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SOME PROBLEMS OF THE WEST CARPATHIAN CRYSTALLINE COMPLEX

Abstract: Two fundamental problems of the Carpathian crystalline complex are discussed in the paper; the nature of metamorphism and the problem of granitoid formation.

The metamorphosis of the West Carpathians are often of polymetamorphic character; in addition to regional alteration they are affected in places also by injection-metasomatic, contact-thermic and diaphthoritic alteration. Regional metamorphism did not exceed the conditions of the garnet-amphibolite facies. Under the conditions of garnet amphibolites also endogene migmatites and selective-mobilization granitoids originated.

The granitoids of the West Carpathians belong to several development cycles: to the pre-Cambrian, Hercynian and Alpine cycle. Their genesis is complicated and in addition to typical magmatogene types also selective-mobilization, palingene, autometamorphic and injection-metasomatic types are represented.

The crytalline complex appears in the West Carpathian only in their Central zone; in the Flysch and Klippen Belt it is known only from pebble material of their conglomerate members. The Central zone is marked by a fold and nappe structure, developed after the Turonian and prior to the Senonian during the Subtatric (D. Andrusov 1930), or Mediterranean (A. Tollmann 1965) folding phase. It is built by two morphotectonic units:

1. the zone of Core mountains and
2. the zone of Slovenské rudohorie Mts.

The morphotectonic zones originated by post-Paleogene tectonics, which brought about in the zone of the Core mountains the articulation of the pre-Senonian structure into megaanticlines and megasynclines, and in the zone of Slovenské rudohorie Mts. its total desintegration.

1. The zone of the Core mountains (Malé Karpaty, Považský Inovec, Malá and Veľká Fatra, Vysoké Tatry and Nízke Tatry, Tribeč, Suchý, Žiar and Malá Magura, Branisko and Čierna hora and the Zemplín island) runs near the northern margin of the Central zone. It has a complicated structure, in which participate Tatride elements and Subtatric nappes (the lower Krížna- and the upper Choč-nappe).

The Tatrides are built by the crystalline core and its Mesozoic in places also Late Paleozoic envelope.

2. The zone of Slovenské rudohorie Mts. is built by two fundamental tectonic units: the Veporides and the Gemerides.

According to an older view the Veporides are built by the crystalline complex of the western tract of Slovenské rudohorie Mts. and the eastern part of Nízke Tatry Mts., by the envelope Permian and the Mesozoic of the Subtatric nappes. The Mesozoic appearing in the area of the Veporide crystalline complex (Veľký Bok unit and Foederata series) was hold for root remnants of the Subtatric

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nappes. Thus investigations of the last years indicated (A. Biely, O. Fusán, J. Kamenický, J. Zelman and al.), that this Mesozoic is a normal envelope of the Veporide crystalline complex and has no analogy in the West Carpathians. For this reason we have to search for the roots of the Subtatric nappes in the region of large overthrusts, where a great spatial reduction set in; the root of the Krížna nappe in the area of the Veporide thrust on the Tatrides (Čertovica line) and the root of the Choč nappe in the area of the Gemerides thrusting over the Veporides (= Ľubietová line).

The Veporide crystalline complex has a complicated sliceanticlinorial structure, originated during the Alpine orogeny. It comports four tectonic slices (zones) of the first order; from north-west to south-east it is the Ľubietová, Kraklová, Kráľova hoľa and the Kohút zone.

The constitution of the individual zones differs partly from the adjacent zones. This feature is conditioned by the mechanical rock selection during tectonic processes and by the natural tendency of formation of thrust planes on the contact of two mechanically heterogenuous rock complexes.

The Gemerides are the southernmost tectonic unit of the Central zone. They are built by the Early and Late Paleozoic of Spišsko-gemerské rudohorie Mts. and by Mesozoic appearing in its northern, southern and subordinately also in its central tract. The nappe remnant of the Muráň Mesozoic shifted on the Veporide Kohút zone and thrust on the Kráľová hoľa zone is also ranged to the Gemerides. The Early Paleozoic is represented by the Gelnica and Rakovec Groups, the Late Paleozoic by the Carboniferous and the Permian.

The crystalline complex of the West Carpathians is built by metamorphites and granitoid rocks. During the pre-Neoidic era it made up a separate complex, named the Slovak massif (M. Máška, V. Zoubek 1960). The Slovak massif had an anticlinorial structure. It has been desintegrated by Neoide tectonics and became a constituent of Neoide structures designated as Tatrides, Veporides and Gemerides.

