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GRANITOIDS OF THE MALÉ KARPATY MTS.; PETROCHEMICAL CLASSIFICATION AND CRYSTALLIZATION PATH

(Figs. 6, Tab. 1)

Abstract: The granitoid rocks of the Bratislava and Modra massifs are classified according to mesonormative diagram Q'—ANOR and R_1R_2-diagram. The Modra granitoids belong to I-type, whilst the Bratislava ones incline to granitoids of S-type. The Bratislava granitoids were almost completely melt at P H_2O = 500 MPa and T = 670 °C — 685 °C, but the magma of the Modra granitoids contained already ~25 % plagioclases under these PT-conditions. The path of crystallization of the studied granitoids was determined.

Резюме: Гранитоидные породы Братиславского и Модранского массивов классифицированы по мезонормативной диаграмме Q'—ANOR и R_1R_2 — диаграмме. Модранские гранитоиды принадлежат И-типу, а братиславские склоняются к гранитоидам С-типа. Братиславские гранитоиды были большей частью вполне таянные при р H_2O = 500 MPA и T = 670 °C—685 °C, а магма модранских гранитоидов содержала уже ~ 25 % плагиоклазов при этих Р—Т условиях. Способ кристаллизации исследованных гранитоидов был установлен.

B. Cambel — J. Valach (1956), J. Veselský (1970) and Š. Dávidová (1970) were dealing with petrochemistry of Variscan postkinematic granitoid rocks of the Malé Karpaty Mts. The considerable amount of chemical analyses (267) and analyses of trace elements of Malé Karpaty granitoids mentioned by B. Cambel et al. (1980c) permit at present to submit not only petrochemical characterization, but also to clear up petrogenetic and petrological aspects of the rocks of the Bratislava and Modra massifs.

Normative classification of studied rocks

A. Streckeisen — R. W. Le Maitre (1979) presented the catanormative classification diagram Q'/F'/-ANOR but recommended to apply Barth's mesonorm for defining the term with more precision in granitoids. The Malé Karpaty granitoids were classified according to Q'-ANOR diagram, however, it was set out from the revised mesonorm exclusively determined for granitoids (P. Mielke — H. G. F. Winkler, 1979). With testing of this mesonormative classification by means of granitoid samples of the West Carpathians with known modal composition (V. Vilinovič — I. Petrík — E. Janíčková, unpublished data) its substantiation and very good agreement with classification of IUGS Subcommission (1973) was established. The dominating rock type of the Bratislava massif is monzogranite, less represented are granodiorites here (Fig. 1). Aplites, pegmatites and vein granitoids most often belong to syenogranites and alkali-feldspar granites. The character

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of granitoids rich in quartz (Q'>60) will be discussed later. In the Modra massif granodiorites are distinctly predominating, rarely tonalites and monzogranites are present. Granodiorites of the Modra massif are apparently more basic than the Bratislava granodiorites. The absence of tonalites is mainly evident in the Bratislava massif. The Bratislava granitoids are two--mica, what is also shown in the mesonorm: from granodiorites to alkali-

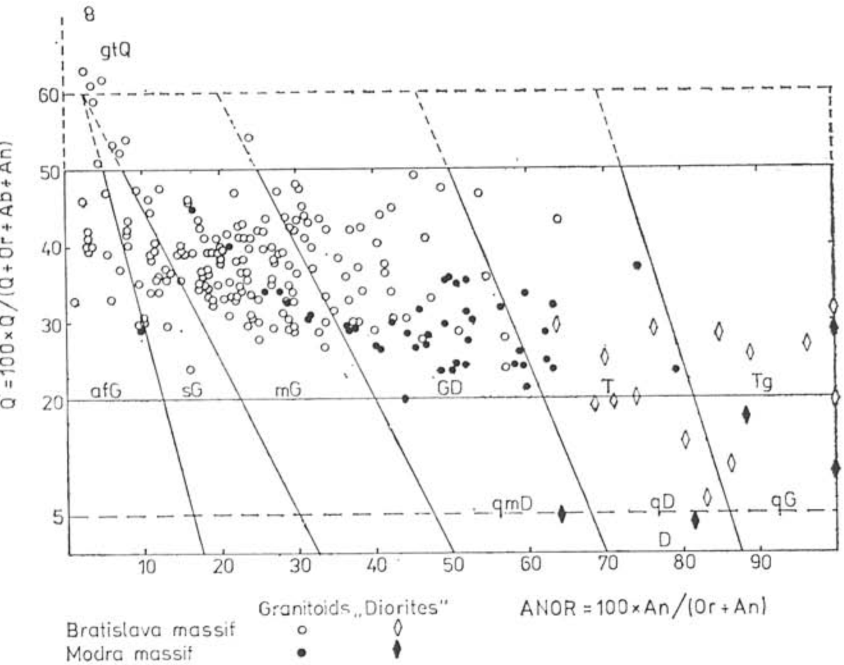

Fig. 1. Position of studied rocks in classification diagram Q'-ANOR (A. Streckeisen — R. W. Le Maitre, 1979) with application of mesonorm (P. Mielke — H. G. F. Winkler, 1979) as a basis of classification. Designation of fields: gtQ — granitoid rich in quartz, afG — alkali-feldspar granite, sG — syenogranite, mG — monzogranite, GD — granodiorite, T — tonalite, Tg — gabbroid tonalite, qmD — quartz monzodiorite, qD — quartz diorite, D — diorite, qG — quartz gabbro.

