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PETROLOGY OF THE ČIERNA HORA MTS. GRANITOID ROCKS

(Figs. 13, Tabs. 4)

Abstract: The basic geochemical-petrological characterization of granitoid rocks of the Čierna hora Mts. is given on the basis of 32 original chemical and 15 spectrochemical analyses. In spite of strong tectonometamorphic reworking of the granitoids the main cause of compositional variation may be identified as fractional crystallization. Another process concurrent with fractionation, assimilation of wall-rock, cannot be excluded on the basis of trace element modelling using DePaolo's (1981) equations.

The presence of epigenetical association (galena, chalcopyrite, pyrite, cassiterite, barite) is inferred from the anomalous concentrations of ore elements (Cu, Pb, Ag, Sn, Ni, Cr, Ba). The coincidence of trace element anomalies with locations of Alpine thrust faults and normal faults intersections suggests the Alpine age of the inferred ore mineralization.

Резюме: В статье приводится основная геохимико-петрологическая характеристика гранитоидных пород Черной горы на основе 32 оригинальных химических и 15 спектрохимических анализов. Несмотря на сильное тектонометаморфическое преобразование гранитоидов, главную причину вариации состава можно определить как фракционную кристаллизацию. Следующий процесс совпадающий с фракционированием — ассимиляцию вмещающих пород нельзя исключить на основе моделирования рудных элементов применяя уравнения ДеПаола (DePaolo, 1981).

Аномальные концентрации рудных элементов (Cu, Pb, Ag, Sn, Ni, Cr, Ba) объясняются наличием эпигенетической ассоциации (галенит, халькопирит, пирит, касситерит, барит). Совпадение аномалий редких элементов с пересечениями альпийских взбросов и нормальных сбросов намечает альпийский возраст предлагаемой рудной минерализации.

The Čierna hora Mts., the most eastern morphostructural unit of the West Carpathian internides containing a standard vertical succesion, i.e. crystalline complex, Palaeozoic and Mesozoic cover formations which are topped by the Gemericum nappe outliers, has been until the last decade regarded as a part of the West Carpathian core mountain range. The systematic research of the region carried out in the meantime has brought a series of important results connecting the structure, tectonometamorphic development, magmatism and wider lithostructural relations of the crystalline basement of the area. Some of them have been shortly discussed in several papers. A comprehensive evaluation of the nature and genetic aspects of the fundamental rock groups of the crystalline basement of the region has not been done yet. The aim of this contribution is to fill the existing gap in granitoid petrology of this the most eastern section of the Veporic crystalline complex.

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Geological and structural relations of the Čierna hora Mts. granitoid rocks

Granitoid rocks occupy a significant territory of the Čierna hora crystalline complex which presently forms an Upper Cretaceous antiformal structure of NW-SE direction (Figs. 1, 3). In the western and central part of the region granitoids are restricted to the both limbs of the antiform while four smaller crystalline segments in the south eastern continuation of the antiform are nearly exclusively built of granitoids (Fig. 1). The crystalline basement as a whole is strongly affected by the Alpine metamorphism.

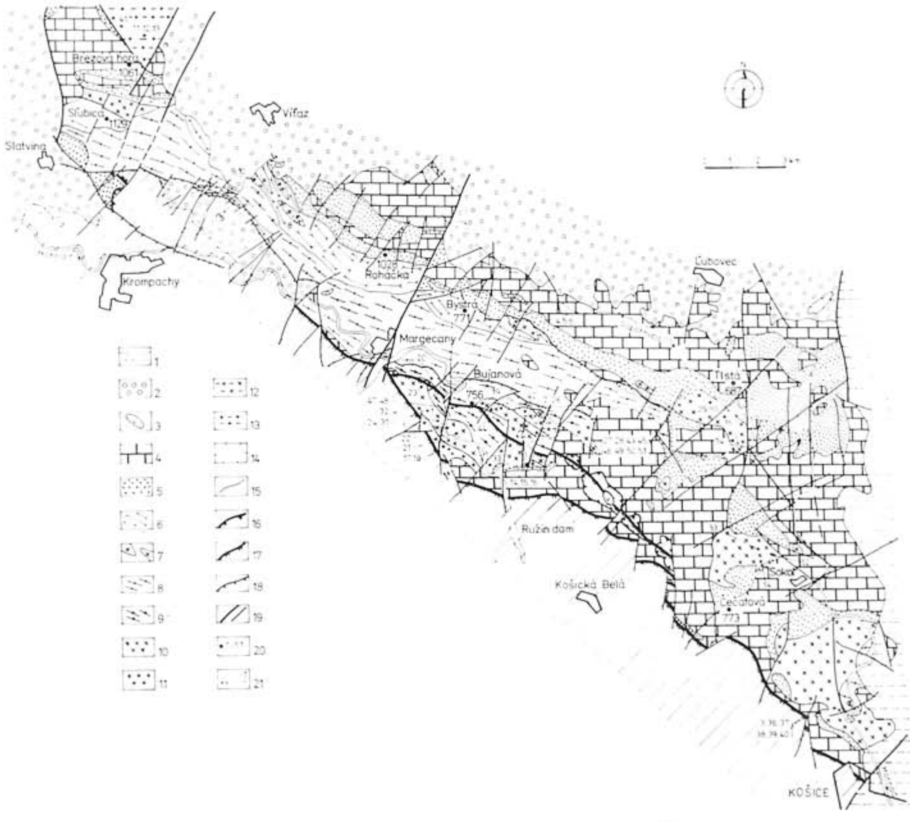

Fig. 1. Schematic structure – geological map of the Čierna hora Mts.
Explanations: 1 – Neogene molasse sediments; 2 – Intracarpathian Paleogene sediments; 3 – Uppercretaceous hornblende-pyroxene diorite; 4 – Mesozoic cover formations; 5 – Upper Paleozoic (mainly Permian) cover formations; 6–12 crystalline basement of the Čierna hora Mts., 6–7 the Miklušovce complex; 6 – stromatite nebulite and ophtalmite migmatites; 7 – aplite granites; 8 – diaphtoritic paragneisses, amphibolites and phyllonites of the Lodina complex; 9–12 The complex of Bujanová; 9 — gneisses, amphibolites and migmatites; 10 — biotite granodiorites; 11 — autometamorphic granites; 12 – melagranodiorites and tonalites; 13 – gneisses, amphibolites, migmatites and granitoids of the Branisko Mts.; 14 – Carboniferous and Permian of the Gemeric unit; 15 – geological boundaries; 16 – the Gemeric nappe sole thrust; 17 – regionally significant thrust fault zones; 18 – local thrust faults; 19 – normal faults; 20 — location of analysed samples; 21 — cross-section lines.

This basic information collected by earlier workers mainly by Fusán — Záruba — Hromada (1954), Fusán (1958) and L. Kamenický (1956) have lately been supplemented by closer relations of granitoids to principal development stages of the region. On the basis of structural and petrographic criteria it was, e.g. possible to demonstrate that the emplacement of granitoids is bound to a late kinematic stage of the Variscan metamorphism of the area, Jacko (1975; 1978; 1985b).

Structurally granitoids penetrate into axial plane foliation of the Variscan regionally synmetamorphic fold fabric, cf. Figs. 2, 3. On the other hand the periplutonic mineral assemblage in surrounding metamorphites — linked to granitoid bodies, mimetically growths in the mentioned axial plane foliation and simultaneously replaces the previous, regionally synkinematic one. These data and a common presence of granitoid fragments in Permian sediments of the area correspond with a preliminary K/Ar dating: 309 mil.y. (Kantor, personal information) of the most widespread granitoid variety of the region — the biotite granodiorite.

Within Čierna hora granitoid rocks the following four basic groups have been distinguished (Jacko, 1975): contaminated granodiorites and tonalites, biotite granodiorites, granites, aplite and pegmatite granites. In the sense of lithostratigraphical division of the Čierna hora crystalline complex (Jacko, 1985a) more important aplite granite bodies are nearly exclusively developed in the Miklušovce complex i.e i.n the northeastern lithostratigraphical unit of the crystalline complex, Figs. 1, 3, where they form subordinate intrafolial bodies within migmatites. For correctness we only should like to add their very common diffuse transitions to country rocks, a lot of restites in these lensoidal bodies of some 10 m to several 100 m thickness and a development of 10 m to 100 m wide aureolas of ophthalmitic migmatites round the bodies.

In the central lithostratigraphical unit of the basement i.e. in the Lodina complex no surface indications of granitoid plutonism have been found up to now.

The distinguished granitoid groups (except of larger aplite granite bodies) form a substantial volume of the last lithostratigraphical unit of the Čierna hora basement called the Complex of Bujanová, Figs. 1, 2. Some of the mentioned lithostructural relations between metamorphites and granitoids which are typically developed in this unit are schematically expressed in Fig. 2. The same relations between granitoid varietes as well as diffuse transitions of all crystalline rocks of the unit are obviously modified by the products of the Alpine dislocation metamorphism, Fig. 2.

In spite of this gradational trend of periplutonic metamorphism of crystalline schists represented by the scale of fine-grained biotite gneisses through feldspathized gneisses, ophthalmite migmatites, pearl gneisses and granite gneisses to melagranodiorites is quite well preserved. Moreover, a very close spatial and compositional relations among some metamorphites, e.g. amphibolites, their xenoliths in biotite granodiorites and the final product of the process: the biotite-hornblende tonalites as well as structural data indicate the substantial hybridization role at marginal zones of an original granodiorite intrusion.

This idea is also supported by common biotitization of hornblende at marginal zones of amphibolite xenoliths and in the biotite-hornblende melatonalites and tonalites. More mobilized irregular patches of these rocks sometimes of dioritic composition are typical by a substantially higher habitual degree of hornblende and plagioclase and also by sphene exsolutions in the vicinity of biotite-hornblende acumulations. On the other hand a periplutonic paragenesis of fine-grained biotite gneisses and feldspathized gneisses evidently replaces some indicative minerals, namely staurolite and garnet, of the previous regionally synkinematic metamorphic stage of the Variscan metamorphism.

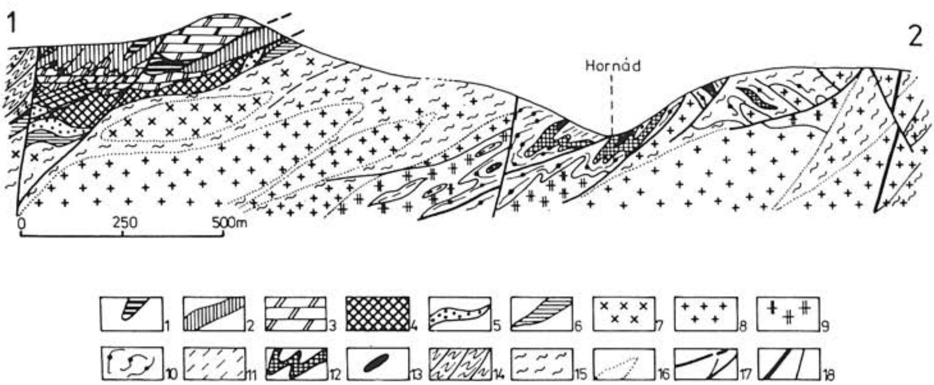

Fig. 2. Cross-section through a part of the Complex of Bujanová.
Explanations: 1 – 5 Mesozoic cover formations of the Čierna hora Mts.,1 – crinoidal limestones (Dogger?); 2 – laminated dark greyish limestones intercalated with marls (Liassic); 3 – benched light greyish dolomites (Upper Triassic); 5 – quartzites (Lower Triassic); 6 – dynamometamorphosed sandstones and schists (Permian); 7–13 – the Complex of Bujanová; 7 – granites; 8 – biotite granodiorites; 9 – biotite melagranodiorites; 10 – ophtalmite migmatites; 11 – biotite gneisses; 12 — medium to coarse grained amphibolites; 13 — very coarse grained amphibolites; 14 — phyllites, paleobasalts; their volcanoclastics and greywacke intercalations of the Gemericum unit; 15 — tectonites; 16 — tectonite vs. kataclastic granitoide boundaries; 17 – thrust faults; 18 – normal faults.

