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BIOTITES OF THE HODRUŠA—ŠTIAVNICA INTRUSIVE COMPLEX GRANODIORITE AND THEIR SIGNIFICANCE FOR THE EVALUATION OF ITS ORE-CONTENT

(Figs. 5, Tabs. 5)

Abstract: In the paper, a mineralogical — geochemical characteristics of biotite from the Hodruša-Štiavnica Intrusive Complex granodiorite (HŠIK) is presented. Except primary magmatic (GRŠ-3) is also present in smaller quantities in certain parts of the intrusion in the Hodruša-Štiavnica Intrusive Complex granodiorite. The chemical composition of individual primary biotite phenocrysts indicates an oxidation magmatic trend which is most prominently developed especially in the part of the granodiorite intrusion where micrographic penetrations of quartz with K-feldspar (GRŠ-3) are present as well. Individual biotite phenocrysts are corroded along the margins — probably due to a decrease of pH_2O in magma, while after this corrosion no further growth of biotite occured. The presence of oxidation trend together with negative correlation of $(\Sigma Fe/\Sigma Fe + Mg)$ to Al^{VI} and increased copper contens (~87 ppm Cu) — positive indications of ore content — can be observed in biotites from only some parts of the Hodruša-Štiavnica Intrusive Complex granodiorite.

Резюме: В статьи дается минералогическая и геохимическая характеристика биотита из гранодиорита Годрушско-Штьявницкого интрузивного комплекса (ГШИК). В гранодиорите Годрушско-Штьявницкого интрузивного комплекса находится кроме первичного магматического биотита в определенных участках интрузии в меньшем количестве тоже вторичный биотит (ГРШ-3). Химический состав индивидуальных фенокристаллов первичного биотита указывает на оксидационный магматический тренд, который наиболее ясно развитый в том участке интрузии гранодиорита в котором находятся тоже письменногранитные прорастения кварца и К-полевого шпата (ГРШ-3). Индивидуальные фенокристаллы биотита являются вдоль каем корродированными — правдеподобно вследствие понижения pH_2O в магме, причем после этой коррозии уже не произошел никакой рост биотита. Присутствие оксидационного тренда вместе с негативной корреляцией $\Sigma Fe/(\Sigma Fe + Mg) — Al^{VI}$ и повышенными содержаниями меди (87 ppm Cu) — это положительные признаки рудоносности — можно наблюдать только в биотитах из некоторых участков гранодиорита Годрушско-Штьявницкого интрузивного комплекса.

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Introduction

Biotite is one of the mineral phases intensively studied in the last years especially from the viewpoint of their use as indicators of ore-bearing capacity of intrusions connected with porphyry copper mineralization belongs also biotite (e.g. Al-Hashimi—Brownlow, 1970; Graybeal, 1953; Beane, 1974; Kesler et al., 1975; Mason, 1978; Chivas, 1981; Hendry et al., 1985).

Applying certain knowledge used as a criterion for distinguishing barren and ore-bearing intrusions in connection with porphyry copper ores, biotite of the Hodruša-Štiavnica Intrusive Complex granodiorite has been studied also petrologically (except biotite, amphibole, Fe-Ti oxide, plagioclase, K-feldspars, quartz have been studied as a part of a petrological study of the Hodruša-Štiavnica Intrusive Complex granodiorite, from the viewpoint of their function in the metallogeny of the central zone of the Štiavnica stratovolcano).

Geological characteristics of the Hodruša-Štiavnica Intrusive Complex

The Hodruša-Štiavnica Intrusive Complex (HŠIK, according to Konečný—Lexa—Planderová, 1983, Fig. 1) represents an assemblage of intrusive rocks of the Banská Štiavnica-Hodruša region, containing rocks of diorite — granodiorite composition, together with their porphyritic varieties. The HŠIK is formed in the central part by a granodiorite intrusion, probably bell-shaped — the "bell-jar" type (according to Mihaliková—Konečný—Lexa, 1980; and on the periphery by a few smaller diorite bodies. The HŠIK, situated in the rocks of the pre-volcanic basement, emerges on the surface in the Hodruša region; in the Štiavnica region it was confirmed by boreholes and mine workings under the volcanic complex. The boundaries with the environment in which the complex occurs (Mesozoic and Palaeozoic rocks) are intrusive. The HŠIK has close time relations to the lower stratovolcanic structure and its formation falls into the later stages of the Lower Badenian stratovolcano evolution.