feldspar granites the average content of normative biotite decreases from 5,9 to 2,0 mass % and the content of normative corundum increases from 2,2 to 3,5 mass %. In the Modra massif from tonalites to monzogranites the content of normative biotite sinks from 6,8 to 4,0 mass % and the content of normative corundum increases from 1,1 to 1,8 mass %. The content of contingent normative hornblende in these rocks varies around 3,5 mass % on an average. The mesonormative classification is in agreement with the results of modal classification of these rocks, mentioned by D. Hovorka (1972), M. Dyda (1975) and J. Macek et al. (1979).

The classification diagram R_1R_2 worked out by H. De la Roche et al. (1979, 1980) provides in comparison with mesonormative classification the following results (Fig. 2): the division of granodiorites and granites is almost perfect, in none of the studied massifs typical tonalites or typical alkaline granites are present. The granite field of R_1R_2-diagram contains all varieties of granites of mesonormative classification Q'-ANOR because R_1R_2-diagram is of less resolving power as it is determined for classification of the whole scale of igneuos rocks. In the diagrams Q'-ANOR and R_1R_2 (Figs. 1, 2)

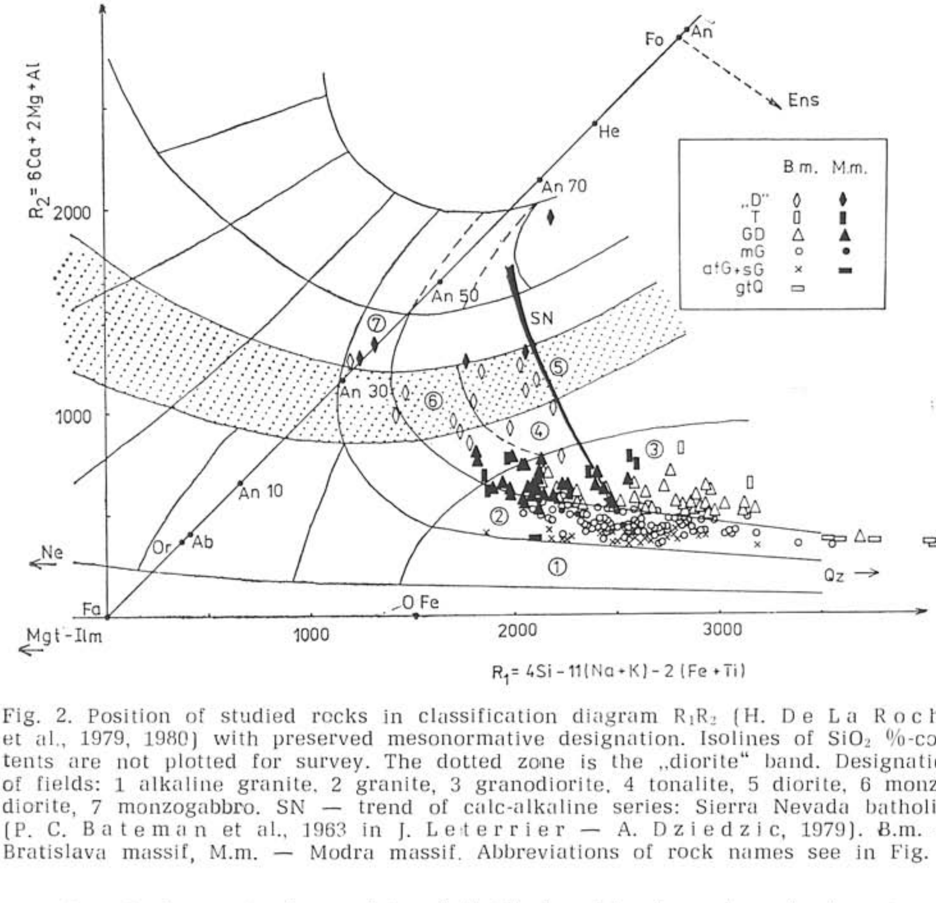

Fig. 2. Position of studied rocks in classification diagram R_1R_2 (H. De La Roche et al., 1979, 1980) with preserved mesonormative designation. Isolines of SiO_2 %-contents are not plotted for survey. The dotted zone is the „diorite" band. Designation of fields: 1 alkaline granite, 2 granite, 3 granodiorite, 4 tonalite, 5 diorite, 6 monzodiorite, 7 monzogabbro. SN — trend of calc-alkaline series: Sierra Nevada batholith (P. C. Bateman et al., 1963 in J. Leterrier — A. Dziedzic, 1979). B.m. — Bratislava massif, M.m. — Modra massif. Abbreviations of rock names see in Fig. 1.

