill area, Soľnisko and Slivničná Valley, 2 - area of Hradná and Bojnianka Valley, 3 - Striebornica and Zlatý Hill area.

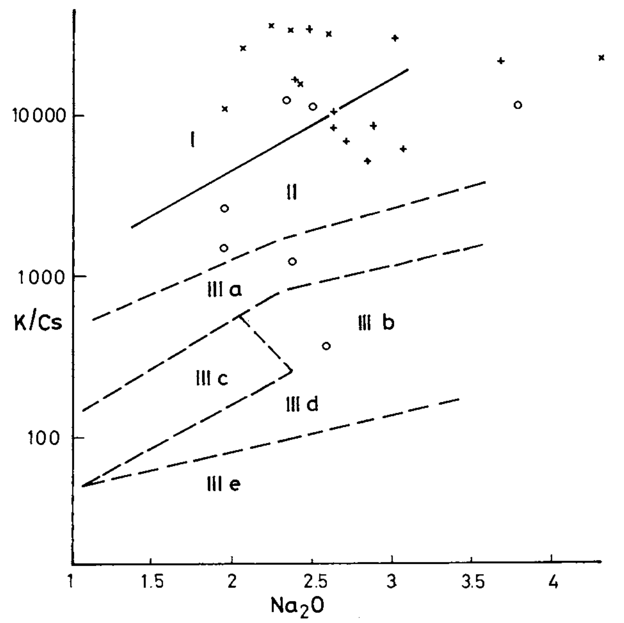

Fig. 11. K-feldspars from the pegmatites of Považský Inovec in the graph K/Cs against Na_2O. Fields according to Černý (1982) for pegmatites I - mica, II-III rare elements, II - lithium, III - caesium. IIIa unproductive, IIIb - without polucite, IIIc, d, e - s with polucite. Captions as for Fig. 10.

which also have similar crystalo-chemical properties and have a tendency to disperse in K-feldspars, crystallizing in the last phases of post-magmatic processes. As can be seen from Tab. 3, the contents of Rb, Cs and Li show a substantial increase in three samples (33 b, f, e) which are from the area of Striebornica, where rare element mineralization was also described (Uher & Broska 1989; Uher 1991). The moderately raised content of Cs, Rb and Li in samples 27, 28 and 35 from the areas of Hrabový Hill and Soľnisko is also noteworthy. Apart from these samples, the contents of Cs in the majority of K-feldspars varies from <3 to 10.9 ppm, the content of Li 0.84 - 6.63 and Rb 86.5 - 593 ppm, which, according to the work of Černý (1982) corresponds to the muscovite provinces of the ceramic types of pegmatite. In so far as the K-feldspars of the pegmatites of Považský Inovec have a different degree of perthitization, the problem of assigning the pegmatites on the basis of their content of trace elements, is best solved by the relative contents, as we trace this in Figs. 10 and 11. In the graph of K/Rb to the content of Or components only 3 samples from the Striebornica area fall into the field of pegmatites, and among these only 2 into the area of rare element productive pegmatites in the sense of Pavlišin & Vovk (1971).

In the graph of K/Cs vs. Na_2O various samples are found in the area of rare element pegmatites, not only from the 3rd area - Striebornica (4 samples in the area of rare element pegmatites with Li), but also from the first area - Soľnisko and Hrabový Hill (5 samples), and others are in the area of muscovite pegmatites, while samples from the area of Hrabový Hill are closer to the border of pegmatites with rare elements, as from the area of the Bojnianka.

The elements Ba, Sr, Pb which also show a mutual positive correlation of a moderate degree (Ba-Sr, c = 0.47; Ba-Pb, c = 0.39; Sr-Pb, c = 0.33) belong to a second group of elements. They show a negative correlation of a medium degree with the elements of the first group: Sr-Li, c = -0.32; Sr-Rb, c = -0.38; Pb-Cs, c = -0.32; Pb-Li, c = -0.35. They also have a similar relationship to Ga: Sr-Ga, c = -0.56; Ba-Ga, c = -0.36; Pb-Ga, c = -0.31. The content of Ba varies in a wide interval from 45 to 11.800 ppm, and Sr from 11.7 to 510 ppm, with samples from the area of the Striebornica having the lowest contents (Tab. 3). These correlative relationships point to the fact that Ba and Sr enter the structure of K-feldspars in different conditions to Rb, Cs and Li. The elements of the second group accumulate in feldspars which crystallized in the first phases of development of pegmatites, and therefore their content is higher in the feldspars of weakly differenciated pegmatites.