Within the intrusive granodiorite complex it is possible to distinguish two extreme types of rock textures, between which there is a gradual and continuous transition (Fig. 2).

The first type (GRŠ-4): The margin of the intrusive body has porphyric texture with allotriomorphic matrix. Phenocrysts are formed by plagioclase, amphibole, biotite, quartz and K-feldspar. The matrix consists of plagioclase, K-feldspar, quartz, Fe-Ti oxides and accessory minerals (mainly apatite and zircon).

The second type (GRŠ-1): The granodiorite texture in the inner part of the intrusive body, at a distance of approx. 300 m from the porphyric margin, is hypidiomorphic, uneven-grained — anisometric. Plagioclases, amphibole and biotite are hipidiomorphic to idiomorphic, K-feldspars and quartz are allotriomorphic, sometimes with poikilitic character.

Within single thin section it is possible to observe certain differences in the size of plagioclase, amphibole and biotite phenocrysts in comparison with K-feldspar and quartz. Continuous transition exists between the two mentioned texture types; in the approximate middle of this, a new texture type developed. This new — transitional-type (GRŠ-3) is characterized by the presence of micrographic penetrations of quartz and K-feldspar. Chemical and modal composition of the individual HŠIK granodiorite rock-types are presented in Tab. 4.

Methods of study

Biotite from the HŠIK granodiorite has been studied optically, with the help of 3-axial Fiodorov's universal stage, in 120 thin sections. Spot quantitative chemical analyses of this mineral phase have been carried out on the electrone microanalyser JXA-733. The correctness of the obtained chemical analyses of

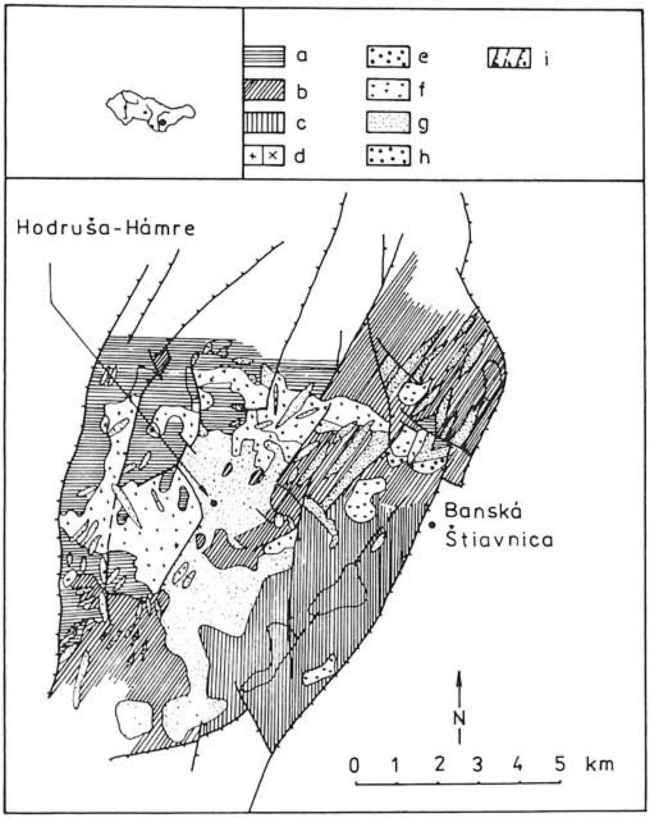

Fig. 1. Schematic geological map of the surroundings of Banská Štiavnica—Hodruša-Hámre (according to Konečný — Lexa, 1984).
Explanations: a — Paleozoic to Paleogene basement; b — undistinguished rocks of the first stage (unspecified andesite porphyry); c — Tanad Intrusive Complex (unspecified andesite porphyry); d — Hodruša—Štiavnica Intrusive Complex, (+) — granodiorite, (x) — diorite; e — Červená studňa formation (tuffaceous claystones, siltstones and epiclastic volcanic sandstones with rare intercalations of lignite); f — Studenec formation (unspecified biotite-hornblende andesites); g — Banisko Intrusive Complex (unspecified quartz-diorite porphyry; h — secondary quartzites; i — faults showing dip; a-identified, b-assumed, marginal faults of c-volcanotectonic horsts.

biotite as well as the Fe^{3+} contents in it have been verified and calculated according to the method of Foster (1960, in Fejdi, 1982). The copper content in biotite has been determined from 0.5 g weight of manually separated biotite, with the help of AAS, on the apparatus SP-90 A Pye-Unicam. The Mg, Fe and Ti contents in selected profiles through some biotite phenocrysts have been determined on the electrone microanalyser JXA-5.