are plotted also prajection points of biotite-hornblende rocks, whoch occur as xenoliths in the studied granitoids. By both ways of classification we obtained for them designations essentialy adequate to modal classification (cf. B. Cambel et al., 1981). These „diorites" are obviously endogenetic inclusions in the sense of W. Büsch — J. Otto (1980).

Main petrochemical feature of Malé Karpaty granitoids

Already B. Cambel — J. Valach (1956), J. Veselský (1970) and D. Bodiš (1977) established oversaturation of the Bratislava massif granitoids with aluminium. B. Cambel et al. (1980c) unambiguously confirmed this statement and characterized the composition of the Modra massif as normal or weakly oversaturated with aluminium. Further on, they state that the process of differentiation in the Bratislava massif was not of great extent.

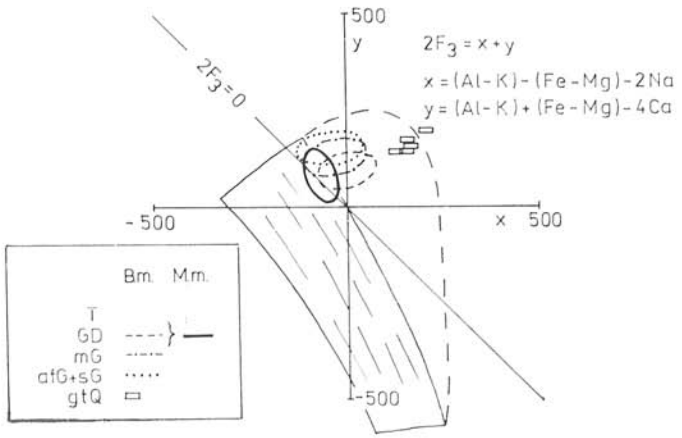

Fig. 3. Specific function for granitoids: $F_3 = Al - (K+Na+2Ca)$ and its genetic application. Field with interrupted hachures — rocks, which originated by differentiation of calc-alkaline and alkaline magmas; dashed bordered field — rocks formed by anatexis (H. De la Roche, 1978). Abbreviations of rocks names: T — tonalite, GD — granodiorite, mG — monzogranite, sG — syenogranite, afG — alkali-feldspar granite, gtQ — granitoid rich in quartz. B.m. — Bratislava massif, M.m. — Modra massif.

The granitoids of the Malé Karpaty Mts. have the character of calc-alkaline rocks. They, however, do not form a typical calc-alkaline series (CA-series), but correspond in their composition to its end members (Fig. 2). In the sense of H. De la Roche's (1978) criteria the Bratislava granitoids originated by anatexis (Fig. 3). The Modra granitoids may be interpreted in two ways: a) product of differentiation of more basic rocks, b) product of anatexis, however, already from the above mentioned absence of more basic members of the differentiation series the manifestation of anatexis results. In case of anatexis, however, there could not have been the same source material, from which the Bratislava granitoids formed. From Fig. 3 also extreme oversaturation of quartz-rich granitoids with aluminium is evident. In the sense of S. J. Shand (1927) in J. L. Anderson et al. (1980) the Modra granitoids are at the boundary of metaluminous and peraluminous rocks. This results also from the fact that the principal mafic mineral in them is biotite, hornblende or muscovite are represented only insignificantly. Granitoids of the Bratislava massif are distinctly peraluminous, as is shown in their two-mica to muscovite character (Fig. 4). On the basis of experiments S. Dimitriadis (1978) mentions that haplogranite magmas containing up to 2,5 % normative corundum can be direct products of re-melting of peraluminous metasediments.