The highest content of Rb, Cs and Li in K-feldspars of the Western Carpathians in comparison with other mountain ranges was found in the Striebornica area (Dávidová & Dávid 1981). Although their contents did not reach such high values as are given by Ljachovič (1981) (Rb up to 5485 ppm), Černý (1982) (>20 Li, >2000 Rb, >50 Cs) for rare elements pegmatites, they fall into the wide interval determined for these pegmatites by Smith (1974), and point to the highest fractionation of a pegmatite melt among the pegmatites of the Western Carpathians. However the Rb content of the majority of K-feldspars, especially from the Bojnianka area corresponds to micaceous pegmatites, for which the average content is Rb = 270 (Kogan et al. 1971). We also observe similar relationships in the content of Cs.

Plagioclases

In quantity plagioclases are less widespread in the pegmatites of Považský Inovec, but their distribution is wider, since they occur in all zones apart from the quartz core and the quartz-muscovite zone.

In the order of crystallization, they are among the first to crystallize of the minerals in the feldspar-quartz-mica zone. Plagioclases with a wide range of of basicity from 30.75 to 3.79 An belong here. The most basic plagioclases, oligoclases to very acid andesines are found in pegmatites placed in the metamorphic part of the crystalline complex (in two-mica paragneisses samples 23 and 24) or in proximity to enclaves of paragneiss in granite (sample 23). They form hypidiomorphic grains of sizes up to 5 cm. They grow according to the albite and albite-Karlsbad law, or occasionally the pericline law. The grains are often affected by secondary changes, such as sericitization and muscovitization. Replacement of plagioclase by K-feldspar in the form of untwinned, less cross-hatched irregular grains (samples 21, 22b, 30) is frequent. Simultaneous crystallization of K-feldspar and plagioclase occurs only occasionally. Myrmecites are sometimes formed at the contact of grains of plagioclase and K-feldspar.

Plagioclases are among the frequent inclusions in K-feldspars in the feldspar-quartz-mica, graphic and block K-feldspar zones. The central parts of plagioclase inclusions are always sericitized or muscovitized to a varying degree. The inclusions are surrounded by unchanged albite borders.

Plagioclases form a second genetic group, which occur as perthite growths in K-feldspars in the aplite (?) feldspar-quartz-mica, graphic and block K-feldspar zones. These are albites with 97.40 to 98.18 % Ab (samples 33b, 22b, 22d). Perthite growths of segregated and segregated (auto)-metasomatic origin are often sericitized (Fig. 6).

Albites from the albite zone are among the youngest plagioclases. They are found only in the Striebornica area (samples 33c, d, e, f, h). Albite is developed here in two forms: saccharoidal (Fig. 12), which is formed by relatively isometric coarsely tabular grains with a maximum size of 0.5 mm, and as cleavelandite in the form of tabular grains often fan-like, arranged in the form of tabular grains with a maximum length of 5 mm (Fig. 13). Both types grow polysynthetically according to the albite law, and less frequently the albite-Karlsbad law, by which the growth lamellae often wedge out. Their composition corresponds to 93.90 - 98.50 % Ab with an Or content up to 1 %. They are almost without change, and only occasionally insignificantly sericitized.

Fig. 12. Granular, saccharoidal albite with albite and albite - Karlsbad twinning from the albite zone. Striebornica sample 33h. Microphoto magnification 35x, crossed nicols.