According to field criteria and succesive relations of mineral parageneses of biotite granodiorites and granites at mutual contact zones the latter variety is relatively younger than the previous one. Such a sequence results also from a development of polymigmatite aureoles at the contacts of granites with migmatites of the periplutonic metamorphic stage. Whilst the neosome of the latter is obviously of pegmatoid composition (consisting mainly of plagioclases, quartz and only of subordinate K-feldspar volume) relatively younger neosome of the polymigmatites, spatially connected with granites consists exclusively of K-feldspar phenoblasts.

Within the Complex of Bujanová aplite granites and pegmatites tend to form irregular lensoide accumulations especially in granites or their dykes of cm-dm thickness cut through all granitoids and migmatites of the unit.

Besides earlier rather occasional petrological information (e.g. Šalát, 1954; Radzo, 1958; J. Kamenický, 1977) some important petrological data on the Čierna hora granitoids have lastly been collected in the results of the integrated study of selected samples of West Carpathian granitoids (the ZK samples) coordinated by the Geological Institute of the Slovak Academy of Sciences. Basic information concerning the modal and chemical composition of the Čierna hora ZK samples are included in the papers of Macek et al. (1982) and Cambel—Walzel (1982) respectively. Following these data and our earlier correlation of the Čierna hora crystalline complex with lithostructural units of the Veporicum (L. Kamenický, 1958; Máška—Zoubek, 1960; Fusán, 1961; J. Kamenický, 1968; L. Kamenický, 1973; Jacko 1975, 1978), L. Kamenický (1982) settled the Čierna hora granitoids with a common the Veporic pluton. Such relations as we suppose are in accord with presented results.

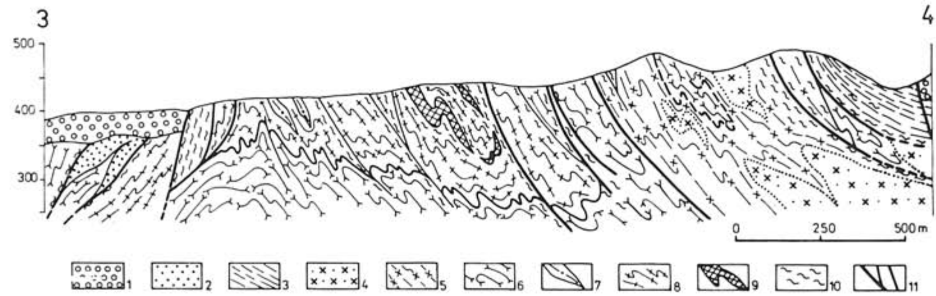

Fig. 3. Cross-section through the Lodina and the Miklušovce complexes.
Explanations: 1 — Intracarpathian Paleogene sediments; 2 — Lower Triassic quartzites of the Mesozoic cover formation; 3 — dynamometamorphosed clastic sediments of the Permian cover; 4–6 — the Miklušovce complex, 4 — aplite granites; 5 — ophtalmite-nebulite migmatites; 6 — stromatite-nebulite migmatites; 7–9 — the Lodina complex; 7 — diaphtoritised quartz-feldsphatitic gneisses; 8 — diaphtoritised biotite gneisses; 9 — diaphtoritised amphibolites; 10 — the Alpine tectonites; 11 — thrust faults and normal faults.

Petrography

As it was stated above four main groups of granitoid rocks have been distinguished within the Čierna hora basement. They are namely: contaminated granodiorites and tonalites, biotite granodiorites, granites, aplites and pegmatites. While granitoids of the first three groups are extensively developed in the Complex of Bujanová, individual aplite granite bodies are typical for the Miklušovce complex, Figs. 1, 2, 3.*

* Reviewer L. Kamenický noted to the petrological-geological part of the paper that, in his opinion, granitoids dealt with in the paper do not form a uniform genetic formation. Group of aplite granites do not belong to differentation sequence and, thus, generalizing opinion on differentiation by fractional crystallization as the only process need not have an universal validity. It is confirmed by hybrid and assimilation granitoids and by autometamorphic or metasomatic processes known in the Čierna hora Mts.

Table 1

Representative major element analyses of Čierna Hora granitoid rocks (in wt. %)

	aplite granites, leucogranites					
	1	2	3	4	5	6
SiO_2	70.55	73.95	71.12	75.98	75.92	76.43
TiO_2	0.03	0.09	0.27	0.10	0.09	0.14
Al_2O_3	16.33	15.23	17.95	13.05	13.39	14.80
Fe_2O_3	0.08	0.39	0.26	1.02	0.39	0.69
FeO	0.65	0.26	0.00	0.00	0.53	0.78
MnO	0.00	0.03	0.00	0.02	0.01	0.00
CaO	0.70	0.49	1.30	0.54	0.37	0.25
Na_2O	4.30	5.17	2.06	4.38	3.83	2.64
K_2O	5.78	3.02	6.43	3.28	3.56	2.95
P_2O_5	0.05	0.19	0.12	0.24	0.14	0.06
H_2O^+	1.05	0.82	0.64	0.92	0.63	0.25
H_2O^-	0.00	0.05	0.06	0.05	0.68	0.45
Total	99.57	100.00	100.59	99.88	99.74	99.77

					granites	
	7	8	9	10	14	15
SiO_2	63.00	74.16	70.89	69.68	70.10	68.25
TiO_2	0.88	0.10	0.29	0.27	0.20	0.29
Al_2O_3	15.68	13.55	13.64	16.22	13.40	17.55
Fe_2O_3	1.47	0.43	1.00	0.65	3.03	0.98
FeO	4.72	0.93	2.50	1.82	2.30	1.40
MnO	0.11	0.01	0.07	0.05	0.04	0.05
MgO	3.61	0.26	0.80	0.99	0.58	0.81
CaO	3.28	0.37	1.38	0.56	1.44	1.05
Na_2O	3.28	2.79	3.80	3.68	3.50	3.69
K_2O	1.45	5.00	2.55	3.98	4.00	3.34
P_2O_5	0.14	0.16	0.08	0.22	0.18	0.20
H_2O^+	2.58	1.34	1.33	1.55	1.70	1.63
H_2O^-	0.33	0.31	0.07	0.06	0.00	0.25
Total	100.53	99.41	98.40	99.73	100.47	99.49

All the granitoid groups except of the first one show rather slight variations in primary structures and composition, cf. Tabs. 1, 2. Principal features of much more expressed petrographical variability within a group: the result of postmagmatic and polystage tectonometamorphic development of the region as a whole, are shortly discussed at the end of this chapter.

Contaminated granodiorites and tonalites

Petrographical varieties of this group form a considerable part of the Ťahanovce, the Sokol and the Sopotnica massifs. Within the Bujanová massif (Fig. 1) they are either developed in granitoids — metamorphite contact zones or in the top parts of biotite granodiorite bodies. An obvious presence of metamorphic mantle restites of cm to dm size is projected into a considerable compositional heterogeneity of the rocks (Tabs. 1, 2). These causal relations follow rather directional than the opposite

1st continuation of Tab. 1

	granites				granodiorites	
	16	17	18	49	21	22
SiO_2	71.66	68.02	70.11	69.03	63.34	63.00
TiO_2	0.21	0.30	0.22	0.40	0.89	0.99
Al_2O_3	14.14	16.02	14.66	14.30	14.88	15.94
Fe_2O_3	0.44	1.99	1.83	1.76	2.40	2.76
FeO	1.78	1.44	2.66	3.23	4.31	4.45
MnO	0.03	0.02	0.04	0.04	0.07	0.09
MgO	0.53	0.39	0.53	1.03	2.12	2.36
CaO	0.96	1.68	0.70	1.93	3.36	2.88
Na_2O	3.75	4.10	3.50	1.96	3.50	2.54
K_2O	3.93	4.42	4.56	4.28	2.54	2.30
P_2O_5	0.08	0.06	0.11	0.14	0.40	0.26
H_2O^+	1.64	1.55	1.34	1.85	2.01	2.03
H_2O^-	0.27	0.06	0.05	0.20	tr.	0.18
Total	98.92	100.05	100.31	100.15	99.82	99.78

	granodiorites				
	24	25	26	27	28
SiO_2	65.35	57.02	70.47	64.24	66.15
TiO_2	0.63	1.20	0.11	0.30	0.43
Al_2O_3	16.23	21.27	15.07	20.62	17.24
Fe_2O_3	1.94	1.48	1.20	0.78	0.67
FeO	3.45	4.02	1.79	1.43	2.93
MnO	0.08	0.02	0.03	0.01	0.05
MgO	1.37	1.76	0.81	0.24	1.38
CaO	2.30	5.15	2.78	4.80	2.77
Na_2O	2.76	4.00	4.82	4.16	4.73
K_2O	3.12	2.36	1.40	2.40	1.73
P_2O_5	0.04	0.70	0.07	0.12	0.37
H_2O^+	2.37	1.10	0.96	1.10	1.08
H_2O^-	0.14	0.10	0.00	0.10	0.15
Total	99.78	100.19	99.51	100.30	99.55

continuation of restite zones, what — in the last case, could be one of the reasons of field observed "dry" granitoids — metamorphite contacts.

A common content of biotite + quartz ± garnet nests and strips of mm — dm size make from obviously medium grained and hypidiomorphic granular granodiorite rather a heterophanous rock of variable structure and composition. Within a representative granodiorite mineral assemblage plagioclases prevail over biotite, quartz, and K-feldspars. Muscovite, apatite, zircon, sphene, allanite, rutile, an ore minerals are present in accessory amounts. A higher epidote content (up to substantial amount) is often typical.

Usually subhedral plagioclases form slightly sericitised 0.X mm grains of 30—−40 % An content or 2.0—4.0 mm phenocrysts. The latter are often zonal and filled with biotite, quartz and/or zircon and apatite. Their inner zones contain 30—36 % An, outer ones 26—27 % An. Subhedral slightly sericitised K-feldspar of 0.5—1.5 mm size together with muscovite and quartz belong to the youngest primary rock components.

Apatite and allanite obviously associate with elongated or irregular nests of chloritised biotite. The former (together with zircon and rutile) also frequently participates in inclusion associations of biotite. Allanite, clearly pleochroic one, is usually overgrown by incomplete epidote rims.