A higher limit value of molar ratio $Al_2O_3/(K_2O+Na_2O+CaO)$ equal 1,1 for distinguishing of I-type and S-type of granitoids was suggested by B. W. Chappell — A. J. R. White (1974) and A. J. R. White — B. W. Chappell (1977). In the sense of the mentioned authors the I-type originated by anatexis of igneous rocks of intermediate composition whilst the S-type

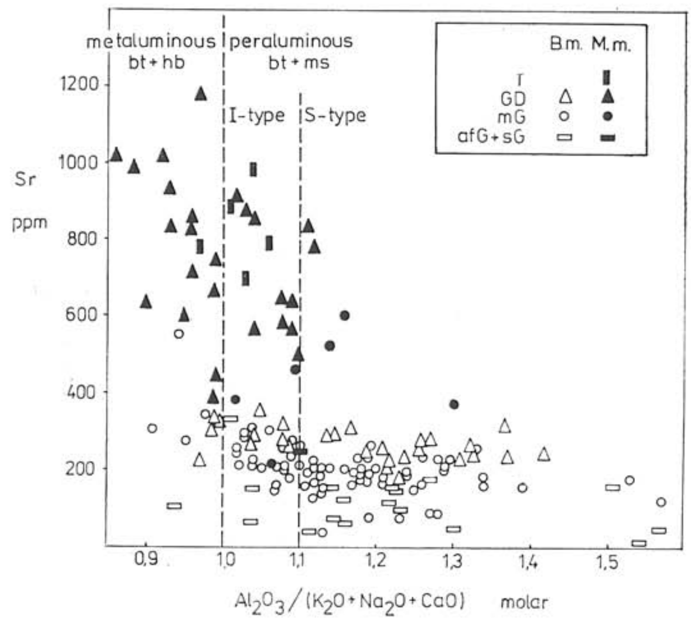

Fig. 4. Sr — $Al_2O_3/(K_2O+Na_2O+CaO)$ dependence. Division into metaluminous and peraluminous according to S. J. Shand (1927) in J. L. Anderson et al. (1980). Division into I-type and S-type according to B. W. Chappell — A. J. R. White (1974). Abbreviations of rock names and massifs see in Fig. 3.

by anatexis of sediments (metapelites). The Modra granitoids (Fig. 4) consequently belong to I-type, Bratislava granitoids to both types, however, more to S-type. Just from this reason that rocks of one series of differentiation (as the Bratislava massif) can belong to both types, T. S. McCarthy — D. I. Groves (1979) consider the value of the above mentioned ratio (1,1) as not unambiguous. B. Cambel et al. (1980b) mention that granitoids of the West Carpathians have most often $Al_2O_3/(K_2O+Na_2O+CaO) \geq 1,1$. The rocks of the Modra and partly also of the Bratislava massif indicate that it need not be so in certain parts of granitoid complexes.

S. Ishihara (1977) in H. Shimazaki (1980) distinguished magnetite- and ilmenite-containing granitoids, which roughly correspond to I-type and S-type (A. J. R. White — B. W. Chappell, 1977). It is necessary to stress here that J. Veselský — J. Gbelský (1978) mention for Modra granitoids besides other accessories only magnetite (they have not found ilmenite), but in the Bratislava massif both ilmenite and magnetite are present. The regularity of presence of ilmenite and/or magnetite regarding to oversaturation of granitoids with aluminium is stated also by V. R. Vetrin (1980). The different contents of Sr in Modra and Bratislava granitoids (Fig. 4) obviously reflect the differences in source materials.

Granite system Qz — Ab — Or — An — H_2O and its application to Malé Karpaty granitoids

CIPW-catanorm is not suitable for the study of granitoids in the granite system (T. F. W. Barth, 1966; G. R. Parslow, 1969; Ch. Hoffmann, 1976), however, in case of very leucocrate varieties it is used also at pre-

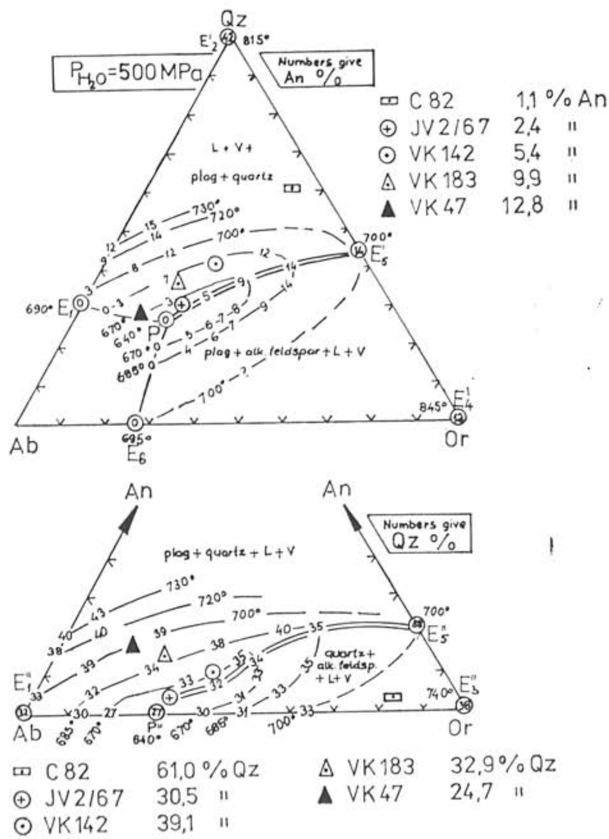

Fig. 5. Projection of isobaric cotectic line and isotherms on three isobaric cotectic surfaces of system Qz-Ab-Or-An-H_2O at P H_2O = 500 MPa (H. G. F. Winkler — R. Breitbart, 1978). Represented are projection points of five from the studied granitoids of the Malé Karpaty Mts.: composition VK47, VK183 is found in the volume of plagioclase at various distance from the cotectic surface plag.+quartz+L+V, VK142 is in the volume of quartz, JV2/67 is on cotectic P—E_5 line, C82 is deep in the volume of quartz (hydrothermally altered rock).