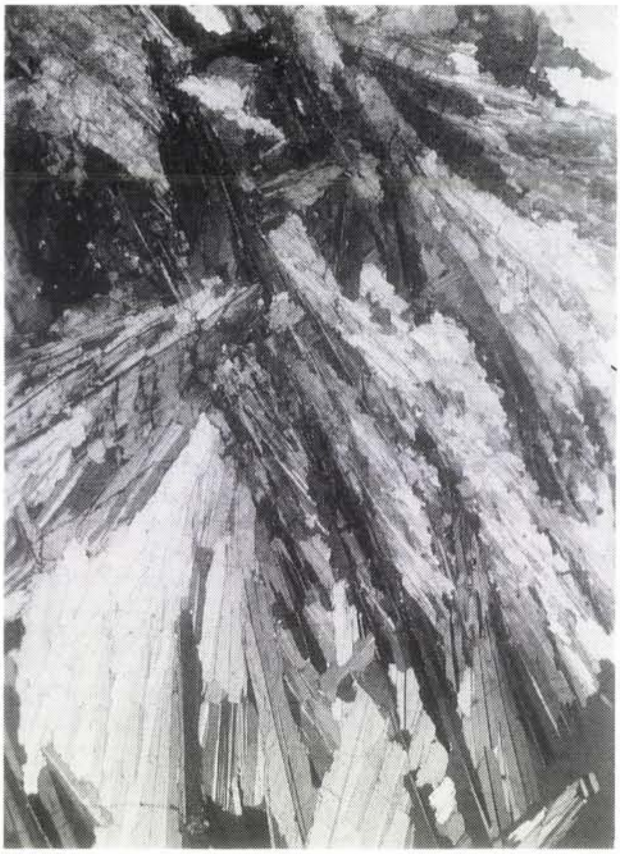

Fig. 13. Tabular crystals of cleavelandite with a fan-like arrangement, from the albite zone. Striebornica sample 33h. Microphoto magnification 8.5x, crossed nicols.

Discussion

The detailed characteristics of the feldspar phases from individual zones of the pegmatites of Považský Inovec enabled us to construct a temperature-genetic diagram of the formation of the pegmatites (Fig. 14). The distribution of Ab components in equilibrium pairs of the coexisting K-feldspars and plagioclases gave a basis for the calculation of the temperature of existence of these solid phases (Tab. 4 - see on the page 232). Two of the various geo-thermometers are chosen: the geo-thermometer of Stormer & Whitney (1977) and its second version, which in calculations considered the thermodynamic parameters for the feldspar pair, microcline - low albite, and that of Whitney

& Stormer (1977), which is appropriate for meso-granites, although according to Brown & Parsons (1981) they are also not ideal. The temperatures of the equilibrium phases of feldspars then calculated according to the recommendations of Stormer & Whitney (1977), as average obtained values, and are given in Tab. 4. In the calculations a pressure of 2 Kb was used. This was derived both from the metamorphic conditions of the surrounding metamorphic facies (Korikovsky & Putiš 1986), and the character of the mineralization of the pegmatites. In its first stages, the crystallization of the pegmatites of Považský Inovec has a magmatogenic character, and begins with crystallization of the feldspar-mica-quartz zone from the pegmatite melt.

The typical fine-grained aplite zone, which originates on the crystallization of feldspar, quartz and mica, in the first phases of the creation of pegmatite, at temperatures of 700 - 600 °C, mentioned among many chiefly zonal pegmatites was not found. Feldspars from this zone, which in composition correspond to almost pure non-perthite K-feldspar (Or 98.02 - 98.68 %) and albite with a low content of the An component (97.44 - 98.43 Ab) show that we are concerned with lower temperature stability 286 - 317 °C (Tab. 4) than that which should correspond to the temperature of the aplite zone.

During the crystallization of the feldspar-quartz-mica zone, plagioclases, acid andesines to oligoclases (An 31 - 20 %) form first, and after them and partly also at the same time, homogeneous K-feldspars crystallize. The temperature of their coexistence is determined from balanced pairs of both feldspars. It varies from 625 to 566 °C (Tab. 4; Fig. 14). In making the determination, the chemical composition of homogeneous K-feldspars at the time of their origin was taken into account. This was found by chemical analysis of separated present-day perthitic K-feldspars, among which the development of autometasomatic perthites was not observed on the basis of the microstructure of perthites, so they were exsolution, exsolution-segregated and segregated perthites.

The subsolid stage is accompanied by slow cooling during which two processes occurred: order of Si-Al in tetrahedral positions in the structure of K-feldspar, and exsolution Na-phases (Fig. 14).