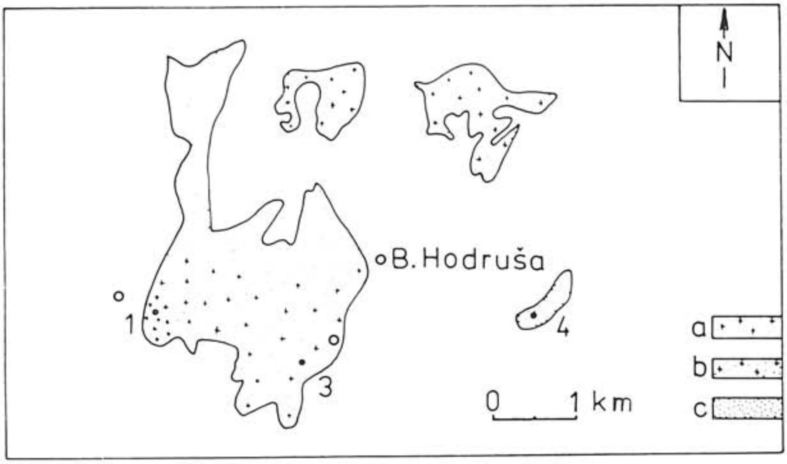

Fig. 2. Areal localisation of individual texture varieties of the HŠIK granodiorite emerging on the surface of the B. Hodruša region.
Explanations: a — granodiorite with hypidiomorphic uneven-grained texture; b — granodiorite containing micrographic penetrations of quartz with K-feldspar; c — granodiorite with porphyric texture; 1 — GRŠ-1; 3 — GRŠ-3; 4 — GRŠ-4.

Results of the study and discussion

We can characterize the biotite occuring in the HŠIK granodiorite, without regard of the parent-rock texture, in the following way:
a) it forms idio- to hypidiomorphic phenocrysts 0.5 to 5 mm in size, which are intensively corroded along the margins and cleavage surfaces;
b) pleochroism in the direction n_α is of light yellowish-brown colour, along n_β and n_γ it is reddish-brown to dark brown, the 2V angle is almost zero ($< 5°$);
c) it encloses apatite, zircon, plagioclase and opaque minerals;
d) it was affected by alterations, especially into chlorite and epidote ± rutile, while within single thin section we can observe different intensities of alteration of biotite phenocrysts, varying between 5 % and 100 % of altered surface of the individual biotite grains;
e) except biotite having the above mentioned characteristisc, in some parts of the granodiorite body, especially in the ones containing micrographic intergrowths of quartz with K-feldspars, we can find fine-scaled biotite substituting in the form of clusters especially amphibole. The position of biotite in the

crystallization process of granodiorite melt is obvious from Fig. 3. In granodiorite in which feldspars are almost unaltered (low extent and intensity of sericitization, carbonatization, argillitization), opaque minerals occur, connected with biotite phenocrysts, in the form of isometric grains, worm-like formations localised on cleavage surfaces of biotite, or as fine grains filling the "bays" on the margins of corroded biotite phenocrysts. Opaque minerals of these types are formed mainly by magnetite containing ilmenite or hematite lamelles, more rarely by ilmenite. In granodiorites affected by alterations (the plagioclases are almost completely or completely altered into a mixture of sericite, carbonate and clay minerals, while K-feldspars are altered only slightly) the opaque minerals occuring together with biotite are formed by isometric pyrite grains, rarely by chalcopyrite, magnetite and clusters or smudges of rutile grains dispersed on the surfaces of altered biotite phenocrysts. Biotite itself is in the earlier mentioned granodiorite altered into chlorite and epidote to the extent of 5 to 100 % of its surface, while in the later mentioned granodiorite it is substituted by chlorite, carbonate and less by epidote. The centres of biotite grains remain frequently unaltered, while the margins are affected by alterations.

Fig. 3. Schematic representation of the crystallization process in the HŠIK granodiorite melt.