Table I

Chemical analyses, mesonorms and location of granitoid rocks shown in Fig. 5

	C82	JV2/67	VK142	VK183	VK47
SiO_2	74,65	74,13	73,70	69,71	67,62
TiO_2	0,30	0,03	0,26	0,33	0,70
Al_2O_3	15,42	14,98	14,09	14,73	16,07
Fe_2O_3	0,55	0,50	0,98	1,81	2,24
FeO	0,38	0,23	0,97	0,68	1,05
MnO	0,01	0,02	0,04	0,04	0,04
MgO	0,59	0,09	0,45	2,04	1,14
CaO	0,33	0,61	1,14	2,01	2,61
Na_2O	0,57	5,13	3,44	4,11	5,32
K_2O	4,93	3,62	4,03	3,49	2,43
P_2O_5	0,10	0,10	0,10	0,20	0,20
H_2O^+	2,14	0,54	0,88	0,80	1,06
H_2O^-	0,05	0,07	0,18	0,28	0,01
Suma	100,02	100,05	100,26	100,23	100,49
ap	0,23	0,23	0,23	0,47	0,47
il	0,28	0,02	0,24	0,31	0,66
or	27,42	21,13	21,89	14,81	11,22
ab	4,82	43,45	29,13	34,81	45,06
an	0,98	2,37	4,99	8,66	11,63
c	8,79	1,73	2,22	1,00	0,39
bt	2,57	0,38	3,07	8,96	4,59
hb	—	—	—	—	—
mt	0,79	0,72	1,42	—	3,24
hm	—	—	—	1,81	—
q	52,02	29,38	36,08	28,68	22,33
R	2,02	0,51	0,75	0,41	0,84

C82 — granitoid rich in quartz, Jur near Bratislava, 250 m SE of Kráľova búda; Bratislava massif.

JV2/67 — syenogranite (aplitoid), Bratislava—Kamzík, 400 m SE of television transmitter; Bratislava massif.

VK142 — monzogranite, Borinka, Propadlé valley, 300 m S of el. p. 461,3; Bratislava massif.

VK183 — granodiorite, Myslenec, Staré hory, 250 m SE of el. p. 212,3; Bratislava massif.

VK47 — granodiorite, upper part of the Kamenný potok valley, 500 m SE of el. p. Krvavý buk; Modra massif.

sent (Th. Marcopoulos — C. Sideris, 1980). The study of granitoids only within the frame of three-component systems, e.g. Qz-Ab-Or or Ab-Or-An is mainly of correlation importance, however, without considerations of the content of the fourth component (An or Qz) is incomplete, as was stressed already longer ago by H. G. F. Winkler (1966). The experimental knowledge on the granite system, interpreted e.g. by T. F. W. Barth (1966); D. C. Presnall — P. C. Bateman (1973), H. G. F. Winkler et al. (1975, 1977) and H. G. F. Winkler — R. Breitbart (1978) may be applied at present to petrological study of Malé Karpaty granitoids by aid of mesonorm of P. Mielke — H. G. F. Winkler (1979). For determination of the path of crystallization the granite system was recommended by M. Štemprok (1978) in our country.

The mesonorms of Malé Karpaty granitoids contain more than 80 % Qz+Ab+Or+An and so correspond to the requirement of the granite system. In Fig. 5 by means of five samples is shown the way of finding the position of composition of the studied granitoid rock in tetrahedron. The mesonorms of these granitoids are given in Tab. 1. Thus, we are able to establish in which phase volume of primary crystallization (plagioclase, quartz, alkali feldspar) or at which cotectic surface or line composition of granitoid rock is found. Fig. 6 a shows that the composition of almost all Modra granitoids is in the phase volume of primary crystallization (further only volume) of plagioclase, only composition of one granodiorite (No. 1) and two monzogranites (No, 2, 3) are just on the cotectic surface plag.+quartz+L+V and two monzogranites (No. 4, 5) in the volume of quartz. The composition of alkali-feldspar granite (No. 6) is just at the cotectic P-E_5 line. Thus, the path of crystallization of the main rock type of the Modra massif — granodiorite — is as follows: plag.→plag. + quartz→plag. + quartz + alk. feldspar.