The development of the crystalline complex in the individual units is rather different. Not only the premetamorphic facial development of the sediments, the intensity and nature of the geosynclinal volcanism, the intensity and the character of metamorphism, but also the representation of granitoids is concerned.

Based on these differences we can group the metamorphites of the West Carpathians into four facially and probably also stratigraphically diverse units denominated:

1. the Jarabá Group — Early to Middle Proterozoic

2. the Kokava Group — (= the Pezinok-Pernek Group of Malé Karpaty Mts.) — Late Proterozoic

3. the Gelnica Group — Upper Cambrian-Silurian

4. the Rakovec Group — (= Harmonia Group of Malé Karpaty Mts.) — Devonian. (Tab. 1—4.)

1. The Jarabá Group (J. Kamenický in M. Maheľ, J. Kame-

Table 1. The development of granitoids in the West Carpathians

pre-Cambrian cycle (?)	Intraalgonkian phase (?)	selektive mobilization granitoids
		palingene, subautochthonous granites of the Králička type
	Assyntian phase (?)	synkinematic intrusions of the type of Muráň gneissose granites
Hercynian-cycle	Bretonian-Sudetic phase	postkinematic intrusions of the Ďumbier granodiorite type
		leucocrate differentiates of the Ďumbier diorite type
		autometamorphic granites of the Prašivec type
		injection-metasomatic granitoids
	Saalian phase	intrusion of microgranites and microgranodiorites in the Kraklová zone
Alpine cycle	Laramide phase	postkinematic intrusion of Gemeride granites, resp. intrusion of granitoids of the islet of Štiavnica

nický, O. Fusán, A. Matějka 1967) is nearly identic with the Tatranská Group of M. Máška, V. Zoubek 1960. It builds the crystalline complex of the Core mountains except for the Malé Karpaty crystalline complex and the Veporide crystalline with exception of the crystalline complex of the Kohút zone. It comports the flysch complex of argillaceous shales and sandstones with a subordinate representation of geosynclinal migmatites, mostly effusives diabases, their tuffs and tuffites, sporadically also intrusive amphibolic diorites. Bituminous shales are represented only scarcely in this complex as layers of centimeter thickness. Its folding and regional alteration is related either to the Intraalgonkian or to the Assynthian folding. The Jarabá Group attains the highest degree of regional metamorphism in the area of the Ďumbier anticlinorium of Nízke Tatry Mts., where it mainly belong to the silimanite-almandine subfacies of the garnet-amphibolite facies. From argillaceous and sandy shales originated biotitic paragneisses and synkinematic migmatites with the mineral association: quartz—plagioclase—biotite ± (microcline—almandine).

Diabases, their tuffs and tuffites as well as diorites were simultaneously transformed into amphibolites with the mineral association:

plagioclase—common hornblende ± (quartz—garnet).

High-temperated regional metamorphic facies, the granulite and eclogite facies, have not been recognized in the West Carpathians. The only occurrence of cor-

Table 2. The chemism of paraschists of the West Carpathian crystalline complex

No.	1	2	3	4	5	6
rock	biotitic paragneiss	biotitic paragneiss	biotitic garnet micaschist	chlorite-muscovitic micaschist	sericite-chlorite tylorite	contactly metamorphosed phyllite
locality	Malá Fatra Mts. SE of Minčol	Považský Inovec Mts. railway val.	Veporské rudohorie Mts. Kohút zone, N. of Hnúšťa	Považský Inovec Mts. SW of Inovec	Veporské rudohorie Mts. Ľubietová zone, valley Kamenistá	Veporské rudohorie Mts. Kohút zone, Hnúšťa
SiO_2	68,28	76,38	52,72	80,26	55,48	70,35
TiO_2	0,81	0,47	0,81	0,68	0,24	0,47
Al_2O_3	15,68	15,48	24,39	7,73	20,19	13,97
Fe_2O_3	0,52	1,29	2,90	1,72	3,97	2,44
FeO	4,61	1,41	4,57	1,87	5,41	1,08
MnO	0,07	0,06	0,11	0,62	0,08	0,04
MgO	2,72	0,02	2,66	2,04	2,70	2,81
CaO	3,02	1,90	1,18	1,20	1,80	1,68
Na_2O	3,70	2,06	5,72	0,85	0,89	3,56
K_2O	1,78	1,30	0,70	1,65	5,47	1,92
H_2O-	0,02	1,57	0,05	0,08	0,03	0,04
H_2O+	0,83	0,16	3,62	1,40	3,63	1,13
P_2O_5	0,04	0,20	0,46	0,32	0,26	0,85
sum	100,08	100,31	99,89	99,82	100,15	100,34