Explanations: ... — presumed beginning or ending of crystallization; —— — crystallization of a mineral phase: Plg — plagioclase; Aph — amphibole; Bi — biotite; Qtz — quartz; K-fld — K-feldspar.

The results of spot chemical quantitative analyses of biotite phenocrysts by electrone microanalyser are presented together with the calculations to end members in Tab. 1.

On the basis of texture criteria, we can consider the studied biotite of the HŠIK granodiorite to be of magmatic origin, crystallizing from melt only after amphibole. With a similar opinion on the genesis of biotite from the HŠIK granodiorite we can meet also in the papers of Šalát (1954), Lexa (1969), Mihaliková 1978).

Probably secondary origin, in the sense of Beane (1974), Lowell—Guilbert (1970) and Nielsen (1968), can be attributed to a fine-scaled variety of biotite which substitutes, in the form of clusters, the primary magmatic amphibole. But not only the from of occurence, but also the total chemical composition of biotite can help us to determine correctly the genesis of this mineral phase. The first ones to attempt an application of knowledge of biotite chemism based on world literature to this mineral phase from the HŠIK granodiorite have been the authors Rozložník—Timčák—Jakabská (1982) who in their paper say: "our biotites are very similar to those studied by Le Bel (1979) and they accompany Cu-porphyry mineralization" (p. 78).

The situation concerning the differences in chemical composition between primary and secondary biotites is probably not as unambiguous as supposed earlier (Beane, 1974; Kesler et al., 1975; Lovering, 1969). The authors Hendry — Chivas — Long — Reed (1985) came in their work to the conclusion that there are two types of alteration biotites. The first one has X_{mg} equal to magmatic biotite and is poor in copper ($mg = 100\ Mg/(Mg + Fe)$). The second type of alteration biotite has higher Mg contents (higher X_{mg} value) in comparison with magmatic biotite and is rich in copper. Except total chemical