The degree of ordering has a wide interval, where on one side almost complete ordering and the origin of maximal microclines occurs, on the other the process of order is insignificant and the K-feldspars are unarranged orthoclases. Orthoclases and intermediate orthoclase- microclines were found mainly in the Striebornica area, and have already been described (Uher & Broska 1989), and the area of Soľnisko and Hrabový Hill. Microscopic observations indicate that the order of Al-Si and the origin of the triclinic phase are also partly caused by the effects of stress, which originated during the exsolution of Na-phase, and according to Gerald & McLaren (1982) is a necessary factor in this phase change. Great changes in the structural order of K-feldspars may be caused by the varying content and activity of fluids in individual areas, at the same time higher water pressure accelerates tetrahedral order (Smith 1974; Yund & Ackermand 1979 and others). The content of Rb also has an influence on the formation of monocline phase (Gordienko & Kamencev 1967), but the contents of Rb in our K-feldspars do not reach the required quantitative threshold. However the observation of Tilling (1968), that K-feldspars which contain more than 80 % Or components are monoclinic was confirmed.

The heterogeneity of exsolution and segregation processes in originally homogeneous K-feldspars in the given area is determined mainly by changes in the concentration of fluids and water vapours, which diffused along intergranular spaces, less by

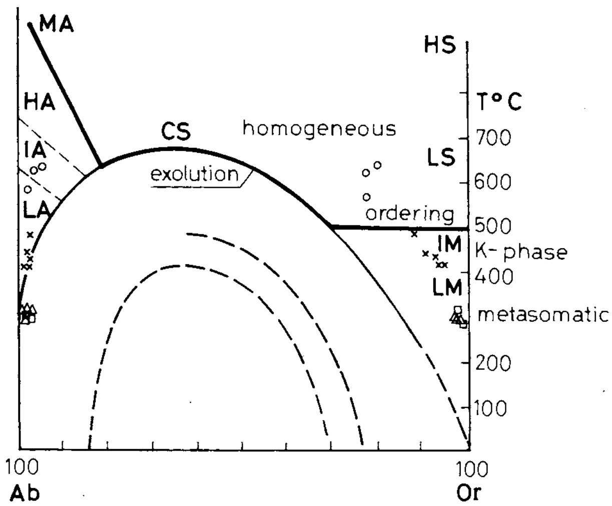

Fig. 14. Supposed phase equilibrium relations in homogeneous, subsolid and metasomatic feldspars from the pegmatites of Považský Inovec Mts. plotted on the modified graph of Brown & Parsons (1989) CS coherent solvus. Captions as on Figs. 7, 8, 9.

chemical composition, inasmuch as the content of the An component, which plays a significant role in exsolution is low and relatively stable (Yund & Ackermand 1979). The exsolution and segregation processes in homogeneous feldspars occurred at 483 to 410 °C (Fig. 14). These temperatures are higher than those mentioned by Yund & Ackermand (1979), according to whom exsolution always stops at 300 °C, without regard to the temperature decrease rate. Waldron & Parsons (1992) mention a higher temperature for the conclusion of exsolution, 380 °C on the basis of the study of perthites with the help of TEM. On the basis of the temperatures obtained for exsolution and segregation, according to the character of the microstructures of the K- and Na-phases of potassic feldspars, as well as the chemical composition of these phases, it can be judged that the cooling was quite slow, so that almost pure albite phase was formed, but it was not sufficiently long for complete unmixing and segregation of the Na-phase to occur. The interruption of the process of unmixing and segregation could have been caused by a change of tectonic regime.

The processes of autometasomatosis were superimposed on the processes of exsolution, segregation and structural ordering. These occurred from 316 to 297 °C (Tab. 4) (Fig. 14), which points to pneumatolytic to partly hydrothermal conditions of crystallization. The low contents of Sr (7.1 - 9.8) and Ba (8 - 28 ppm) in autometasomatic albites from the Striebornica area (Tab. 3) testify to this. Na-autometasomatosis, which, according to the experiments of London et al. (1989), enables the crystallization of fine-grained albites with mica, in the case of water saturation, occurs together with processes of unmixing and segregation. In the pegmatites of Považský Inovec, gradual replacement of the older zones of pegmatites and especially K-feldspars by albite occurs so that segregated-metasomatic, metasomatic perthites, chessboard albites, saccharoidal albites to fan-like albites-cleavelandites gradually form. These were observed so far only in the Striebornica area. Alexeyev et al. (1991) also traced the replacement of orthoclase by albite in the temperature interval 300 - 250 °C. The higher contents of Rb and Cs, as well as low contents of Ba and Sr, and low ratios of K/Rb, and Rb/Cs in K-feldspars from the Striebornica area, and partly also from Hrabový Hill and Soľnisko (samples 27, 28a, 35e, 36) also point to a greater fractionation of the pegmatite melt in these areas, as in other pegmatites.