Analyses no. 1, 3 and 6 derive from the material of D. Hovorka, analyses no. 2, 4 and 5 from the material of J. Kamenický. Analyse no. 1 was realized by A. Polakovičová, analyse no. 2 by K. Vnuková, analyse no. 4 by P. Lešták and analyses no. 3, 5 and 6 by O. Karelová.

dierite appearing in micaschists of the Kohút zone is the product of the thermic effect of Hercynian granodiorites (J. Vrána 1962). North-and southward from the paragneiss arch of Nízke Tatry Mts. the regional metamorphism of the Jarabá Group is gradually falling and corresponds mostly to the quartz-disthen-muscovite subfacies of the garnet-amphibolite facies with the mineral association:

quartz—muscovite—biotite—plagioclase ± almandine plagioclase—common hornblende ± (quartz—garnet).

The amphibolite garnet and sillimanite-almandine of the paragneisses of the High Tatras appear in the proximity of the Hercynian granodiorites and are the products of their contact-thermic effect.

In the Nízke Tatry Ďumbier zone, but also in the Veporide Ľubietová zone and in the massif Sľubica of Čierna hora Mts. the regional metamorphism of the Jarabá Group is strongly affected by the synkinematic migmatization allied to the same geological process as the regional alteration. In the lower parts of the regionally metamorphosed complex were mobilized granitoid elements chiefly alkalies, leading to in situ feldspathization of paragneisses, or to their ichioresis into the upper horizons where they induced the migmatization or granitization.

Table 3. The chemism of amphibolites of the Carboniferous and the crystalline complex of the West Carpathians

No.	1	2	3	4	5	6
rock	garnet amphibolite	epidotitic amphibolite of the diaphtorite zone	epidotitic amphibolite of the diaphtorite zone	uralitic amphibolite	epidotitic amphibolite	amphibole
formation	Jarabá Group			Pezinok-Pernek Group	Carboniferous	
locality	Vysoké Tatry Mts., Baranec	Považský Inovec Mts. Svolí vrch.	Veporské rudohorie Mts., Ľubietová zone, Muráň	Malé Karpaty Mts., Köberling, NE of Rybnička	Považský Inovec Mts. Horanská dol. valley	Spišsko-gemerské rudohorie Mts., SE of Turčok
SiO_2	45,74	56,33	56,46	45,57	51,88	49,10
TiO_2	0,56	0,60	0,64	1,71	0,86	0,70
Al_2O_3	17,06	17,18	14,16	16,06	13,42	15,33
Fe_2O_3	2,78	2,73	3,35	2,50	2,84	3,52
FeO	16,14	4,60	5,12	8,94	5,60	7,10
MnO	0,19	0,14	0,18	0,18	0,16	0,17
MgO	11,63	3,94	8,50	9,19	6,07	7,02
CaO	9,80	7,19	9,43	11,42	9,62	10,61
Na_2O	1,60	4,60	3,42	3,31	5,30	4,90
K_2O	2,00	1,80	0,91	0,61	2,77	0,82
H_2O-	0,08	0,17	0,11	0,10	0,04	1,20
H_2O+	2,01	0,57	1,99	0,57	1,18	0,18
P_2O_5	0,21	0,06	0,26	0,19	0,45	0,13
sum	99,89	99,91	100,51	100,35	100,19	100,78

The analyse no. 1 is from the paper of A. Gorek 1959, analyses no. 3, 4 and 5 from the paper B. Cambel, J. Kamenický, E. Krist 1961 and analyse no. 2 from the material of J. Kamenický. Analyses no. 1—5 were elaborated by E. Rubínová and analyse no. 6 by J. Jarkovský.

A variegated series of migmatites originated with transitions from inhibition paragneisses over stromatic and ophtalmitic migmatites with up to 10 cm feldspar chiefly microcline eyes, up to massive nebulitic migmatites and metasomatic granitoids. The mineral association of synkinematic migmatites is the same as that of the adjacent paragneisses. Thus it follows, that it originated still under the conditions of the facies of garnet amphibolites.

In the extreme development stage of this process partial anatexis set in, as well as the remelting of the most extensive part of the paragneiss complex, the origin of a palingene magma and the subautochthonous intrusion of leucocrate granite of the Králička type in Nízke Tatry Mts.