2nd continuation of Tab. 1

	granodiorites		contaminated granodiorites & tonalites			
	29	30	42	43	44	45
SiO_2	60.87	63.40	59.47	58.86	51.38	46.20
TiO_2	1.67	0.78	1.00	0.90	1.60	1.30
Al_2O_3	15.83	16.22	20.85	20.06	19.08	23.20
Fe_2O_3	2.93	2.16	2.90	2.12	3.42	3.80
FeO	4.14	2.86	1.72	3.00	5.46	6.60
MnO	0.12	0.07	0.03	0.04	0.10	0.03
MgO	3.04	1.96	1.76	1.76	5.68	3.68
CaO	3.03	2.97	5.04	4.48	7.60	10.08
Na_2O	3.01	4.45	4.00	4.20	2.80	2.08
K_2O	2.53	2.33	1.72	2.30	0.44	0.56
P_2O_5	0.88	0.19	0.24	0.48	0.30	0.06
H_2O^+	1.43	1.66	1.38	1.92	1.92	2.28
H_2O^-	0.23	0.21	0.12	0.10	0.12	0.10
Total	99.71	99.26	100.23	100.22	99.90	99.97

	contaminated granodiorites and tonalites		
	23	50	51
SiO_2	64.22	65.73	61.90
TiO_2	0.60	0.66	0.91
Al_2O_3	20.25	15.70	16.70
Fe_2O_3	1.00	1.26	2.69
FeO	2.58	4.67	5.39
MnO	0.02	0.08	0.07
MgO	1.44	1.93	1.94
CaO	3.02	1.89	2.36
Na_2O	3.80	3.01	2.06
K_2O	1.84	3.09	3.06
P_2O_5	tr.	0.26	0.03
H_2O^+	1.30	1.45	2.46
H_2O^-	0.14	0.13	0.16
Total	100.21	99.86	99.73

T o n a l i t e s — present mainly in the Sopotnica and the Sokol massifs, differ from granodiorites either compositionally by a higher biotite, plagioclase and sphene content and relatively lower K-feldspar and quartz amounts (Tab. 2) or by a granularity degree — their substantial minerals vary from 1.5—5.3 mm in size.

In granite contact aureoles the both discussed varieties are locally enriched with plagioclase and K-feldspar. Such zones are of q u a r t z — m o n z o d i o r i t i c composition. Seldomly mobilised coarse-grained hornblendites have m e l a m o n z o d i o r i t i c composition (cf. Tab. 2, sample 45).

Biotite granodiorites

This, the most widespread plutonite type of the Complex of Bujanová, is typical by sharp contacts to metamorphites but the transitional ones to other granitoids. Its main and satellite bodies usually follow general (prevailingly directional) elements of the Variscan structure of the basement.

Usually grey-greenish hypidiomorphic granular biotite granodiorites have ca. 1.5 to 3.5 mm size of main rock-forming minerals except of some feldspars which reach

Table 2

Modal compositions of main rock types of Čierna Hora granitoid rocks (in vol. %)

Sample	3	4	7	8	14	17	18	21	22
Qtz	32.0	45.8	48.4	52.9	34.9	32.7	31.5	22.7	24.4
Plg	29.0	32.4	30.6	18.8	27.6	27.3	26.8	48.1	37.9
K-fs	38.0	15.0	15.3	18.0	27.6	31.4	34.2	10.3	14.6
Bio	—	2.7[1]	3.3	5.6	5.6	4.4	4.4	11.8	10.7
Mus	—	3.5	1.5	3.8	4.0	2.0	2.1	1.7	1.2
Epi	—	—	—	—	—	2.1	0.3	3.7	9.0
Ores	—	0.8	0.2	0.6	—	—	—	0.4	0.8
Acc[2]	1.0	0.9	0.3	0.9	0.3	0.3	0.7	1.7	2.3
Sample	**30**	**36**	**52**	**42**	**43**	**45**	**50**	**53**	**54**
Qtz	22.9	29.0	31.5	10.4	22.9	0.1	32.5	28.6	23.3
Plg	48.6	44.0	41.8	48.5	37.2	35.0	19.0	33.1	52.4
K-fs	10.3	20.0	8.8	12.0	6.8	6.2	29.7	5.2	3.5
Bio	14.9	6.5	15.5	17.6	16.7	1.2	12.4	29.8	17.6
Mus	—	—	—	0.4	0.4	—	4.8	2.0	—
Epi	1.7	—	0.9	7.7	13.4	9.6	—	—	1.4
Hb	—	—	—	—	—	39.5	—	—	—
Ores	0.3	—	1.0	2.0	0.5	2.1	0.5	0.7	1.0
Acc[2]	1.6	0.5	1.6	3.4	2.9	8.4	1.6	1.3	1.8

Notes: [1] Bauerite; [2] Indistinguished sum of accessories (including ores, excluding epidote). Sample 8 contains garnet (0.1 %), sample 30 contains titanite (0.4 %), sample 43 contains allanite (1.2 %), apatite (0.5 %) and titanite (0.7 %), sample 45 contains apatite (5 %), titanite (1.3 %).

up to 4.0—5.1 mm. Obviously subhedral plagioclases (An 30—33 %) are commonly filled with biotite, apatite ± quartz and with superimposed assemblage, mainly sericite, epidote-zoisite or by a complete saussuritic assemblage. At their contacts with K-feldspars myrmekites are formed. Slightly pertitised and sericitized K-feldspar is usually filled with muscovite, drop-like quartz, only rarely with biotite.

A moderate chloritized biotite, slightly cataclastic quartz and muscovite fulfill spaces among feldspars. Muscovites and quartz sometimes form symplectitic intergrowths. Accessory zircon, rutil, but mainly apatite are commonly enclosed in biotite. Rare, obviously deeply brown and subhedral allanite, frequently filled with quartz, apatite and skeletal titanomagnetite is often overgrown by epidote corona.

Granites

Into this plutonite group we include a wider granitoid scale showing transitional contacts with the both previous granitoid groups. A common feature of all varieties of this group is a modal prevalence of K-feldspars over plagioclases, a presence of at least two K-feldspar generations, a substantially higher quartz content than in the previous groups and an accessory to moderate amount of both micas. All varieties of the group belong to the granite group of the Streckeisen's (1973) classification.

Mapable granite bodies are developed only at the southern slopes of the Bujanová massif. Their platy to lensoidal bodies, emplaced either between metamorphites and granitoids or between plutonites of the both previous groups indicate their succesive position in the Variscan plutonism of the region.

Representative granites are medium to coarse-grained locally evidently porphyritic light green-greyish rocks with feldspars and quartz as the only substantial components. Micas, zircon, apatite, as well as, the Alpine syn- to postkinematic assemblage (sericite, epidote-zoisite, chlorite, albite, sutural quartz, leucoxene and Fe-oxides) are present only in accessory amounts.

Usually subhedral plagioclases form either 1.0 to 2.5 mm grains or 3.0—5.0 mm tabular phenocrysts. The both have 28—33 % An content and they are filled with biotite, muscovite, quartz exceptionally also by zircon. In more intensively deformed zones plagioclases are overgrown by thin but very expressive albite rims (An 4—6 %).

Sub- to anhedral K-feldspar I of 0.X to 1.2 mm size filled with drop-like quartz and chloritised biotite is commonly enclosed in tabular plagioclases and replaced by albite from the margin. K-feldspar II is developed either as sub-to euhedral slightly pertitised phenocrysts of 4.0—7.0 mm (max. up to 1.4 cm) size or as typically microclinised grains of the same habit and granularity (sometimes also of 0.X mm size), or as antiperthitic domains in plagioclases growing in their 010 and 001 cleavage planes. It is partially replaced only by quartz. Its phenocrysts enclose all the other rock components sometimes also their aggregates (e.g. quartz, plagioclases, biotite and apatite) with well-preserved primary relations among them.

Muscovite and apatite are bound to biotite nest-like aggregates. Biotite is either partly chloritised or baueritised and enveloped or replaced by muscovite. The last one also grows in plagioclase claevages (Figs. 4, 5), stressing its two generation development.

Aplite and pegmatite granites

In spite of very close spatial relations of the both types the pegmatite variety is developed only in subordinate amounts. Except of the Miklušovce complex aplites and pegmatites are more widespread in the terminal segments (the Ťahanovce and Bujanová ones) of the Complex of Bujanová. They are present in granitoids as well as in surrounding metamorphites forming either sill and dyke bodies of cm–dm (exceptionally also of meters) thickness or strip accumulations of analogous size. The last forms are especially typical for the terminal parts of granite, indicating (together with a similar type and mode of the components) very close successive relations of the both granitoid groups.

In obviously panallotriomorphic-granular aplites of ca. 0.5 to 1.5 mm (max 3.0 to 4.5 mm for only some feldspars) grain-size, feldspars and quartz are commonly present in principally same modal relations. Muscovite, biotite, zircon, apatite, ore minerals and the superimposed assemblage (sericite, chlorite, epidote, leucoxene and ± sagenite) are present in accessory amounts. Plagioclases have 16—20 % of An content. Quartz and muscovite sometimes exhibit mutual intergrowths. Biotite is usually baueritised. Feldspars are slightly sericitised.

Besides of dykes, rather scarce pegmatites also form "cores" of lensoidal aplite nests in granites. They principally differ from aplites by a higher mica (especially muscovite) content as well as by the same quartz and sometimes also by microcline amounts.

Granitoid tectonites

Southern slopes of the Bujanová massif belong to classical areas of the West Carpathian granitoid tectonites. It is useful to point out that the above described petrological features of all distinguished granitoid varieties in this area are only preserved in 10—100 m lensoidal blocks "floating" in a tectonite matrix (Fig. 3). Results of our structural and petrographic research have shown that the tectonites are products of the polystage — Alpine tectonometamorphic development of the region. The rock varieties of all the granitoid groups have been principally altered in a similar way. For this reason an

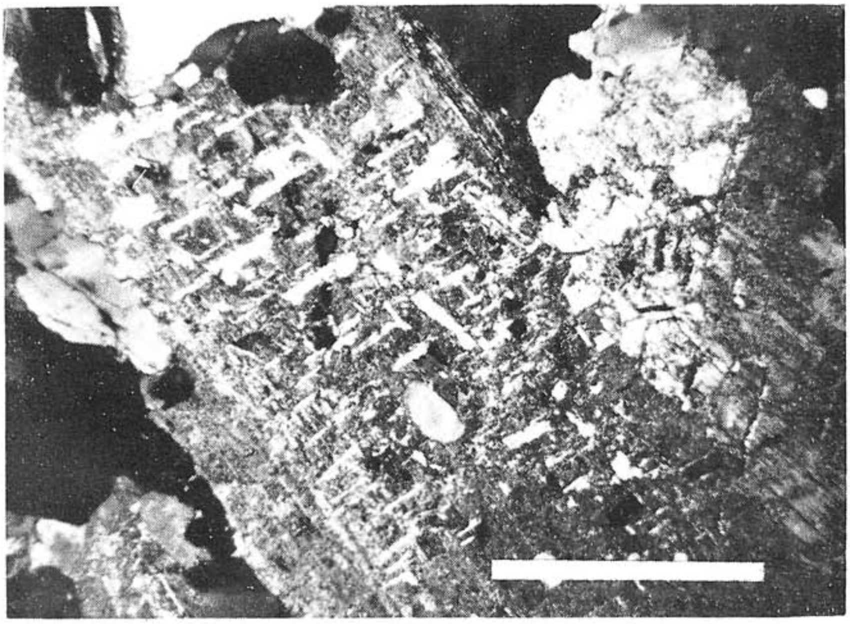

Fig. 4. Photomicrograph of secondary muscovite growing in plagioclase cleavages. Biotite-muscovite granite 14 (ČH170/11). The scale bar represents 1 mm, Nicols X.