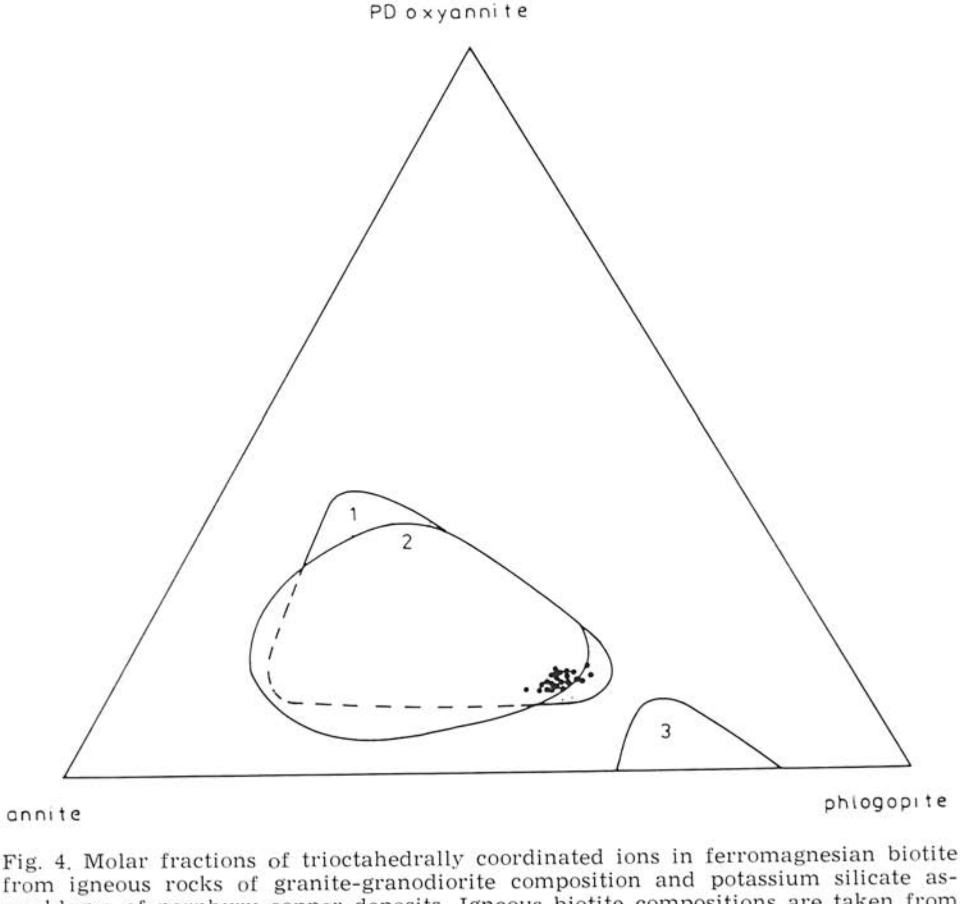

Fig. 4. Molar fractions of trioctahedrally coordinated ions in ferromagnesian biotite from igneous rocks of granite-granodiorite composition and potassium silicate assemblages of porphyry copper deposits. Igneous biotite compositions are taken from Foster (1960) and Heinrich (1946); Heinrich's composition plots not include Al^{3+} and Ti^{4+} at the Fe^{3+}, and Mn^{2+} at the Fe^{2+} apices respectively (according to Beane, 1974).

Explanations: 1 – magmatic biotite according to Foster (1960); 2 – magmatic biotite according to Heinrich (1946); 3 — alteration biotite according to Beane (1974); Apex annite — represents $KFe_3^{2+}AlSi_3O_{10}(OH)_2$, or $Fe^{2+}(Mn^{2+})$; Apex phlogopite — represents $KMg_3AlSi_3O_{10}(OH)_2$, or Mg^{2+}; Apex proton-deficient oxyannite — represents $KFe_3^{3+}AlSi_3O_{12}(H_{-1})$, or $Fe^{3+}(Al^{3+} + Ti^{4+})$; — biotite from the HŠIK granodiorite.

Table 1

Spot quantitative chemical analyses of biotite from the HŠIK granodiorite

	biotite								
sample	GRŠ-1					GRŠ-3			RŠ-18
	contents of oxides (weight %)								
SiO_2	37.35	37.25	37.23	37.50	37.80	38.15	38.24	38.36	37.40
Al_2O_3	13.87	13.63	13.81	13.55	13.74	13.96	14.21	14.78	13.84
FeO	17.30	16.35	16.26	16.13	16.03	15.35	14.43	14.52	15.20
MgO	12.56	12.65	12.97	13.01	13.31	13.61	14.01	14.66	13.24
TiO_2	4.75	4.75	4.91	4.70	4.77	4.85	4.61	5.23	4.24
MnO	0.12	0.17	0.20	0.03	0.17	0.09	0.26	0.22	0.34
K_2O	9.17	8.97	9.04	9.09	9.18	8.84	9.13	9.78	9.01
Na_2O	0.25	0.24	0.24	0.19	0.23	0.18	0.26	0.02	0.28
CaO	0.02	0.00	0.00	0.00	0.10	0.04	0.28	0.26	0.01
Sum	95.39	94.01	94.68	94.20	95.33	95.07	95.43	97.83	93.57
	molar ratio to 22 atoms 0								
Si	5.637	5.676	5.634	5.693	5.670	5.697	5.681	5.573	5.697
Al^{IV}	2.363	2.324	2.366	2.307	2.330	2.303	2.319	2.427	2.303
Al^{VI}	0.104	0.123	0.097	0.118	0.099	0.154	0.169	0.105	1.936
Fe	2.183	2.084	2.060	2.048	2.011	1.916	1.793	1.764	1.936
Mg	2.827	2.874	2.925	2.944	2.977	3.029	3.102	3.175	3.007
Ti	0.539	0.544	0.559	0.536	0.538	0.544	0.516	0.572	0.486
Mn	0.015	0.023	0.026	0.004	0.022	0.012	0.032	0.027	0.043
ΣX	5.668	5.648	5.667	5.650	5.647	5.655	5.612	5.643	5.653
K	1.766	1.744	1.745	1.762	1.758	1.684	1.731	1.813	1.751
Ca	0.003	0.000	0.000	0.000	0.016	0.007	0.046	0.003	0.002
Na	0.074	0.071	0.072	0.058	0.067	0.051	0.074	0.074	0.086
Sum	1.843	1.815	1.817	1.820	1.841	1.742	1.851	1.890	1.839
$\Sigma\Delta$ [+]	1.182	1.211	1.215	1.190	1.175	1.242	1.201	1.249	1.153
	atoms ratios and end members								
Mg / Fe	1.259	1.379	1.419	1.437	1.480	1.580	1.730	1.799	1.553
$100 \times \frac{Fe}{Fe + Mg}$	43.57	42.03	41.32	41.02	40.31	38.74	36.62	35.71	39.16
X_{phl}	49.87	50.88	51.66	52.10	52.71	53.56	55.27	56.26	53.19
X_{ann}	38.77	37.30	36.74	36.32	36.00	34.09	32.51	31.37	35.00
X_{PDdoxy}	11.34	11.80	11.58	11.57	11.28	12.34	12.20	11.99	11.79