Amphibolites of the synkinetic migmatites are very resistent to migmatization. In extremely granitized paragneisses they show also the character of amphibolites. The contribution of alkalies displays firstly by the replacement of common

Table 4. The chemism of the main types of the West Carpathian granitoid rocks

no	rock		SiO_2	TiO_2	Al_2O_3	Fe_2O_3	FeO	MnO	MgO	CaO	Na_2O	K_2O	H_2O-	H_2O+	P_2O_5	total
1	Ďumbier granodiorite	Nízke Tatry, Ďumbier	68,56	0,34	15,32	0,72	3,68	0,10	2,42	3,42	3,10	2,16	0,12	0,55	0,07	100,56
2	(trondhjemite)	Vysoké Tatry, Svišťovka	69,55	0,42	15,94	1,10	0,75	0,09	1,12	2,68	4,59	2,91	1,07	1,17	0,05	100,44
3		Malá Fatra, the valley of Váh, near Strečno	67,19	0,26	15,51	1,90	1,08	0,06	0,99	5,65	4,12	2,35	0,04	0,90	0,24	100,29
4	Prašivec granite	Vysoké Tatry, Tichá dolina valley	73,11	0,22	13,26	1,67	0,73	0,03	0,80	2,05	4,21	3,56	0,02	0,71	0,13	100,50
5		Veľká Fatra, valley of the Ľubochňanka	73,45	0,02	16,07	1,00	0,72	0,02	0,39	1,43	3,56	3,07	0,09	1,05	0,11	100,98
6	Sihla granodiorite	Veporské rudohorie Mts., Kráľová hoľa zone N of Sihla	65,60	0,42	17,06	1,65	2,04	0,08	3,12	5,21	2,45	1,64	0,05	0,72	0,46	100,50
7	Vepor granite	Veporské rudohorie Mts., Kráľová hoľa zone quarry near Dobroč	70,88	0,29	14,22	0,89	1,37	0,06	0,91	2,21	4,00	5,00	0,03	0,71	0,27	100,84
8	Hronček granite	Veporské rudohorie Mts., Kráľova hoľa zone, Hronček	73,10	0,18	13,07	1,94	1,09	0,05	1,25	1,66	2,56	3,64	0,05	0,75	0,15	99,46
9	granite porphyry	Nízke Tatry, Králička	73,51	0,10	16,31	0,20	0,42	—	1,25	1,66	0,25	3,95	0,06	2,29	0,37	100,35
10	Muráň gneissose granite	Veporské rudohorie Mts., Kohút zone, 500 m SE from Muráň	73,44	traces	12,30	1,57	1,10	traces	0,39	1,09	3,72	5,17	0,20	0,31	traces	99,29
11	Gemer granite Gemeride	Spišsko-gemerské rudohorie Mts., south of Hnilec	73,92	0,19	12,89	2,21	0,83	0,04	0,25	1,08	2,47	4,47	0,92	0,62	—	100,02
12	granite of the Králička type	Spišsko-gemerské rudohorie Mts., N of Betliar	74,87	0,20	12,88	2,17	1,04	0,06	0,28	1,33	1,46	4,01	0,13	0,70	0,18	99,36

The analyses no. 1, 3, 4, 5, 6, 8, 9, 11 and 12 are from the material of J. Kamenický, analyse no. 7 from the material of E. Krist and analyse no. 10 from the material of D. Hovorka. The analyse no. 2 is from the paper of G. Gorek (1959). The analyses no. 1, 3, 6 and 9 were elaborated by E. Rubínová, analyses no. 2, 5 and 10 by K. Vnuková, no. 8 by T. Slezák, analyse no. 4 by O. Karelová and analyses no. 11 and 12 by J. Jarkovský.

hornblende by biotite. In a further stage plagioclase uses to be albitized, resp. stromatitic amphibolic migmatites originate.

2. The Kokava Group (J. K a m e n i c k ý in M. M a h e ľ, J. K a m e n i c k ý, O. F u s á n, A. M a t ě j k a 1967) nearly corresponds to the Kohút Group of M. M á š k a, V. Z o u b e k 1960. The metamorphites of the Kohút zone belong to it. Its stratigraphical equivalent is likely the Malé Karpaty Pezinok-Pernek Group. The Kokava Group is most probably of Late Proterozoic age. It is built by a complex of argillaceous sandy shales with subordinate but typical lydite and carbonate intercalations. Geosynclinal basic volcanites of small extension are the syngenetic member of the sedimentary complex. Its folding and regional alteration is related to the Assyntian folding phase. Eliminating the effects of the Hercynian plutonism its regional alteration compared with the Jarabá Group is less intensive. It is metamorphosed under the conditions of the quartz-staurolite subfacies of the garnet amphibolite facies, up to the quartz-albite-epidote-biotite subfacies of the greenschist facies.