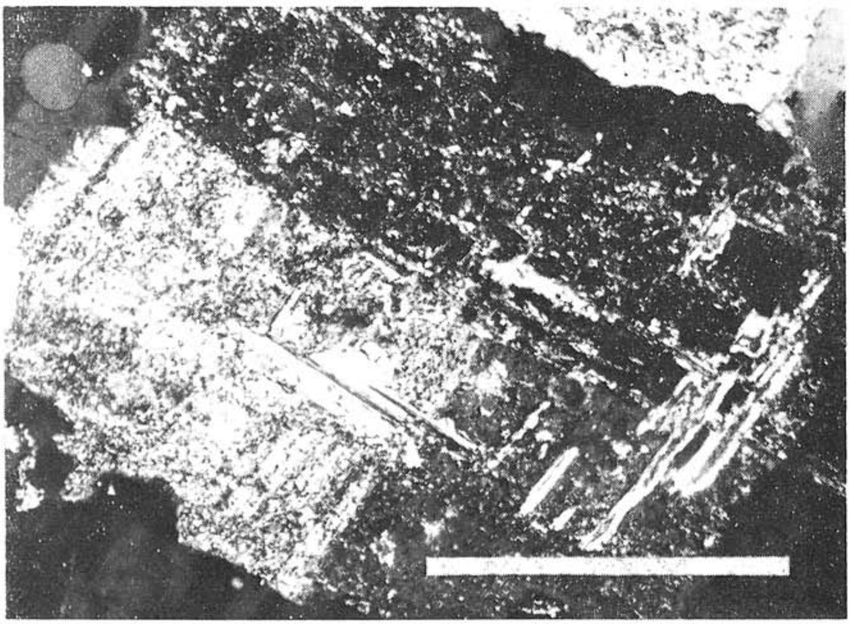

Fig. 5. Photomicrograph of secondary muscovite growing in plagioclase cleavages, the same sample as in Fig. 4. The scale bar represents 0.5 mm, Nicols X.

overview of products of regionally the most expressive deformation-recrystallization processes, successively bound to the development of the Margecany upthrust zone structures we shall demonstrate at the example of the most widespread biotite granodiorite group.

Blastokakiritic granodiorites

Blastokakirites form a substantial volume of the mentioned lensoidal granitoid block. Tectonometamorphic alterations in these tectonites have not radically changed granitoid structures and mineral habit. Commonly undulose quartz, feldspars and/or accessories are usually splitted and only exclusively flattened or granulated. Micas exhibit kink folding and plagioclase lamellae are bounded in some places. Low thermal alterations of rock components are much more extensive. They include the selective sericitisation and saussuritisation of plagioclases, formation of marginal albite rims round feldspars, perthite and chess-board albite development in K-feldspars, blastesis of 0.X mm albite-oligoclase (An 7—13 %) grains at the feldspar destroyed margins and chloritisation of biotite. Feldspar's joints are healed with calcite, epidote-zoisite and quartz.

Blastocataclastic granodiorites

This, the most widespread tectonite variety of the region, is typical by a sigmoidal distortion and preferred orientation of the rock components as well as by an absence of a rock foliation. Although all the substantial rock-forming minerals are macroscopically expressed, quartz and feldspars are converted into a lensoidal granulate with sutural recrystallization of the former and extensive sericitisation and or saussuritisation of feldspars. Epidote-zoisite nests are locally transposed into preferred orientation of the tectonite. Buckled and rupturally deformed micas are usually accumulated into lensoidal nests. Extensive biotite chloritisation is often accompanied by leucoxene and ore minerals admixtures.

Blastomylonitic granodiorites

These quite common tectonites macroscopically reminding porphyroids differ from the previous type by a complete absence of primary structures, by desintegration of rock components into porphyroclasts and matrix, by absence of feldspar porphyroclasts and an unaltered biotite, and by the development of platy foliation planes which are continuously covered by chlorite and sericite.

Granulated and lensoidally flattened quartz porphyroclasts have ca. 2.0 to 3.0 mm, max. 6.0 to 8.0 mm in size. Segmented grains are mended by sutural quartz or by quartz-calcite aggregate. Irregularly granulated feldspar detritus is squeezed out into dynamofluidal strips. Matrix of 0.0X to 0.X mm granularity is differentiated into diffuse quartz — chlorite/sericite strips with dimensional orientation of the last two minerals.

Granitoide phyllonites

Development of these tectonites is restricted into tectonically activated granitoide — metamorphite or, more frequently, granitoide — cover units contacts where they form lensoidal bodies of dm, max. up to 1.7 m thickness. They exhibit expressive laminated or listric foliation continuously covered by sericite and/or chlorite film. Porphyroclasts of phyllonites reach up to 35 % of rock volume and are nearly exclusively formed by quartz of ca. 2.0 mm size. Relics of feldspars, muscovite and apatite are present in accessory amount having 0.X mm in size. A typical feature of phyllonitic tectonites is high degree of metamorphic differentiation of the matrix into prevailingly sericite or chlorite strips with subordinate amount of quartz and calcite. Albite-oligoclase (An 8–12 %), leucoxene and ores are present as accessories. The matrix, dynamofluidally embedding porphyroclasts, is of 0.0X to 0.X mm granularity.

Petrochemical characterization of the Čierna hora granitoid rocks

The petrochemistry of Čierna hora granitoids is characterized by 32 original chemical analyses performed at the Department of Geology and Mineralogy, Technical University Košice and in the Geological Institute of D. Štúr by analysts Radzo, Gregorová, Letková (Tab. 1). The analyses are supplemented by 16 published analyses from various sources in Figures.

Main chemical features are illustrated in Harker variation diagrams, Fig. 6. Major elements show the characteristic behaviour described also in other West Carpathian mountain ranges (Cambel et al., 1985): with increasing SiO_2 content all other oxides contents decrease with exception of K_2O and Na_2O which increases or remains about constant, respectively. The behaviour is typical for granitoid rocks and reflects the accumulation of less Ab-rich plagioclases and biotite in more basic granitoids (tonalites, granodiorites), and more Ab-rich plagioclases, K-feldspars and quartz in silica-rich differentiates. The described trends are recognizable in Fig. 6, scattering of points is, however, considerable especially in FeO and K_2O contents. The complicated and long-termed post-magmatic history of granitoids involving sub-solidus and dynamometamorphic processes contributes, undoubtedly, to this dispersion. Feldspars are particularly sensitive to blastocataclasis being replaced by sericite in more acid rock types, or by sericite + epidote + titanite in more basic types. The petrographically grouped varieties (see section Petrography): aplites and pegmatites, granites, biotite granodiorites, and contaminated granodiorites form a common variation trend with exception of contaminated (hybrid) granitoids Ns. 42,43 and hornblende-bearing types 44—46 which differ from the trend formed by granitoids or are compositionally separated. It is the situation similar to that in the Malé Karpaty Mts. (Vilinovič, 1981; Cambel et al. 1982).

The relation between granitoid and diorite rocks does not suggest a direct genetical connection, on the contrary, the absence of hornblende in granitoid rock types may indicate a different source and P-T-X conditions of granite parental magma. The relation of granitoid and hornblende-bearing basic rocks is illustrated in AFM diagram, Fig. 7.

All granitic rocks are plotted in granitic tetrahedron, Fig. 8 and compared with phase boundaries in the granitic system Qz-Ab-An-Or-H_2O at P_{H_2O} = = 500 MPa (according to Winkler et al., 1977). The samples are distinguished according to the volume of primary crystallization in which they fall: solid circles lie in the primary crystallization volume of plagioclase + L + V, open circles lie in the volume of quartz + L + V, dots are in the volume of K-feldspar + L + V. Half-filled circles are situated on the cotectic surface quartz + plagioclase + L + V. Diorite varieties were not plotted. The mesonorm calculation after Mielke — Winkler (1979) was used to obtain normative granitic components.

It can be seen from the Fig. 8 that the major part of samples is situated in the plagioclase volume and the lesser part lies in the quartz volume. A single sample (1) lies in the orthoclase volume. This fact is an expression of a typical feature of West Carpathian granitoids: the predominance of Na over K. The samples lying in the plagioclase volume are in petrographical sense tonalites and granodiorites whereas those in the quartz volume are granites. The

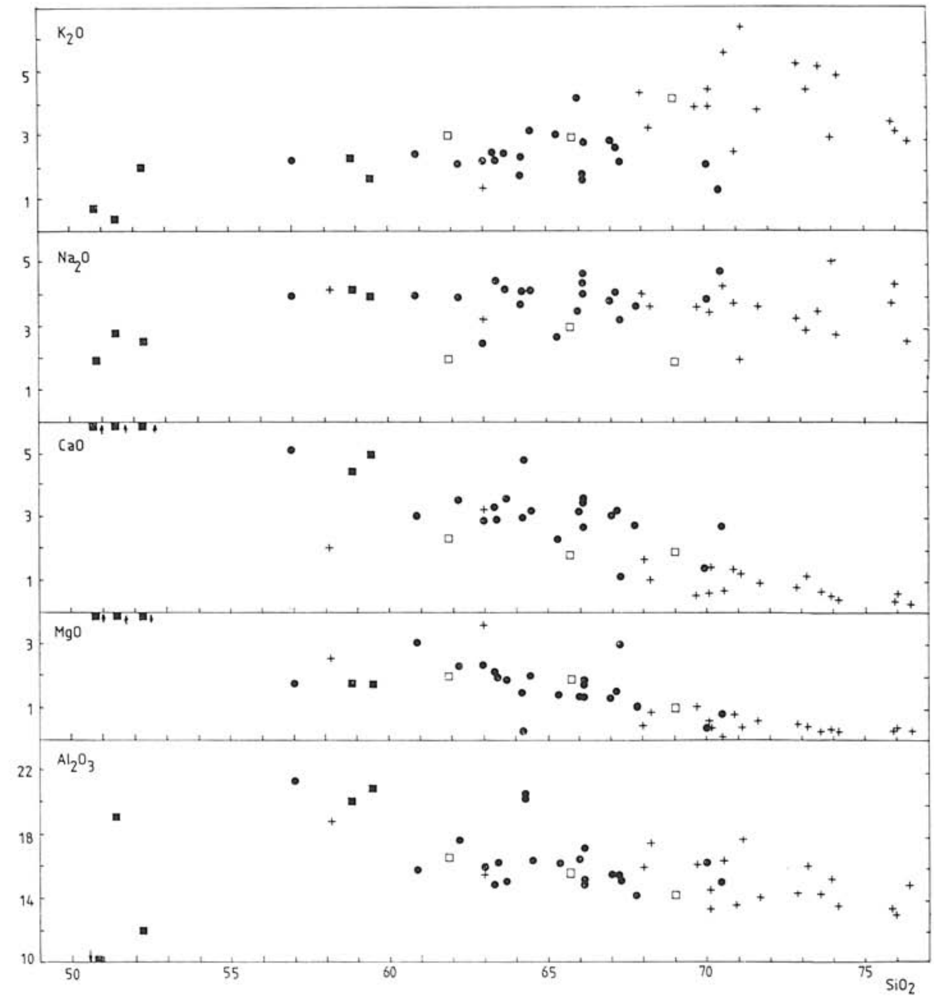

Fig. 6.

great majority of samples is situated far from cotectic surfaces Plg + Qz + L + + V and Or + Qz + L + V, many tonalites being deeply in the plagioclase volume. It is obvious that such a distribution of samples is caused by a variation in the Plg/Qz ratio in analysed samples, the accumulation of plagioclase in tonalites, causing a shift of projection points away from the cotectic surface towards the Ab — An join.