In the process of albitization, potassium ions are freed. These are partly consumed in the formation of coarse-flake muscovite grown in quartz. An insignificant proportion are used in the crystallization of the youngest potassic non-perthitic very pure K-feldspar (Or 95.50 - 98.73 %), which form crystals under 0.03 mm in size thinly distributed in the albite aggregate.

Conclusion

The character of feldspars as the most widespread pegmatite forming minerals, the phases of which occur in almost all pegmatite zones provided information about the conditions of formation of the pegmatites of Považský Inovec Mts.

Aplite-like rocks, which occur in the pegmatites of Považský Inovec and were described as the aplite zone (Klinčuchová 1989), do not represent the first phase of crystallization of pegmatite, when the melt penetrates into a cooler environment, but are probably the result of autometasomatic processes. Several facts testify in favour of this view. The aplite-like rocks do not form a typical marginal or contact zone, but stars and lenses irregularly distributed among other zones of the pegmatites. The K-feldspars are non-perthitic without growths, relatively homogeneous, of small dimensions and restricted distribution. They correspond to relatively pure K-feldspars with 98.02 - 98.68 % Or. The plagioclases are albites with a high content of Ab from 97.44 - 98.43 %, typical granular development with frequent albite growths. At 286 - 318 °C, the temperatures of phase equilibrium of these feldspars are low for the formation of marginal zone pegmatites. The absence of the aplite zone and the formation of a coarse grained feldspar-quartz-mica zone on the margins of the pegmatites, support the fact that the pegmatite melt penetrated into a relatively superheated environment of the parental granitoids, less than into metamorphic rocks.

In the feldspar-quartz-mica zone, acidic andesines to oligoclases were found as the first crystallized plagioclases, while the more basic varieties were identified in pegmatites which are found in metamorphites. Homogeneous K-feldspars crystallize at the same time as them and somewhat later, at temperature phase equilibrium from 625 to 566 °C, probably in the form of monoclinic phases. Among the majority of pegmatite bodies, the development of zones ends here and the subsolid phase follows. Among larger bodies, the development of further zones occurs, that is of graphic pegmatite characterized by overgrowths of quartz and K-feldspar, zones of block K-feldspar and block quartz. The contents of trace elements also testify to the gradual nature of the formation of K-feldspars in individual zones. K-feldspars from the feldspar-quartz-mica zone contain more Ba and Sr, which enter into the earlier crystallizing K-feldspars and less Cs and Rb, which concentrates in feldspars of later crystallization stages. Sample 33, in which the high content of Cs and Rb is influenced by the environment forms an exception.

In the subsolid stage, a process of order of Al-Si in tetrahedrical positions occurs, as well as exsolution and segregation of the Na-component in monoclinic K-feldspar of these zones. These processes locally reach varying stages. From the point of view of structural ordering, without regard for zone, maximal microclines are the most widespread in the pegmatites of Považský Inovec. Intermedial microclines are less frequent. This most frequently occurs in the feldspar-quartz-mica zone. Monocline-orthoclase and intermediate microclines are found in the area of the Striebornica, Soľnisko and Hrabový Hill, which could point to the maintenance of a high temperature regime in this area. On the other hand, it was precisely in this area that the development of autometasomatic zones was recorded. They could accelerate the process of ordering.

Exsolution and segregation processes occurred approximately from 483 to 410 °C, which points to moderately high temperatures corresponding to the first phases of exsolution and segregation. It appears from this that the processes of arrangement, as well as the processes of exsolution and segregation were interrupted. It continued into the processes of autometasomatosis only in some places. In some bodies of pegmatite a quartz-muscovite zone with large scales of muscovite (Striebornica) or fan-like muscovite (Bojnianka) developed.