The direct contact of the Kokava Group with the Jarabá Group is effected by the Hercynian granodiorite intrusion resp. by alpine tectonics. Therefore it is not sure whether these series passed gradually into one another, or they were separated by a stratigraphical hiatus.

In the conditions of the quartz-staurolite subfacies, from argillaceous shales of the Kokava Group originated biotitic and garnet-biotitic micaschists with the mineral association:

quartz—biotite—almandine—plagioclase ± (staurolite—muscovite).

From geosynclinal volcanites originated amphibolites with the association:

common hornblende—plagioclase ± (garnet—quartz—epidote—zoisite).

In turn the following mineral associations originated in the conditions of the greenschist facies:

quartz—muscovite—chlorite—biotite ± albite

talc—actinolite—chlorite ± quartz

calcite—dolomite—tremolite

green hornblende—epidote—albite a o.

The regional metamorphism of the Kokava Group was fortified by the effect of the Hercynian granodiorite intrusion, which manifested itself in a twofold manner:

a) injection-metasomatically and

b) contact-thermically.

By migmatization the source of which was the intruding magma (increase of migmatization intensity in the direction of the granodiorite massif) various types of migmatites originated, with transitions up to massive metasomatic granodiorites, widespread just in the Kohút anticlinorium.

The contact effect of the granodiorite intrusion has in the Kohút zone regional extension. In the initial phase of the contact alteration cordierite-biotite knotted schists of the amphibole hornfels facies originated, with the mineral associations:

biotite—cordierite—quartz—sericite

biotite—cordierite—quartz—albite ± sericite
biotite—cordierite—quartz—albite—garnet—sericite.

Sericite is the product of cordierite pinitization.

The Pezinok-Pernek Group of Malé Karpaty Mts. was contactly deep-metamorphosed by the Hercynian granodiorite. By heating of the already regionally metamorphosed mantle, from biotite phyllites and biotite or biotitic-garnet micaschists contact biotite and biotit-garnet gneisses originated with the association:

quartz—biotite—plagioclase ± (garnet—muscovite—graphite—staurolite—andalusite—sillimanite) (L. Zelenka. A. Matějka 1931).

3. The Gelnica Group builds the central part of the Gemerides. It is constituted in premetamorphic development from a 3—5 km thick sedimentary complex of argillaceous shales with layers of sandy shales and sandstones with abundant representation of graphitic shales with lydite beds and carbonate lenses. A typical feature of this Group is the huge development of geosynclinal volcanites of the nature of quartz porphyries, their tuffs and tuffites. Basic volcanites are represented in this Group only subordinately. The total thickness of the porphyry complex in the central part of the Gemerides is 1—2 km. By its development the Gelnica Group reminds of the greywacke zone of the Austrian Eastern Alps. Stratigraphically we assign it to the Upper Cambrium to Silurian. Its folding and regional metamorphism is allied to the Spiš phase of the Caledonian orogeny. It took place in the conditions of the quartz-albite-muscovite-chlorite subfacies of the greenschist facies.

By transformation of its sedimentary members various types of phyllites originated, with the mineral association:

quartz—sericite—chlorite—graphite ± albite, carbonates were weakly mramorized or metasomatically replaced by ankerite and siderite (region of Kobeliarovo-Nižná Slaná-Volovec). Quartz porphyries and their pyroclastics were at the same time transformed into porphyroids up to sericite-quartzy shales with the mineral association:

quartz—muscovite—chlorite—albite and
quartz—muscovite.

Biotite as a product of regional metamorphism is lacking in the Gelnica Group. For this reason there is a certain metamorphic leap between the Kokava Group of the Kohút zone and the Gemeride Gelnica Group. Basic rocks were altered into epidiabases and calcite-epidote-chloritic shales. On the places of pressure shadows the alteration is so weak, that rocks still show the native sedimentary or eruptive character. In contact aureoles of the Gemeride granite of Low Cretaceous age, sediments of the Gelnica Group were altered into knotted and spotted shales and contact hornfelses with the association:

quartz—chlorite—muscovite
quarzt—biotite—muscovite—albite.

The effect of the Gemeride granite on porphyroids in consideration of their near chemism was different. It displayed by the strong recrystallization of their groundmass and by intensive sericitization to muscovitization of their feldspar components.