The position of projection points remote from cotectic surface, i.e. lying in the area of higher temperatures is a main reason for the suggestion of restite origin of biotite, accessory minerals, and a considerable part of plagioclases (e.g. Winkler — Breitbart, 1978; Winkler, 1983). We account the observed distribution for in different way: the trend of projection points approximately perpendicular to the cotectic surface Pgl + Qz + L + V is a result

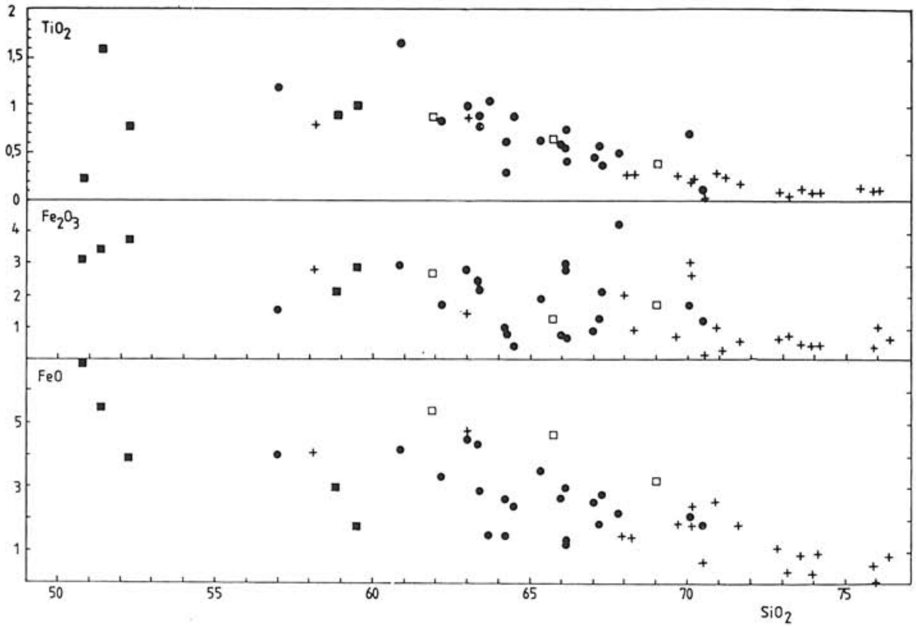

Fig. 6. Major element variation diagrams (oxides in wt. %).
Explanation: Crosses: granites, aplites, pegmatites. Solid circles: biotite granodiorites. Solid squares: contaminated (hybrid) granodiorites, tonalites and dioritic rocks. Open squares: granite gneisses and a migmatite.

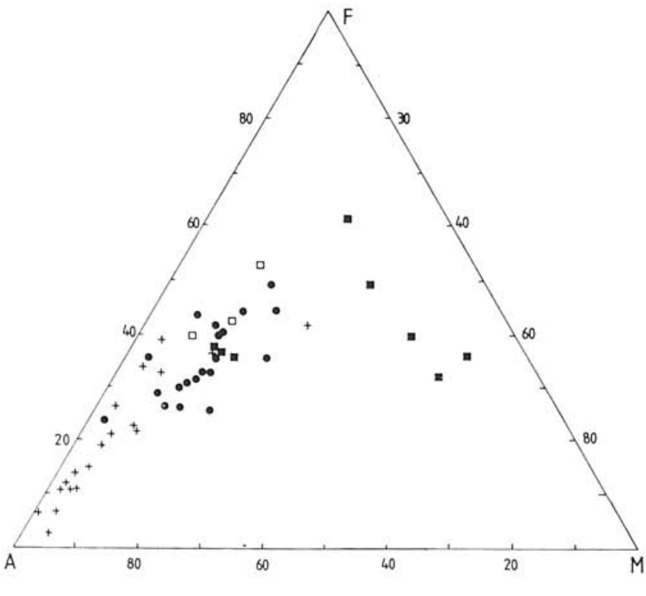

Fig. 7. AFM diagram of Čierna hora granitoid and dioritic rocks. Symbols as in Fig. 6.

of primary accumulation of plagioclase (+ biotite, and a part of accessory minerals) due to fractional crystallization (Fig. 9). A petrographical consequence of this process is formation of tonalite varieties. An important fact is, that, original melt must have had more acid composition than the tonalites crystallized from it. Besides, it must have been situated on the cotectic surface Plg + Qz + + L + V, i.e. it must have been in equilibrium with quartz, as was proved by Presnall — Bateman (1973). The fact that the parental magma was situated on cotectic surface makes it unnecessary to consider too high melting temperatures and, consequently, preserving higher proportion of restite minerals. Plagioclase "surplus" can more easily be accounted for by the cumulative nature of Čierna hora tonalites. The Modra granodiorites and tonalites of the Malé Karpaty Mts. were interpreted in a similar way (Vilinovič — Petrík, 1983). The parental magma may have originated by equilibrium melting (batch melting) and it later differentiated both to more acid and to more basic compositions. Similar conclusions follow from works of Tindle — Pearce (1980) and Lee — Christiansen (1983).

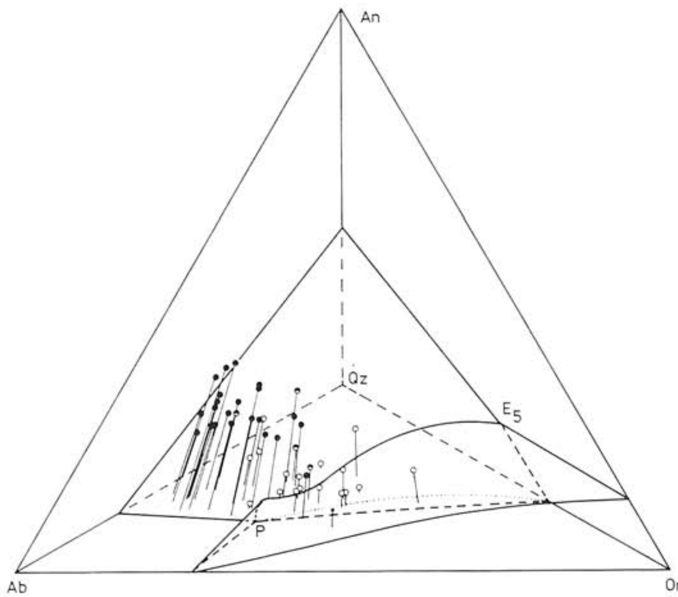

Fig. 8. Granitoid rock compositions plotted in granitic tetrahedron Qz-Ab-An-Or. Cotectic lines according to Winkler et al. (1979) at 500 MPa.
Explanation: Solid circles, open circles and half-filled circles: rock compositions situated in the volume of primary crystallization of plagioclase, quartz, and on the cotectic surface Plg + Qz + L + V, respectively. A dot is a single sample in the orthoclase volume.

Trace element contents

Trace element contents of Čierna hora granitoids are represented by 15 spectrochemical analyses, Tab. 2. The analyses were performed in the Geological

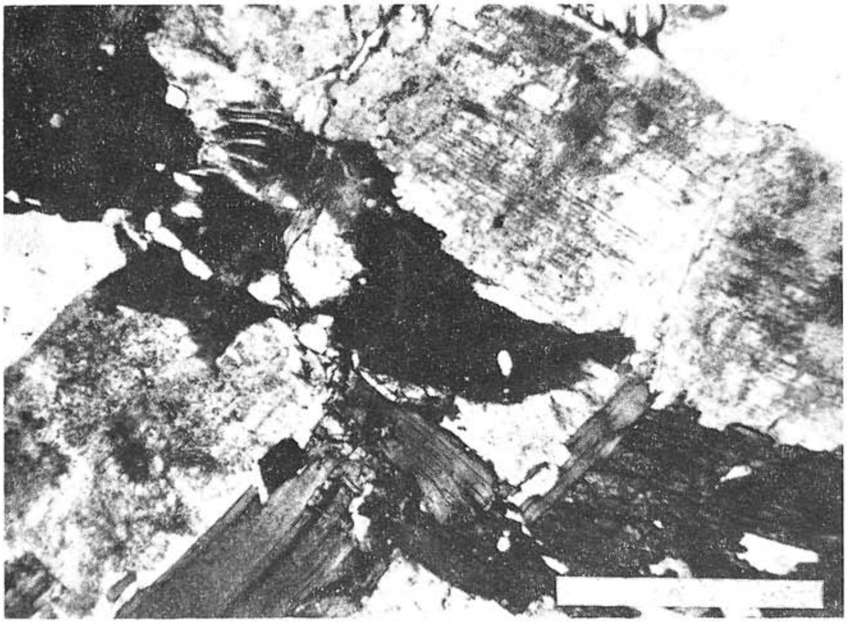

Fig. 9. Photomicrograph of a plagioclase + biotite + accessories (sphene, apatite, epidote, ores) accumulation: a cumulus-like texture. Sample 29 (ČH150), biotite granodiorite-tonalite. The scale bar represent 1 mm. Nicols X.

Institute of the Centre of Geosciences, Slovak Academy of Sciences by analysts J. Medveď and H. Beličková. Analytical methods and precision limits are given in Cambel — Medveď (1981).

Geochemical variations of trace elements with increasing SiO_2 content are shown in Fig. 10. Trace element concentrations result from magmatic, post-magmatic, and, possibly, metamorphic processes. The primary differentiation process, fractional crystallization, causes the characteristic decrease of compatible elements concentrations (e.g. Ba, Sr, Zr, V, Co) and the increase of incompatible element concentrations (B, Sn?) with increasing degree of crystallization. The primary distribution of trace elements due to fractionation of plagioclase (Sr), biotite (Ba, V, Ni, Co) and accessory minerals (Zr, Sc, Y) are, however, often disturbed by secondary processes. Cu, Ni, Pb, Sn and Sc, Y or B are particularly sensitive. Fig. 10 shows a considerable scattering of the mentioned elements. Even Ba and Sr, commonly used in trace element modelling, are heavily disturbed.