The albite zone, as one of the most important autometasomatic zones of pegmatite, which is connected with higher fractionation of the pegmatite process, was found only in the area of the Striebornica. According to traces such as the development of chessboard albite, the contents of trace elements in K-feldspars, that is the increased contents of Cs and Rb and reduced contents of Sr and Ba, and the chemical composition of garnets (Klinčuchová 1989), which are accompanied by traces in the Striebornica area, the development of this zone may also be assumed in the area of Hrabový Hill and Soľnisko. The albite zone, as the last in the development of the pegmatites in Považský Inovec, has a temperature of phase equilibrium of feldspar in the range of 316 - 297 °C, which points to hydrothermal conditions of coexistence of albite and homogeneous K-feldspar (adularia?).

Acknowledgements: I thank RNDr. E. Šamajová of the Geology Institute of the Natural Science Faculty of the Comenius University for the preparation of X-ray photographs, Ing. V. Streško and Ing. J. Polakovičová of the same institution for preparing analyses by the AAS and ICP-OES method, RNDr. P. Siman and RNDr. P. Konečný from the Dionýz Štúr Geology Institute for preparing analyses on an X-ray analyser and L. Oswald for microphotography.

References

Afonina G.G., Makagon V.M. & Shmakin B.M., 1979: Diagram of structural state alkali feldspars, roentgen coordinates and determine methods. *Izv. Akad. Nauk. SSSR, Ser. geol.*, 5, 73 - 82 (in Russian).

Alekseyev V.A., Medvedeva L.S. & Prisyagina N.I., 1991: Kinetics, mechanism and modeling of silicates transition in hydrothermal solutions. *Geochimija*, 9, 1219 - 1229 (in Russian).

Barth T.F.W., 1969: Feldspars. *Wiley-Interscience*, New York, 1 - 261.

Borg I.Y. & Smith D.K., 1969: Calculated X-ray powder patterns for silicate minerals. *Geol. Soc. Amer. Mem.*, 122, 1 - 896.

Broska I. & Uher P., 1991: Regional typology of zircon and its relationship to allanite, monazite antagonism. *Geol. Carpathica*, 42, 271 -277.

Brown W.L. & Parsons I., 1981: Towards a More Practical Two-Feldspar Geothermometer. *Contr. Mineral. Petrology*, 76, 369 - 377.

Brown W.L. & Parsons I., 1989: Alkali feldspars: ordering rates, phase transformation and behavior diagrams for igneous rocks. *Mineral. Mag.*, 53, 25 - 42.

Černý P., 1982: Short course in Granitic pegmatites. In Science and Industry. *Mineralogical Association of Canada*, Winnipeg, 1 - 555.

Černý P., Meintzer R.E. & Anderson A.Y., 1985: Extreme fractination in rare - element granitic pagmatites: selected examples of data and mechanisms. *Canad. Mineralogist*, 23, 381 - 421.

Černý P. & Chapman R., 1986: Adularia from hydrothermal vein deposits: extremes in structural state. *Canad. Mineralogist*, 24, 717 - 728.