4. The Rakovec Group (D. A n d r u s o v 1965) is developed near the northern margin of the Gelnica Group; in the southern part of the Gemerides it is lacking with exception of small occurrences south of Smolník. It is made up of a complex of argillaceous and sandy shales with subordinate representation of bituminous shales and carbonates. It is noted also by its large development of geosynclinal diabase effusions, accompained by pyroclastics with a local development of intrusive amphibolic diorites. It appears in the stratigraphic roof of the Gelnica Group and in the basement of the Gemeride Carboniferous (Moscovian), where it occurs already in the form of pebble material and thus represents probably the Devonian. Some members of the Harmonia Group are its stratigraphic equivalent. Other members of the Harmonia Group may belong to the Permian. Its folding and epizonal alteration (phyllitic shales, phyllites, epidiabases, chlorite-albitic shales a o.) are connected with the Bretonian and Sudetic phase of the Variscian folding. It took place in the conditions of the quartz-albite-muscovite- chlorite subfacies of the greenschist facies. The following mineral association originated by this transformation from the sedimentary volcanogene complex:

quartz—muscovite—chlorite $\pm$ albite
albite—epidote—chlorite $\pm$ quartz
albite—epidote—chlorite—calcite $\pm$ quartz.

These rocks frequently have still preserved their native stratification.

Diabases of the Rakovec Group were prior to their regional alteration intensely spilitized. Quite massive rocks devoid of features of tectonic effect and crystallitization schistosity, totally transformed are the evidence of it. TP conditions during spilitization were not too different from the conditions of regional metamorphism of the Rakovec Group, as spilitization yielded the same mineral association:

albite—epidote—chlorite $\pm$ quartz
albite—epidote—chlorite—calcite $\pm$ quartz.

In addition to regional transformation the Harmonia Group was affected also by contact alteration of regional degree of the Hercynian granodiorite intrusion. By contact alteration originated from originally argillaceous-sandy rocks knotted and spotted sericite-biotitic phyllites, spotted andalusite-muscovite-biotitic cherts and muscovite-biotitic cherty gneisses. Bituminous shales were transformed into knotted and spotted graphitic phyllites, calcareous-siliceous cherts with garnet, diopside, wollastonite, vesuvian and plagioclase originated from carbonates.

In addition to regional alteration the West Carpathian crystalline complex was affected also by periplutonic metamorphism allied to the Sial plutonism of the Hercynian, in a less amount also of the Alpine cycle.

The metamorphism induced by the Hercynian granitoid plutonism is of three kinds:

a) injection-metasomatic
b) deep-contact and
c) contact-thermal.

a) The injection-metasomatic alteration took place in the deep-seated parts of the granitoid intrusion, where the temperature differences between the crystalline mantle and the intruding magma were not substantial: the magma was in these parts of high chemical activity. These factors enabled the penetration of granitoid elements into the mantle and the formation of postkinematic migmatites to metasomatic granitoids. When granitoid elements penetrated the amphibolites, their dioritization up to syenitization set in during the extreme development stage of this process (Malá Fatra, Čierna hora).

b) The deep-contact alteration was till now noted only in the region of Malé Karpaty, Považský Inovec and the Veporide Kohút zone. However its extension in the West Carpathians is probably substantially wider. The effect of the Sial plutonism is manifested in this case by the heating of the already metamorphosed mantle and by the increase of its crystallinity grade. Phyllites and micaschists were so transformed into contact gneisses with frequent diagonal biotite, andalusite, sillimanite and cordierite (Kohút zone).

c) The contact-thermic alteration allied to the Hercynian granodiorite plutonism is known only from the region of Malé Karpaty Mts. The Harmonia Group is here affected by contact alteration. By contact metamorphism of argillaceous-sandy rocks originated knotted and spotted sericitic-biotite phyllites, andalusite-muscovite-biotitic spotted cherts and muscovite-biotitic gneisses. Bituminous shales were transformed into knotted and spotted phyllites and carbonates into calcareous-siliceous cherts with garnet, diopside, wollastonite, vesuvian, plagioclase.

The Alpine sial plutonism revealed only in the Gemerides. The local contact alteration of the Gelnica Group appearing in the granite mantle is allied to the intrusion of Gemeride granites. Phyllites are altered into knotted and spotted shales up to contact hornfelses with new-formed chlorite, biotite, quartz and hematite. The contact effect on porphyroids is less pronounced; it displays mainly by the recrystallization of the groundmass under the formation of sericite up to muscovite.