In their composition, granodiorites and monzogranites of the Bratislava massif (Fig. 6 b, c) are lying close to the cotectic surface plag. + quartz +

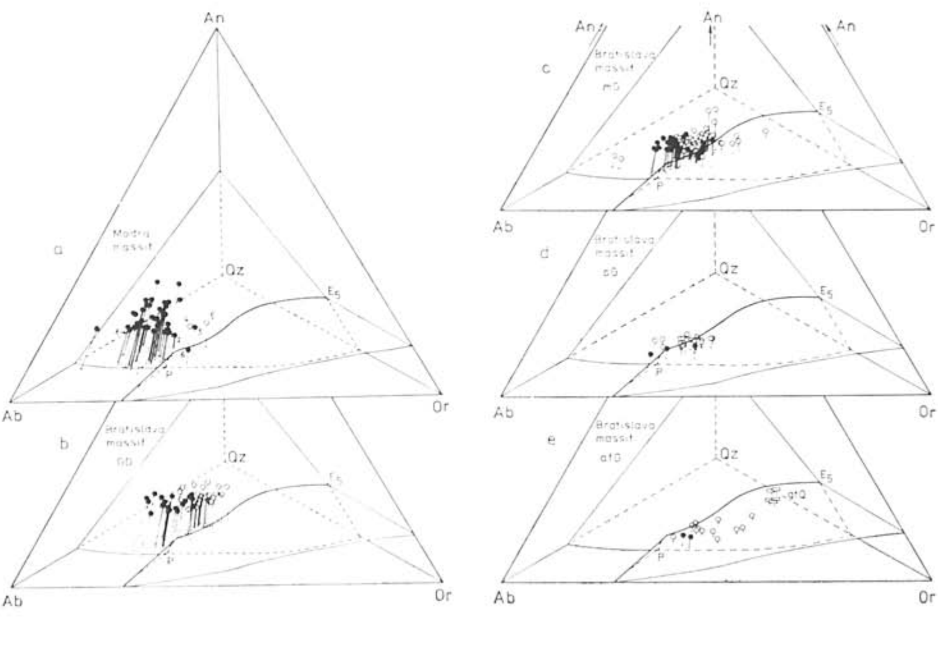

Fig. 6 a, b, c, d, e. Projection of isobaric cotectic P—E_5 line and cotectic surfaces in tetrahedron Qz-Ab-Or-An-H_2O at P H_2O = 500 MPa according to data of H. G. F. Winkler et al. (1975). The rocks of the Modra massif are represented as a whole, the importance of numbers see in the text (Fig. 6 a). In Fig. 6 b, c, d, e the position of individual samples of distinguished groups of the Bratislava massif granitoids is shown. Full circle — composition is found in the volume of plagioclase or at the surface of quartz saturation. Open circle (rectangle) — composition is found in the volume of quartz. The connecting lines of projection points with the basis represent contents of An-component. Abbreviations of rock names see in Fig. 1 or 3.

L + V, in individual cases either in the volume of plagioclase, quartz or directly on the surface. From the above said following path of crystallization results: plag. or quartz--plag. + quartz--plag. + quartz + alk. feldspar. A rather frequent occurrence of oval quartz grains enclosed in plagioclases evidences such a way of crystallization.

Syenogranites and alkali-feldspar granites (Fig. 6 d, e) are found in the volume of quartz and close to the P-E_5 line. So quartz will crystallize in them as the first, consequently, the composition of the melt will be shifted to the cotectic surface plag. + quartz + L + V or directly to the P-E_5 line. Because the cotectic surface quartz + alk.feldspar + L + V is moderately swelling to the volume of quartz (Ch. H o f f m a n n, 1976), after the crystallization of quartz the composition of melt may reach rather this surface and before the simultaneous crystallization plag. + quartz + alk.feldspar will for some time crystallize quartz + alk. feldspar.

Granitoids rich in quartz (Fig. 6 e) are too deep in the volume of quartz and so do not fulfil the criterion of the magmatic origin (H. G. F. W i n k l e r — R. B r e i t b a r t, 1978) and this testifies about the metasomatic influence on their mineral association. B. C a m b e l (1956) designed these rocks as hydrothermally sericitized granitoids. They are formed by the association quartz + completely sericitized feldspar + muscovite and are the end-product of the sericitization (greisenization) trend, indicated in the triangle Qz-Ab-Or by M. Š t e m p r o k — V. Š k v o r (1974) in M. Š t e m p r o k (1979). This process influenced also some monzogranites and alkali-feldspar granites. Two samples of monzogranites of the Bratislava massif found in the volume of quartz near to the connecting line Qz-Ab (Fig. 6 c) contain alkaline feldspar, represented only by chess-board albite, testifying to an intense manifestation of sodium in the concluding stages of their origin.