Dávidová Š., 1970: K-feldspara from the pegmatites Malé Karpaty Mts. *Acta geol. geogr. Univ. Comen., Geol.*, 19, 177 - 199 (in Slovak).
Dávidová Š.: The Grade of order of potassium feldspars of pegmatites in the tatrides. *Geol. Zbor. Geol. Carpath.*, 29, 275 - 294.
Dávidová Š. & Dávid A., 1981: Distribution of some trace elements in feldspars from pegmatites of the tatrides. *Geol. Zbor. Geol. Carpath.*, 32, 35 - 54.
Gerald J.D.F. & McLaren A.C., 1982: The microstructures of microcline from some granitic rocks and pegmatites. *Contr. Mineral. Petrology*, 80, 219 - 229.
Goldsmith J.R. & Laves, 1954: The microcline-sanidine stability relations. *Geochim. Cosmochim Acta*, 5, 1 - 19.
Gordiyenko V.V., 1971: Concentration of Li, Rb, and Cs in potash feldspar and muscovite as criteria for assessing the rare metal mineralization in granite pegmatites. *Int. Geol. Rev.*, 13, 134 - 142.
Gordiyenko V.V. & Kamentsev I. Ye., 1967: On the nature of rubidium ad mixture in potassic feldspar. *Geochemistry Int.*, 4, 408 - 412.
Heier K.S., 1962: Trace elements in feldspars a review. *Nor. Geol. Tidsskr.*, 42,2, 415 - 454.
Jones J.B., Nesbitt R.W. & Slade P.G., 1969: The determination of the ortoclase content of homogenized alkali feldspars using the $\bar{2}01$ X-ray method. *Mineral. Mag.*, 37, 489 - 496.
Klinčuchová E., 1989: Mineralogical-petrological characterization of pegmatites of Považský Inovec Mts. *Manuscript, archive of Fac. of Natural Sci., Comenius Univ.*, 1 - 67 (in Slovak).
Kogan V.I., Nazvanova V.A. & Sokolov N.A., 1971: Rubidium and Cesium. *Nauka*, Moskva, 1 - 82 (in Russian).
Korikovsky S.P. & Putiš M., 1986: Metamorphic zoning and diaphtoresis of the Považský Inovec Mts. *Geol. Zbor. Geol. Carpath.*, 37, 115 - 136 (in Russian).
Laves F., 1955: Remarks on a paper by V. Marmo "on the microcline of the granitic rocks of Sierra Leone". *Scheiz. Mineral Petrogr. Mitt.*, 35, 296 - 298.
London D., Morgan G.B. & Hervig R.L., 1989: Vapor - undersaturated experiments with Macusani glass + H_2O at 200 MPa, and the internal differentiation of granitic pegmatites. *Contr. Mineral. Petrology*, 102, 1 - 17.
Lyachovich V.V., 1972: Trace elements in rockforming minerals of the granitoids. *Nedra Publ.*, Moskva, 1 - 199 (in Russian).
Maheľ M., 1986: Geology of the Czechoslovak Carpathians. Paleoalpine units. *VEDA*, Bratislava, 1 - 508 (in Slovak).
Marfunin A.S., 1962: Feldspars - phase relations, optical properties, geological distribution. *Trans. Inst. Geol Ore Deposits., Petr. Min., Geochem.*, Moskva, 78, 1 - 275 (in Russian).
Pavlišin V.I. & Vovk P.K., 1971: Rare alkalis in minerals from "pocket pegmatites". *Mineral. Sbor.*, 25, 27 -37 (in Russian).
Rudenko S.A., 1954: Morphological and genetical classification of feldspars perthites. *Zap. Vsesoyuz. Mineral. Obshch., Ser.* 2, 83,, 23 - 36 (in Russian).
Smith J.V., 1974: Feldspar minerals I. *Springer - Verlag*, Berlin, 1 - 627.
Smith J.V., 1974: Feldspars minerals II. *Springer - Verlag*, Berlin, 1 - 690.
Stormer J.C. & Whitney J.A., 1977: Two feldspar geothermometry in granulite facies metamorphic rocks. *Contr. Mineral. Petrology*, 65, 2, 123 - 133.
Tilling R.I., 1968: Zonal distribution of variations in structural state of alkali feldspar within the rader creek Pluton, Boulder Batholith, Montana. *J. Petrology*, 9, 331 - 357.
Uher P. & Broska I., 1989: Muscovite pegmatite with minerals of the rare elements from Moravany nad Váhom. (Považský Inovec Mts.). *Miner. slovaca*, 21, 163 - 173 (in Slovak).
Uher P., 1991: Be-Nb-Ta granitic pegmatites - a new type of rare - element mineralization in the Western Carpathians. *Geol. Carpathica*, 42, 331 - 339.
Vilinovičová Ľ., 1989: K-feldspars of the granitoid rocks from the Strážovské vrchy crystalline complex. *Geol. Zbor. Geol. Carpath.*, 40, 599 - 620.
Waldron K.A. & Parsons I., 1992: Feldspar microtectures and multistage thermal history of syemites from the Coldwell Complex Ontario. *Contr. Mineral. Petrology*, 111, 222 - 234.
Whitney J.A. & Stormer J.C., 1977: Two-feldspar geothermometry, geobarometry in Mesozonal granitic intrusions: three examples from the Piedmont of Georgia. *Contr. Mineral. Petrology*, 63, 51 - 64.
Yund R.A. & Ackermand D., 1979: Development of perthite microstructures in the Storm King Granite N.Y. *Contr. Mineral. Petrology*, 70, 273 - 280.