2. Granitoids show in the West Carpathians large development and in some Core mountains (Malé Karpaty, Tribeč, Malá and Veľká Fatra, Vysoké Tatry a o.), even in the Kráľová hoľa zone and Kohút zone of the Veporides they strongly predominate over crystalline schists. On the other hand granites show only unsubstantial occurrence in the Gemerides.

The processes of granitoid formation are quite complicated in the West Carpathians and they belong to several tectono-magmatogene development cycles.

At present we may consider the Hercynian and Alpine-Carpathian development cycle as proved, but from paleogeographic view the existence of a pre-Cambrian granite-forming cycle is probable.

The Carpathian granitoids are very interesting from the genetic point of view and except for the magmatic types, various metamorphic types are also represented.

The pre-Cambrian cycle — is likely allied to the Intraalgonkian and Assyntian folding phase.

During the Intraalgonkian folding and the regional metamorphism of the Jarabá Group, in places (in the Ďumbier crystalline complex of Nízke Tatry Mts., the Ľubietová zone of the Veporides, the massif Sľubica) the mobilization of granitoid elements and the synkinematic granitization of the metamorphic complex in the lower tract of this complex set in (under the conditions of the garnet amphibolite facies). We qualify granitoids of this type as selective-mobilisation granitoids (M e h n e r t 1959). They are most frequently of the nature of biotite granodiorites.

Composition: Quartz > plagioclase > orthoclase ± microcline—biotite ± muscovite with an accessory amount of apatite, zircon and other minerals.

They are noted by a rapid change of mineral constitution and texture development. In addition to massive types, also types with undistinct and pronounced schistosity are represented, which are a palimpsest after the original schistosity of granitized paragneisses.

The palingene subautochthonous intrusion of the leucocrate granite of the Králička type in Nízke Tatry Mts. belongs probably also to the Intraalgonkian tectogenesis. The granite of the Králička type belongs by the origin of the magma still to synkinematic processes, but by temporal relation of the intrusion to the culmination of the tectonic process, it is already near to postkinematic processes. Therefore its texture is rather massive. It includes frequently unremelted relics of migmatized paragneisses and that is why it has locally streaky texture.

It is a light aplitic, most frequently two-mica granite with the mineral constitution: quartz > orthoclase > plagioclase, with subordinate muscovite and biotite. Sillimanite is frequently present as accessory.

Synkinematic intrusions of the Muráň gneissose granites belong also to the Assyntian phase. They have been mostly observed in the Kohút crystalline complex (V. Z o u b e k 1954) and in Vysoké Tatry Mts. (A. G o r e k 1959). They usually form minute lense-shaped bodies located concordantly with the schistosity of the ambient migmatites paragneisses to micaschists. According to some authors (D. H o v o r k a, M. H v o ž ď a r a 1965) the Muráň gneissose granites are of metamorphic origin. They are of orthogneiss nature and are noted for a relatively constant mineral composition: quartz, orthoclase, plagioclase with a subordinate representation of biotite. Their contact with the mantle is relatively sharp and likely intrusive.

The Hercynian granitization cycle was active most intensely in the West Carpathians. Its existence is evidenced on one hand by the occurrence of granitoids in conglomerates of the north Gemeride Carboniferous, on the other hand by the contact metamorphic effect of the Modra granodiorite on the Malé Karpaty Harmonia Group, at least some members of which according to the occurrence of tentaculites and crinoids are of Devonian age (R. H o r n ý, I. C h l u p á č in

M. Máška, V. Zoubek 1960). The Hercynian age of the majority of post-kinematic Tatraveporide granitoids was confirmed also by the K/A method (J. Kantor 1959). At least two granitization phases acted during the Hercynian cycle: the Bretonian-Sudetic and the Saalian phase.

a) The Bretonian-Sudetic orogeny phase displays in the West Carpathians by the lack of the Low-Carboniferous and the independent spatial occurrence of the Gemeride Upper Carboniferous in the Rakovec Group, belonging most probably to the Devonian. The large postkinematic intrusion of most of the Tatraveporide granodiorites of the Ďumbier type in Nízke Tatry Mts. is also allied with this folding. The Ďumbier granodiorite stands petrographically very near to the so called common granodiorite of Vysoké Tatry Mts. and the Sihla granodiorite of the Kráľova hoľa and Kohút zones partly also to the granodiorite of the Veľká Fatra Mts. Smrekovica type. The granodiorites of Malé Karpaty, Tribeč, Inovec, Malá Fatra etc. belong also to this group. As far as they were not notably affected by pressure, they are of massive nature, constant mineral composition (quartz > plagioclase > orthoclase with subordinate representation of biotite ev. muscovite). In Malé Karpaty Mts. they come also in intrusive contact with the mantle (Harmonia Group), which they do contactly transform.