From analysed samples, Ns. 16, 24, 26 are conspicuous with their high contents of the characteristic group of elements: Cu, Ag, Pb, Sn, Ni, Cr, Sr, Ba and B. Other samples (8, 6, 49, 51, 45) have higher contents of Sc, Y, samples Ns. 16, 28 the content of Zr. Concentration anomalies found in samples 16, 24, 26 are explained by the presence of ore association: galena (Pb, Ag?), chalcopyrite (Cu, Ag?), pyrite (Co, Ni), magnetite (Cr, V), cassiterite (Sn), together with barite (Ba, Sr) and tourmaline (B). Another accessories: xenotime, zircone and/or mo-

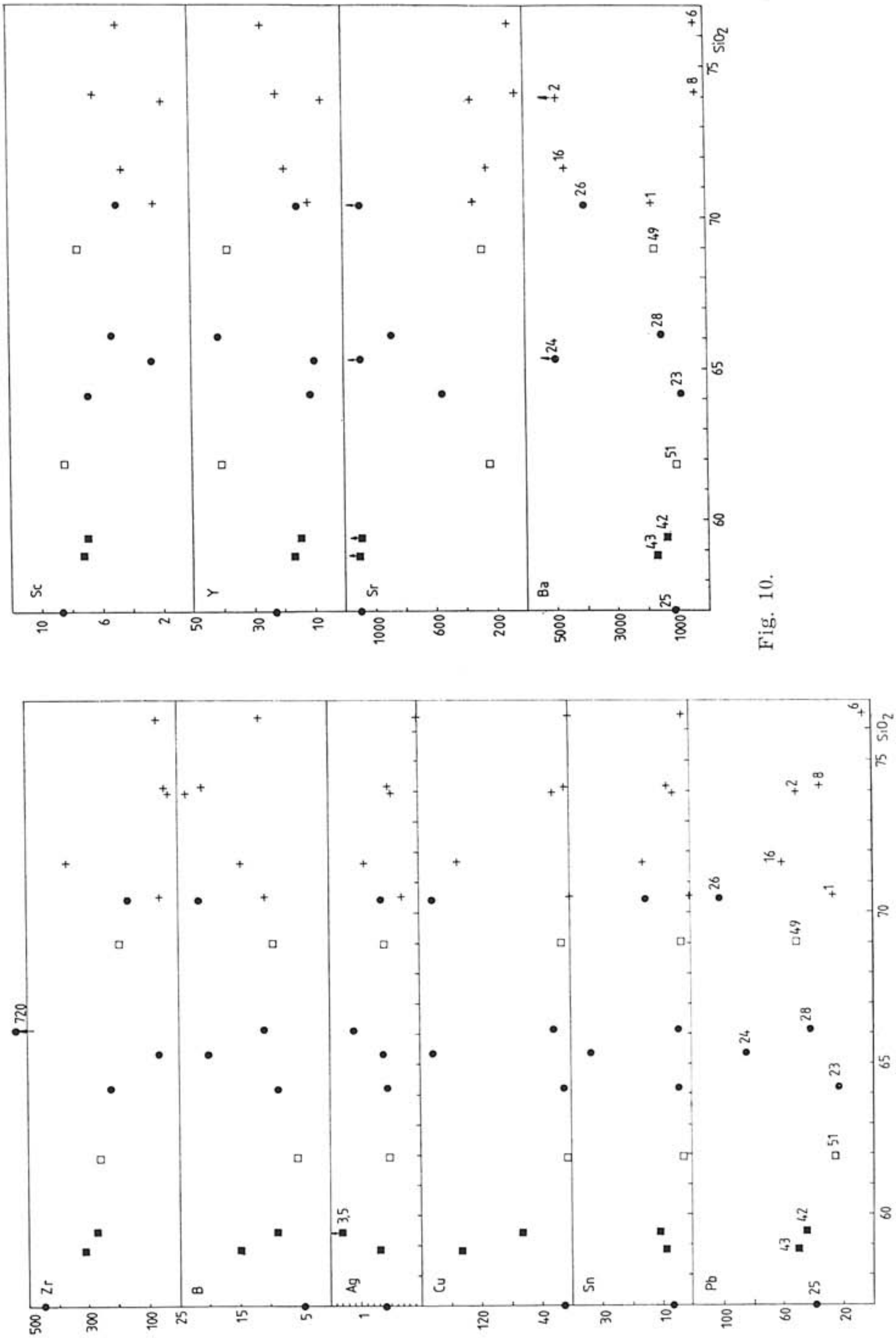

Fig. 10.

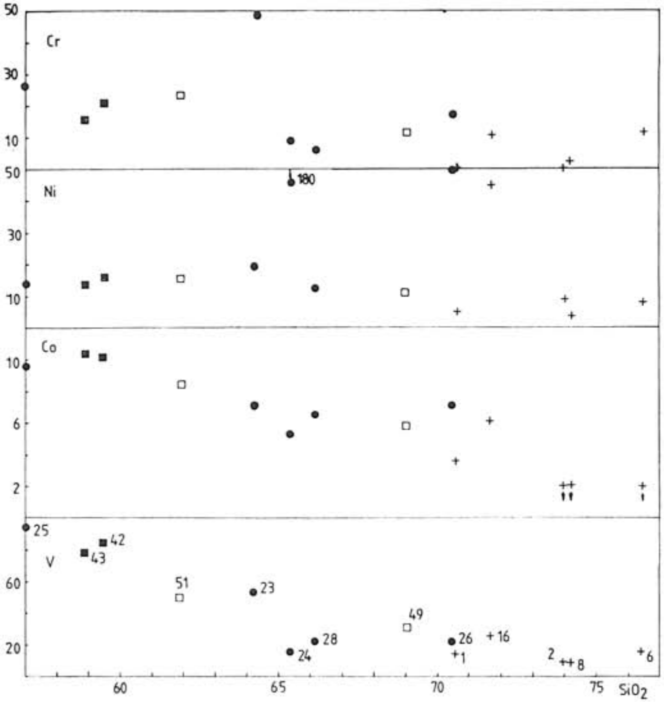

Fig. 10. Trace element variations with increasing SiO_2 content. *Notes:* Symbols as in Fig. 6. Numbers refer to sample numbers in Tab. 3. Concentrations of trace elements in ppm, SiO_2 in wt. %.

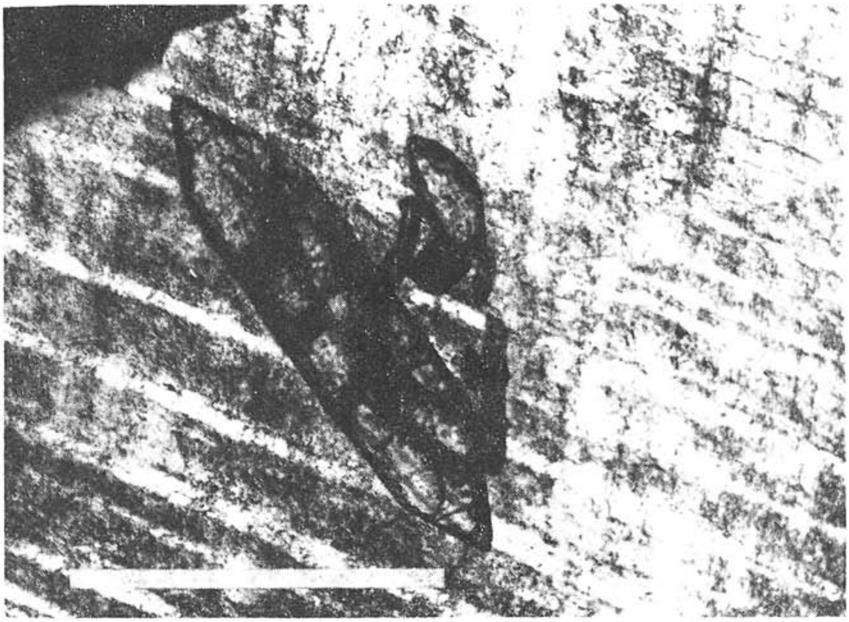

Fig. 11. Photomicrograph of granodiorite 24 (ČH158) showing a large zircon grain (768 × 167 μm). The sample has the highest Zr content (780 ppm). The scale bar represents 0.5 mm. Nicols X.

nazite, apatite, allanite may cause anomalous concentrations of Zr, Sc, and Y in samples Ns. 6, 8, 49, 51, 28 (Fig. 11). Vanadium and cobalt are less sensitive to ore mineral contents. These elements have distinct compatible behaviour and they form negative trends in variation diagrams. The fractionation of biotite and, possibly, magnetite is the supposed cause of the behaviour. Boron is the only analysed element showing positive trend, even though with considerable scattering. Similar trends are assumed for Rb and Cs (not analysed in the present work).

The causes of compositional variations

The fractional crystallization was preferred in preceding parts as a process responsible for compositional variations of Čierna Hora granitoid rocks. In our opinion, the process accounts for the observed distribution of both major and minor elements in sequence tonalite → granodiorite → granite in the most satisfactory way. Fractional crystallization is widely used in interpreting of genesis and differentiation of granitic melts (Tindle — Pearce, 1981; Michael, 1984; Sultan et al., 1986), and, on the basis of trace element modelling, it was suggested for granitoids of the Malé Karpaty Mts. (Vilinovič — Petrík, 1984; Cambel et al., 1985).

Besides fractional crystallization other processes could have undoubtedly worked. Among them, the process of assimilation (contamination)[1] should be taken into consideration (e.g. Pitcher — Berger, 1972). Contaminated (hybrid) biotite granodiorites and tonalites occur in marginal parts of the Bujanová complex. The samples Ns. 44—48 represent this type. Relations among granitic rocks (dots), contaminated granodiorites and tonalites, and their minerals are show in Fig. 12. The samples Ns. 42, 43 are granitoids without hornblende, the samples 44—48 are basites containing hornblende as an essential component. The chemical composition of basites which, in comparison with granitoids, are considerably scattered can be accounted for by varying proportions of main minerals: hornblende, plagioclase and epidote. On the contrary, the compositional variations of granitoids are controlled by plagioclase, biotite and quartz. The samples 42, 43 are shifted away of granitoid trend towards the higher content of CaO and to lower contents of MgO and SiO_2. It is caused by the increased content of epidote, cf. Tab. 2 (for numbering see also Fig. 6). The epidotization may be due to chemical interaction between granitoids and Ca-Al-Fe-rich fluids related with existing basites. The process, however, is common also in more basic varieties of granitoids where it reaches almost regional character. Besides, the basites form only a small part of the metamorphic cover, and it is thus possible that at least a part of Ca-Al-Fe rich fluids comes from the granodiorites and tonalites. The high mobility of the fluids is evidenced by abundant epidote veins in Alpine dislocations as well as in adjacent sediments of Palaeozoic and lower Triassic age.