Discussion

The melts, from which the granitoids of the Malé Karpaty Mts. crystallized, originated by equilibrium melting, because their composition is found not only on the cotectic surface of quartz saturation but also in the volume of plagioclase as well as in the volume of quartz (Fig. 6). If they originated by fractional melting, then their composition must have been situated exclusively on the surface of quartz saturation (D. C. P r e s n a l l — P. C. B a t e m a n, 1973), most often on the P-E_5 line (Figs. 5, 6). W. J o h a n n e s (1978, 1980), however, considers the cotectic compositions of the granite system as metastable, non-equilibrium, because during melting plagioclases do not attain an equilibrium composition. The mentioned author designates metastable melting as a rock-forming factor, proved by zonal plagioclases. Granitoids of the both studied massifs contain zonal plagioclases (J. M a c e k, 1971).

Monzogranites and granodiorites of the Bratislava massif, forming almost the whole massif in volume, are found near the cotectic surface plag. + quartz + L + V in the area of low temperatures (T = 670° — 685° C) on the basis of the study of one hundred and forty samples in the granite system at P H_2O = 500 MPa. A slight rise in temperature, however, causes that small amounts of solid plagioclase or quartz are melting (H. G. F. W i n k l e r — R. B r e i t-b a r t, 1978). Thus, these rocks were almost completely melten under given PT-conditions, in which way homogenization was made easier and an contingent more extensive differentiation was restricted. This statement supports the opinion of D. H o v o r k a (1979) on total anatexis at the formation of West Carpathian granitoids. Also, missing hybrid structures and the presence of sillimanite, andalusite and spinel only in form of scarce grains (M. M i š í k, 1955; J. V e s e l s k ý — J. G b e l s k ý, 1978) and the results of M. D y d a (1975) indicate an almost complete melting of the source material.

Typomorphic mineral of the Bratislava granitoids is muscovite, which, partly together with biotite, is a manifestation of their peraluminous character. In silicic liquids garnet with more than 10 mol % of spessartite is stable in the cordierite stability field at P<500 MPa while garnet with 2—6 mol % of grossulare and 2—10 mol % of spessartine crystallizes at P = 500—700 MPa from granite magma (T. H. G r e e n, 1977). The Bratislava granites contain garnet with 6—14 mol % of spessartite (J. G b e l s k ý, 1977), however, in their melts water played an important role because, in that case, instead of cordierite, muscovite is originated (A. J. R. W h i t e — B. W. C h a p p e l l, 1977). From the above said, abundant myrmekite is also an evidence. Its occurrence may be interpreted in the sense of M. J. H i b b a r d (1979) as a phenomenon separating stages of crystallization before and after saturation with water.

In the sense of O. F. T u t t l e — N. L. B o w e n (1958) in R. F. M a r t i n — B. B o n i n (1976) Malé Karpaty granitoids are subsolvus, i.e. plagioclase and alkali-feldspar are found in them side by side. So, they must have crystallized under pressures $P\,H_2O > 250$ MPa. K-feldspar in Bratislava granitoids is often present in two forms: in the interstitial and in the porphyritic form respectively. Although typical megacrysts of K-feldspar are not developed in the studied rocks, porphyric K- feldspar aften poikilitically encloses sericitized plagioclases, biotite and quartz. These enclosures are sometimes zonally arranged. In the sense of M. J. H i b b a r d (1979) poikilitic porphyric K-feldspars are pre-myrmekite and the interstitial ones post-myrmekite. S. V r á n a in A. K l i n e c (1964), D. H o v o r k a (1978, 1979), V. V i l i n o v i č (1978) consider these porphyric K-feldspars as magmatic. On the basis of the study of Bratislava monzogranites-granodiorites it may be stated, that composition of their melts passed from cotectic surface plag. + quartz + L + V to the cotectic line of contemporaneous crystallization plag. + quartz + alk. feldspar ($P\text{-}E_2$) at temperatures higher than in the case of the Modra granodiorite. Consequently, also the amount of melt, which had to crystallize after this moment, was greater in the Bratislava granitoids than in the Modra ones. This way development of K-feldspar was determined: in Bratislava granitoids it could form poikilitic hypidiomorphic crystals and to the end of the process also interstitial grains, in the Modra granitoids it formed only so called oikocrysts. In oikocrysts forming an optically continuous ground-mass idiomorphic plagioclases, biotite and quartz were as if „swimming". Such texture, observed mainly in granodiorites, resembling the presence of „cumulus" minerals and crystallized „intercumulus" melt is described by T. S. M c C a r t h y — D. I. G r o v e s (1979) as the result of fractional crystallization.