The origin of leucocrate aplitic granite appearing in places (Vysoké Tatry Mts., Ľubochňa massif and on other sites) on the periphery of the Ďumbier granodiorite, is also allied to the postkinematic Bretonian-Sudetic phase. It is probably its magmatic differentiate.

In Vysoké Tatry Mts., in the Ľubochňa massif, the Ďumbier anticlinorium of Nízke Tatry Mts., the postkinematic granodiorites of the Ďumbier type are locally affected by alkaline, mostly kali metasomatism, with the formation of auto-metamorphic granite up to granodiorite of the Prašivec type (A. Michalík 1952, A. Gorek 1959). The alkaline metasomatism acted firstly in the domal parts of the intrusion, where alkalies accumulated for a long period and their escape was unabled by the impermeable roof made up of the crystalline mantle. The original plagioclase was albitized by alkali metasomatism and replaced by orthoclase, or the less frequent microcline. Rocks of this type are marked by the porphyroblastic facies of beige to red K-feldspars.

In the apical sections of the intrusion the granodiorite of the Ďumbier type frequently holds mantle xenoliths of diverse stage of metasomatic „reworking" and in places (Malá Fatra and other sites) passes into hybrid granodiorite. It is noted by a great inhomogeneity, an increased amount of biotite and indistinct schistose texture, which is the relict after the schistosity of the granitized mantle.

During the intrusion of the Ďumbier granodiorite locally the migmatization set in of its already regionally metamorphosed mantle built by the Jarabá and Kokava Group. In advanced development stage of this process, the paragneisses ev. micaschists were granitized, on the other hand amphibolites were dioritized up to syenitized. We denominate this genetic group injection-metasomatic granitoids.

Injection-metasomatic granodiorites are known firstly in the Kohút zone. They frequently hold beds of paragneisses, imbibition or stromatitic migmatites, in which they pass gradually. Constitution: quartz > plagioclase > orthoclase, with subordinate biotite representation. Biotite shows even in extremely granitized variaties frequently shaped orientation.

Metasomatic diorites, quartz syenites are known till now only in Čierna hora and Malá Fatra Mts. By the penetration of granitoid elements from the intruding magma into the amphibolite frame common hornblende was partly metasomatically replaced by biotite, plagioclases were partly albitized and slight SiO_2 increase with formation of quartz set in.

Gabbrodiorites passing into diorite, quartz diorite up to granodiorite, occurring in the Rakovec Group in the area of Dobšiná, amphibole diorites also in the area of Švedlár, Mníšek n/Hronom and between Košická Belá and Vyšný Klátov belong probably also to old Hercynian granitoid rocks. Recently L. Rozložník (1965) holds these rocks for the product of granitization of diabases and their tuffs of the Rakovec Group, allied to the Sudetic folding phase. According to our observations their magmatically-intrusive nature is beyond doubt.

b) The Saalian granitization phase took place only in the Kraklová zone of the Veporides. It reveals by the formation of microgranites and microgranodiorites, passing in the NE vicinity of Brezno gradually into granite porphyrites and granodiorite porphyrites.

The granodiorites of the Saalian phase are only of subordinate significance.

The Alpine granitization cycle is allied to the Laramide phase of Cretaceous folding and with the Neogene of andesites and rhyolites.

Only Gemeride granites and granite porphyries are of Laramide age. They show in the Gemerides only subordinate distribution (Zlatá Idka, dol. Hummel. Betliar, Hnilec); they pierce the Gelnica Group, metamorphosing it contactly under the formation of knotted streaky schists and contact hornfelses.

They are of massive nature, granitic texture, mineral composition: quartz > orthoclase > plagioclase > biotite ± muscovite with frequent tourmaline.

According to recent views (L. Rozložník, J. Šalát 1963), the intrusion of the „Hodruša granodiorite and diorite" presents dyke-subvolcanic forms — the equivalents of neovolcanic surface forms.

The intrusion of the Hercynian granitoids is in places accompanied by aplite, pegmatite (Malé Karpaty, Nízke Tatry, Považský Inovec) and lamprophyre veins (Malá Fatra and other localities).

Granitoids of the pre-Cambrian and Hercynian cycle are frequently affected by Alpine mylonitization and are altered into various types of mylonites, from kakirites over blastomylonites up to mylonitic shales, made up substantially of quartz, sericite and chlorite.

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