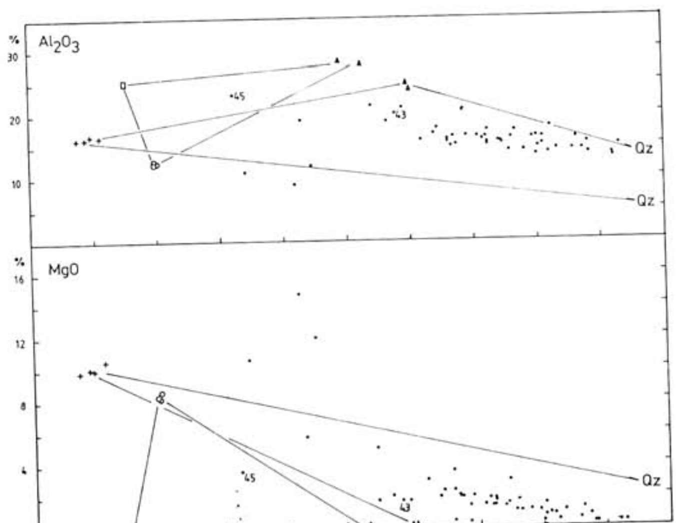

Fig. 12. Al_2O_3 and MgO vs SiO_2 variations for granitoid rocks compared with mineral compositions of contaminated (hybrid) rock samples 43 (biotite + plagioclase + quartz) and 45 (hornblende + epidote + plagioclase).

Explanations: Dots: granitoid rocks, open circles: hornblendes, crosses: biotites, solid triangles: plagioclases, squares: epidotes. Triangles connect coexisting minerals.

[1] In Slovak carpathian literature the process is traditionally referred to as hybridization.

For the samples representing the process of assimilation of wall rock by granitic magma a certain degree of approximation of one rock type composition by the other might be expected. In fact, however, assimilation is not a simple mixing process. After B o w e n, 1927 (ex M c B i r n e y, 1979) the process of assimilation is concurrent with fractional crystallization. The latent heat of crystallization causes growth of temperature of magma which promotes melting of wall rock, i.e. the assimilation (M c B i r n e y, l.c.). After T a y l o r, 1980 the process of magmatic assimilation is at least a 3-end-member problem: magma, wall rock and cumulates. Assimilation will not drastically influence magma composition (in terms of major elements) because its composition is controlled by phase relations of the same mineral assemblages as it would be in the case of spontaneous fractionation. Assimilation causes only slight perturbations in the normal liquid line of descent (B o w e n l.c. ex T a y l o r l.c.).

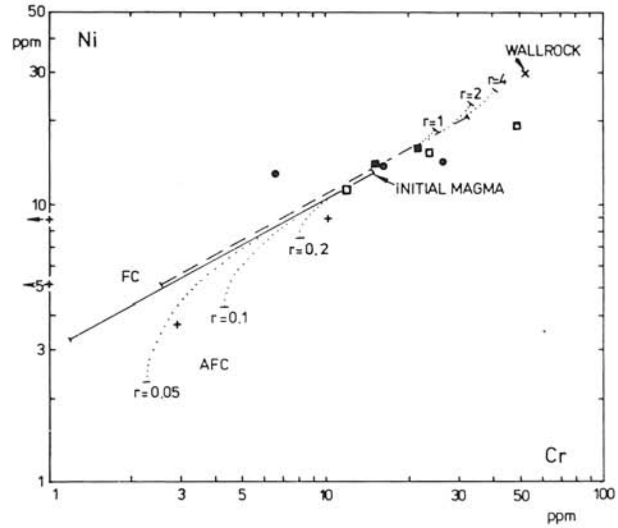

Fig. 13. Evolution of Ni and Cr contents in granitoid and contaminated (hybrid) rocks. *Explanations:* Rock symbols as in Fig. 6. Evolution lines of fractional crystallization (FC) an assimilation-fractional crystallization (AFC) were calculated using D e P a o l o's (1981) equations. FC: solid line – evolution of remaining liquid, dashed line – evolution of coexisting solids. The lines were terminated at 10 % of liquid remaining. AFC is characterized by dotted evolution curves at various assimilation rates (r = assimilation rate / crystallization rate). Initial magma composition: Ni 13 ppm, Cr 15 ppm, wallrock composition (contaminant gneiss): Ni 30 ppm, Cr 52 ppm. Bulk distribution coefficients (D^{bulk}) were calculated from assumed initial magma composition (C_O) and most evolved rock compositions (C_L) using Rayleigh equation.

D e P a o l o, 1981 derived equations describing trace element behaviour in the coupled process of assimilation and fractional crystallization (AFC). The equations show that effects of AFC differ significantly from those of simple end-member mixing. The model solution of AFC on Cr and Ni concentrations in evolving liquids is shown in Fig. 13. The elements were chosen on the basis of composition contrasts between granitoids (< 25 ppm Ni, < 30 ppm Cr) and supposed contaminant — wall rock gneisses (> 50 ppm Cr, > 30ppm Ni). Model trends of AFC and simple fractional crystallization (FC) with various parameters (see explanations to Fig. 13) show that crystallizing liquids are only slightly influenced by assimilation of gneisses unless unlikely high assimilation rates (assimilation four times higher than crystallization) are supposed. Even in this case the crystallizing/assimilating magma reach concentrations not higher than 26 ppm Ni and 40 ppm Cr. With decreasing assimilation rate the evolving trends of Ni and Cr approximate those of FC. Actually, Fig. 13 shows the dominant effect of FC. It follows that on the basis of model distributions of Ni and Cr the assimilation process cannot be excluded as a concurrent process of fractional crystallization of granitoid magma. The positive corroboration would require the isotopic study of both granitic and wallrock metamorphic rocks.

Some metallogenetic implications

Owing to the constant above-average scheelite, cassiterite and gold contents in heavy mineral concentrates from the Miklušovce complex (Jacko et al., 1984, 1985) where only aplitoid plutonites occur, as well as owing to the conclusion of Veselský et al. (1983) concerning the connection of W-Au mineralization with leucocratic differentiates in the Malé Karpaty Mts., we have tested potential primary tungsten enrichment of analysed granitoids from both the discussed and prognostic — metallogenetic aspects.

According to the experimental results of Štemprok — Voldan, 1982 specialized granitic melts can dissolve up to 9000 times more tungsten than there is granite average value (1.5 ppm). Above the granite liquidus temperature it may result in exsolving of alkali tungstenates, ferberite and scheelite. The specialized melts are characterized by high SiO_2 content (> 73 %) and low total iron (Fe_2O_3 + FeO < 1 %) and water (H_2O^+ < 1.0 %) contents.

Only samples 2, 5 correspond consistently to the conditions, and with exception of total iron also Ns. 4 and 6. It is noteworthy that samples Ns. 4, 5, 6 are from aplitoid granite of the Miklušovce complex NE of the Bystrá Hill (Fig. 1), i.e. from the body which is the only one characterized by more extensive pegmatite development in the complex. From the analysed aplitic granites from the western part of the complex (samples 7, 8) the latter corresponds to the criteria in terms of SiO_2 and CaO. From the Bujanová complex aplites (sample 2, the Ružín dam) and, except SiO_2, also sample 1 (southern margin) correspond to the criteria. Medium-grained granites have higher SiO_2, FeO, CaO contents.

The above mentioned relations suggest the possibility of accumulation of some trace elements due to primary evolution of Čierna hora granitoid magma. The genetic relations are, however, more complicated.

Increased trace element contents may be connected with the regionally widespread Alpine hydrothermal ore mineralization in the Branisko and Čierna hora Mts. Space distributions of anomalous samples and inferred mineral associations (chalcopyrite, galena, cassiterite, magnetite, pyrite, barite, tourmaline) coincide remarkably with the course and contents of actual quartz-siderite, quartz-sulphide, and quartz-tourmaline periods of Alpine hydrothermal mineralization of the region (Jacko et al., 1984, 1985).

Namely, the Fe, Cu, Sn, W (Pb, Zn, Ag, Au) mineralization of the Rolová thrust fault zone, i.e. the tectonized contact of Lodina and Bujanová complexes

Table 3
Trace element contents in Čierna hora granitoid rocks (in ppm)

Sample	Ba	Be	B	Pb	Sn	V	Cu	Ag	Ni	Zr	Co	Y	Sc	Cr	Sr
1	1800	~2.3	10.5	24.5	<1	13	~2.6	~0.3	5.1	59	3.6	11.8	~2.5	<1	275
2	>5000	3.1	23.4	49.5	5.4	9	22.4	~0.44	8.9	33	<2	7.6	~2.1	<1	360
6	360	~2.8	11.7	5.2	~2.3	14.5	~2.3	<0.1	8.8	68	<2	27.5	5	10.1	104
8	320	~2.6	21	34	7.2	8.1	7.5	~0.51	3.7	43	<2	22.4	6.6	~2.9	61
16	~4750	3.7	14.5	59	15.5	24	148	~0.92	45	360	6	19.5	4.7	10.4	224
49	1780	~2.3	9.6	49.5	3.2	31	12.3	~0.60	11.2	200	5.8	38	77	11.8	282
24	>5000	~2.5	20.4	84	33.5	15	182	~0.63	180	70	5.2	9.9	~2.7	9.1	>1100
25	1120	~2.4	4.8	38	6.8	94	9	~0.60	14.6	450	9.6	23.4	8.7	26.5	>1100
26	~4000	~2.7	21.4	101	15	22	180	~0.65	50	170	7.2	15	5.0	17.6	>1100
28	1500	3	11	41	5.1	22	22	~1.1	12.9	720	6.5	41.5	5.4	6.6	900
42	1340	~2.7	9	45	11	85	68	3.5	15.9	282	10.2	14.5	6.5	21.4	>1100
43	1770	~2.6	15.1	50	8.7	78	148	~0.69	13.8	320	10.4	16.4	7.3	16	>1100
45	655	~2	13.6	16.8	13.2	224	48	~1.82	14.1	102	20.4	36	16.6	15.1	>1100
23	880	3	8.7	23	4.4	53	10.5	~0.54	19.1	229	7.1	12.1	6.9	49	560
51	1040	~2.2	5.6	25.7	3.4	49	5.8	~0.54	15.1	268	8.5	40.5	8.7	23.6	234

Analyst H. Beličková, J. Medveď.

is concerned here in the immediate vicinity of which the epidotized samples Ns. 42, 43 were taken. The sample No. 42 with the highest silver content (3.5 ppm) is from the area of old burrowing works. Quartz-tourmaline veins and Fe, Cu, W, Hg, Ba mineralization occur in the more important Bujnisko thrust fault zone which directionally intersects the Bujanová complex being also the feeder of the Alpine hornblende-pyroxene dioritic body at the Spálený Hill. The above-average contents of Pb, Zn, Sb, Mo, Sr, Ni and Co occur also in stream sediments.

It is characteristic that main part of trace element anomalies in analysed rocks (Ns. 2, 26, 28, 45, 49, 51) occurs in the area of crossing of thrust fault zones with normal (mainly NE-SW) faults, i.e. in the area of the first order ore-localizing factor in the region of Branisko and Čierna hora Mts. (J a c k o et al. l.c.). The multi-elemental anomaly of the sample 16 (Tab. 3) suggests the SW continuation of the fault system. The similar anomaly of the sample 24 conspicuously agrees with crossing of NW-SE and NNE-SSW disjunctive zones.

The extraordinarily rich polymetallic association evidenced by various methods exceeds markedly the primary petrochemical potential of Čierna hora granitoid rocks as well as chalcographically found assemblages of hydrothermal mineralization in the area of the Čierna hora Mts. These assemblages cannot account for both regional and above-average accumulations of Sn, Mo, Cr, Ni, Co and Hg, Ba, Ag, Sb, Cu, Pb, Zn in the Branisko and Čierna hora Mts. Moreover above-average occurence of cinnabar, kassiterite, barite, pyrite, haematite and gold was found in the vicinity of fault zones of adjacent Palaeogene areas.