The study of Modra granodiorite shows that with the melt, the composition of which is found on the cotectic surface plag.+quartz+L+V at T ≐ 685° C, already about 10 % of solid An-component, i.e. ~ 25 % of plagioclase is associated. Thus, also at higher temperatures T>685° C this melt contained a small amount of plagioclases. Here it is necessary to seek the cause of that phenomenon that biotite often encloses small idiomorphic sericitized plagioclases or has an interstitial development in the cluster of plagioclase grains. Plagioclase is namely the only tectosilicate, capable of nucleation in the melt of granodiorite composition with the presence of Fe and Mg (M. T. Naney — S. E. Swanson, 1980). Therefore also biotite formed by crystallization from melt — it is not o restite. This statement supports the results of the study of biotites from West Carpathian granitoids (I. Petrík, 1980; I. Petrík in B. Cambel et al., 1980 a). According to this author the change of the chemical composition of biotites (increase in their Fe-content) from more basic to acid granitoids is an evidence of their magmatic origin. So far, the problem of the influence of biotite and muscovite on melting has not been solved from the view-point of granite system. Mainly larger amounts of muscovite have considerable influence on PT-conditions of melting (H. G. F. Winkler — R. Breitbart, 1978; P. J. Wyllie, 1979).

Syenogranites and alkali-feldspar granites of the Bratislava massif are products of rest magma, which cooled in joints of the already intruded massif (B. Cambel — J. Valach, 1956). Thus, they formed at lower pressure and in smaller depth than monzogranites and granodiorites. This is in agreement with their position in the volume of quartz of the granite system at P H_2O=500 MPa (Fig. 6 d, e). With lowering og pressure, namely reduction of the phase volume of primary crystallization of quartz takes places (D. C. Presnall — P. C. Bateman, 1973) and so, at about P H_2O≐300—400 MPa composition of these acid derivatives will be found near the lower part of the cotectic P-E_5 line, near the ternary minimum (point P).

Conclusion

From the petrochemical and petrological study of Malé Karpaty granitoids the following knowledge results:

a) According to mesonormative classification diagram Q'-ANOR the main rock type of the Bratislava massif is monzogranite, granodiorites are less represented. The Modra massif is formed mainly by granodiorites, which are more basic than the Bratislava granodiorites.

b) Magmas, from which granitoids of both massifs crystallized, formed by anatexis, however, their source material was different to certain extent, because the Modra granitoids belong to the I-type and the Bratislava granitoids most often to the S-type of granitoids in the sense of B. W. Chappell — A. J. R. White (1974).

c) From application of the granite system Qz-Ab-Or-An-H_2O at P H_2O= 500 MPa to Malé Karpaty granitoids the statement results that under the given pressure and T = 670°C—685°C granitoids of the Bratislava massif were almost completely melted, while the magma of the Modra massif contained already about 25 % of crystallized plagioclases. Such paths of crystallization have been established:

Modra massif (tonalites, granodiorites and majority of monzogranites):
plag.→plag.+quartz→plag. + quartz + alk. feldspar,
Bratislava massif (granodiorites and monzogranites):
plag. or quartz→plag.+quartz→plag. + quartz + alk. feldspar,
Bratislava massif (syenogranites and alkali-feldspar granites):
quartz→plag. + quartz + alk. feldspar.

Appendix

Average chemical composition of studied granitoids

	Bratislava massif					Modra massif		
	gtQ(5)	afG(14)	sG(19)	mG(95)	GD(45)	mG(6)	GD(29)	T(7)
SiO_2	75,51	73,88	74,02	72,94	70,98	70,90	67,63	67,18
TiO_2	0,24	0,11	0,12	0,23	0,38	0,41	0,63	0,65
Al_2O_3	14,69	14,52	14,54	14,75	15,12	15,12	15,82	16,52
Fe_2O_3	0,83	0,78	0,76	1,15	1,52	1,26	1,99	1,56
FeO	0,35	0,40	0,42	0,64	1,06	0,71	1,36	1,55
MnO	0,01	0,04	0,03	0,05	0,05	0,04	0,05	0,05
MgO	0,67	0,45	0,36	0,56	1,04	0,97	1,14	1,03
CaO	0,33	0,62	0,85	1,29	2,03	1,55	2,64	3,13
Na_2O	0,36	3,43	4,14	3,75	3,58	4,24	4,78	4,79
K_2O	4,60	4,50	3,86	3,71	3,12	3,40	2,52	1,98
P_2O_5	0,10	0,24	0,15	0,13	0,14	0,16	0,20	0,19
H_2O^+	2,21	0,95	0,72	0,82	0,84	1,15	1,07	1,09
H_2O^-	0,14	0,08	0,10	0,14	0,17	0,25	0,21	0,23

Remark: the abbreviations of rock names see in Fig. 1. the numbers in parenthesis indicate the number of analyses.

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