For these and other reasons discussed in more detail in works of J a c k o et al. (1984, 1985), we consider the large anomaly of basic masses in the area Košice — Prešov — Gelnica — Seňa — found by P l a n č á r et al. (1977) and to the NE of the Čierna hora Mts. confirmed by G n o j e k — F i l o (in press), for the main source of regionally widespread polymetallic association (Cu, Pb, Zn, Sn, W, Mo, Ag, Au, Ba, Sb, Hg). The surface manifestation of the anomaly is, in sence of discussed relations, the Alpine body of hornblende-pyroxene diorite at the Spálený Hill. Regarding to the presence of this association in Palaeogene of the Šarišská vrchovina Mts. and Bachurňa as well as its evident connections with the succesively youngest structures in the Branisko and Čierna hora Mts. The young Neogene mineralization occurs here developed probably in the form of Cu, Pb, Zn sulphides and sulfosalts, scheelite, kassiterite, barite and cinnabar.

Conclusions

The presented confrontation of compositional variability of Čierna hora granitoid rocks with lithostructural relations of the crystalline complex and with the results of complex metallogenetic research of the region confirms unambiguously the probability of polygenetic origin especially of trace element association in granitoids. In spite of strong tectonometamorphic reworking of granitoids geochemical evaluation showed the primary cause of differentiation — fractional crystallization. The granitoid sequence: tonalites, granodiorites, aplites forms a common differentiation trend characterized by the decrease of compatible elements: Al, Mg, Fe, Ca, P, Cr, Ni, Co, V, and by the

Table 4

Microprobe analyses of main rock-forming and accessory minerals of Čierna hora granitoid and dioritic rocks

Sample no.	17 (ČH1027)			43 (ČH136)		
Mineral	Plg	Bio	K-fs	Plg	Bio	Epi
SiO_2	61.47	35.22	64.24	59.74	33.67	36.51
TiO_2	0.07	3.31	0.00	0.00	2.96	0.05
Al_2O_3	23.59	16.90	18.76	25.03	16.30	22.73
FeO_{tot}[1]	0.26	22.50	0.01	0.08	21.88	14.36[2]
MnO	0.00	0.06	0.00	0.00	0.15	0.11
MgO	0.00	8.03	0.00	0.00	9.83	0.00
CaO	2.82	0.06	0.03	6.14	0.00	23.60
Na_2O	10.01	0.02	0.30	8.20	0.00	0.00
K_2O	1.95	10.09	16.72	0.25	10.28	0.00
Total	100.16	96.18	100.06	99.44	95.07	97.36
			Structural formulae			
O =	8	22	8	8	22	12.5
Si	2.748	2.716	2.977	2.678	2.637	2.946
Al^{IV}	1.243	1.284	1.025	1.322	1.363	—
Al^{VI}	—	0.252	—	—	0.141	2.163
Fe^{2+}	0.010	1.451	—	0.003	1.434	0.873[3]
Mn	—	0.004	—	—	0.010	0.007
Mg	—	0.923	—	—	1.147	—
Ti	0.002	0.192	—	—	0.174	0.004
Ca	0.135	0.005	0.002	0.295	—	2.042
Na	0.867	0.003	0.027	0.713	—	—
K	0.111	0.992	0.988	0.015	1.061	—

increase of incompatible elements Si, K, Sn (?) during differentiation process. The plagioclase accumulation in cumulate-rich tonalites causes that granitoids display the trend approximately perpendicular to the cotectic surface Plg + + Qz + L + V in granitic system. The fractionation changes original composition of parental magma which must have been situated on the cotectic surface, consequently making unnecessary to assume too high melting temperature.

Besides the crystal fractionation the assimilation of wall-rock (metamorphic mantle) may have operated. The modelling of the coupled process of assimilation-fractional crystallization (D e P a o l o, 1981) showed that assimilation does not significantly influence concentrations of Cr and Ni in melt. It means that the assimilation process cannot be excluded on the basis of Ni and Cr contents even though the positive confirmation would required isotopic study.

The complicated evolution of Čierna hora granitoid rocks is expressed by anomalous contents of characteristic element association: Pb, Cu, Ag, Sn, Ni, Cr, Ba, Sr, B in three samples from the Bujanová complex. The presence of the multielemental anomaly is accounted for by the inferred ore mineral association (galena, chalcopyrite, pyrite, cassiterite, barite, tourmaline). Owing to occurence of the anomalous samples in areas of crossing of Alpine thrust fault

Continuation of Tab. 4

Sample no.	43	45 (ČH 29)				
Mineral	Sph	Hb	Plg	Epi	Bio	Ilm
SiO_2	31.11	39.78	56.25	37.51	34.57	0.04
TiO_2	36.42	1.53	0.05	0.10	3.57	51.38
Al_2O_3	1.63	12.48	27.75	25.06	16.43	0.00
FeO_{tot}[1]	0.82[2]	20.73	0.16	10.80[2]	21.14	46.23
MnO	0.02	0.15	0.00	0.03	0.00	3.08
MgO	0.00	8.38	0.03	0.02	10.08	0.00
CaO	28.99	11.17	8.90	23.95	0.00	0.01
Na_2O	0.00	1.56	6.72	0.00	0.02	0.00
K_2O	0.01	1.58	0.14	0.06	10.36	0.00
Total	99.00	97.37	99.99	97.53	96.19	100.74
Structural formulae						
O =	5	23	8	12.5	22	3
Si	1.024	6.167	2.529	2.978	2.661	0.001
Al^{IV}	0.063	1.833	1.470	—	1.339	—
Al^{VI}	—	0.447	—	2.346	0.152	—
Fe^{2+}	0.02[3]	2.688	0.006	0.646	1.361	0.978
Mn	0.001	0.020	—	0.002	—	0.066
Mg	—	1.936	0.002	0.002	1.157	—
Ti	0.902	0.178	0.002	0.006	0.207	0.977
Ca	1.023	1.855	0.429	2.038	—	—
Na	—	0.469	0.586	—	0.004	—
K	—	0.312	0.008	0.005	1.018	—

Notes: [1] Total Fe as FeO; [2] Total Fe as Fe_2O_3; [3] Fe^{3+}. The analyses were performed at the Slovak Technical College (JXA-5A microprobe, D. Jančula analyst). Raw data were corrected using the procedure of Bence—Albee (1968) and correction factors of Albee—Ray (1970).
The kind assistance of D. Jančula is greatly appreciated.

zones with normal faults, and multielemental character of the anomalies exceeding primary geochemical potential of granitoid magma we suppose the epigenetical origin of the ore mineralization tentatively assuming the basic masses (hornblende-pyroxene diorite) in the SE region of the Čierna hora Mts. as the main source of ore mineralization.

LOCALIZATION OF SAMPLES

Aplite granites and leucogranites:

1. Aplite granite, Valachovo 400 m NE of elev. p. 616.2, Bujanová complex, sp. no. ČH416.
2. Aplite granite, Ružín-Kunazov, 130 m NW of elev. p. 410.1, sp. no. ČH185.
3. Aplite granite, Ťahanovce, a quarry on the south bank of the Hornád river, Bujanová complex, sp. no. ČH2.
4. Aplite granite, Barónske, 500 m SW of elev.p. 693.5, Miklušovce complex, sp. no. ČH165 Ba.
5. Aplite granite, the same locality as sample 4, sp. no. ČH192 Ba.

6. Aplite granite, Barónske, Miklušovce complex, ČH6/Ba.
7. Aplite granite, Vyšná dolina, 400 m ESE of elev.p. 618, Miklušovce complex, sp.no. ČH157.
8. Pegmatite, Kluknava, Predná dolina, 550 m ESE of elev.p. 618, Miklušovce complex, sp. no. ČH158.
9. Pegmatite, Kluknava, Dolinský potok, 500 m NW elev.p. 618, Miklušovce complex, sp. no. ČH55B.
10. Aplite granite, Kluknava, Dolinský potok, 700 m NW of elev.p. 618, Miklušovce complex, sp. no. ČH49A.
Granites:
14. Biotite-muscovite granite, Košické Hámre, Dubina, road cut, 1350 m SW of the administrative building of the Ružín dam, Bujanová complex, sp. no. ČH170/11.
15. Biotite-muscovite granite, the same loality as sample 14, sp. no. ČH170a.
16. Biotite-muscovite granite, the same localization as sample 14, sp. no. ČH170c.
17. Biotite-Muscovite granodiorite, Hoľa, 600 m NW of elev.p. 618.4, Bujanová complex, sp. no. ČH1027.
18. Fine- to mediumgrained biotite-muscovite granodiorite, Hoľa, 550 m NW of elev.p. 618.4, Bujanová complex, sp. no. ČH1025.
49. Medium grained granodiorite, Ružín, the quarry for the dam, Bujanová complex, ČH2/72.
Granodiorites:
21. Medium-grained biotite granodiorite, Hoľa, 65 m N of elev.p. 618.4, Bujanová complex, sp. no. ČH250.
22. Medium-grained biotite granodiorite, Terbecín, old railway cut, 800 m NW of elev.p. 618.4, Bujanová complex, sp. no. ČH64.
24. Fine-grained two-mica granodiorite, Rolová, Terbecín, old quarry, 1300 m SW of elev.p. 676.8, Bujanová complex, sp. no. ČH67.
25. Fine-grained biotite granodiorite, Bujanová, 300 m SW of elev.p. 756 m, Bujanová complex, sp. no. ČH501a.
26. Fine-grained biotite granodiorite, Kunazov, 400 m from the dam body, Bujanová complex, sp. no. ČH186.
27. Coarse-grained metasomatic granodiorite, Ružín, 100 m NW of the dam wall, Bujanová complex, sp. no. ČH28.
28. Albite granodiorite, Ružín, the big quarry for the dam, Bujanová complex, sp. no. ČH158.
29. Medium-grained biotite granodiorite, Sopotnica, forrest road cut, 800 m NE of elev.p. 556, Bujanová complex, sp. no. ČH150.
30. Medium-grained biotite granodiorite, the same locality as the sample 29, sp. no. ČH150a.
Contaminated (hybrid) granodiorites and tonalites:
42. Medium-grained contaminated biotite granodiorite, Ružín-Štolda, 600 m ESE of elev.p. 756.3, Bujanová complex, sp. no. ČH161.
43. Medium-grained contaminated biotite granodiorite, Ružín, a cut for the dam wall, S bank of the Hornád river, Bujanová complex, sp. no. ČH136.
44. Hornblende diorite, Bujanová, S slope, 450 m WSW of elev.p. 756.3, Bujanová complex, sp. no. ČH18/72.
45. Granitized coarse-grained hornblendite, Ružín, the quarry for the dam, Bujanová complex, sp. no. ČH29.
23. Ophthalmitic migmatite, Rolová-Rovné, Bujanová complex, sp. no. ČH349.
50. Medium-grained pearl-gneiss, Ružín, the quarry for the dam, Bujanová complex, sp. no. ČH-R/10.
51. Porphyroblastic two-mica granite gneiss, the same locality as sample 50, sp. no. ČH-3/72.

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