Explanations: Roman digits represent the cation coordinations. The calculation is based on the presumption that the tetrahedric layer has no vacancies ($\Sigma Si + Al^{IV} = 8.000$) and all Ti is in the octahedral layer.

ΣX — number of octahedrally coordinated cations; $\Sigma\Delta[+]$ — relative excess of charge of the octahedral layer (according to Foster, 1960, in Fejdi, 1982); X_{phl} — molar fraction of phlogopite; X_{ann} — molar fraction of annite; X_{pDoxy} — molar fraction of PD oxyannite in the chemical composition of biotite. For a more detailed explanation see text.

composition, some authors have as well investigated the changes in chemical composition within individual biotite phenocrysts (e. g. Mason, 1978) from barren as well as mineralized intrusive rocks. At the same time, in biotites from mineralized intrusions they have observed a trend of Mg-enrich-ment and decrease of Fe and Ti contents from the centre to the margin of phenocrysts, which is actually contrary to the one characteristic for magmatic zonality trend of mafic minerals crystallizing from melts.

As it follows from the chemical composition of biotite from the HŠIK granodiorite (Fig. 4 and Tab. 1), the values of atomic ratios Mg Fe in them vary in the range of 1.29—1.84. Thus, these biotites not only cannot be classed with magmatic ones, because those have the value of Mg Fe <1, but as well not all of them comply with the requirements for alteration biotites (Mg/Fe > 1.5, according to Beane, 1974).

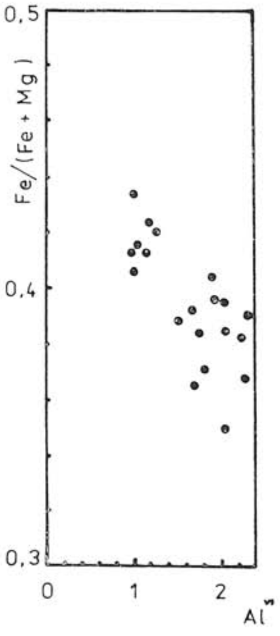

Fig. 5. The relationship of ΣFe (ΣFe + Mg) to Al^{VI} values in biotite from HŠIK granodiorite.

On the basis of the position of biotie of this type in the crystallization process, as well as on the basis of its chemical composition, it can be assumed that this mineral phase crystallized from magma in a relatively wide range, including the magmatic stage, while in its final stages of evolution this phase reacted with the surrounding melt (due to an increase of fO_2 or a decrease of pH_2O), producing magnetite, K-feldspar and water, according to the reaction suggested by Wones—Eugster (1965). The processes taking place in this late magmatic stage caused certain changes in the biotite composition — an increase of Mg content and a decrease of Ti content. This trend is obvious from Tab. 2, along with other facts. Let us notice that not in all granodiorite sam-

Table 2

Ti, Mg and Fe contents as TiO_2, $Mg/(Mg + Fe)$ in biotite phenocrysts from the HŠIK granodiorite, from centres towards margins

biotite					
a					
TiO_2			$Mg/(Mg + Fe)$		
4.79 —	4.91	— 4.75	0.57 —	0.58	— 0.56
4.75 —		— 4.70	0.57 —		— 0.59
4.77 —		— 4.68	0.58 —		— 0.59
4.77 —		— 4.85	0.59 —		— 0.61
b					
4.67 —	4.67	— 4.61	0.61 —	0.62	— 0.63
4.85 —	4.83	— 4.66	0.60 —	0.60	— 0.62
5.23 —	4.83	— 5.22	0.64 —	0.64	— 0.65
c					
3.92 —	4.05	— 4.24	0.61 —	0.63	— 0.60
4.13 —		— 4.62	0.61 —		— 0.60
centre		margin	centre		margin

Explanations: a — granodiorite with hypidiomorphic uneven-grained texture; b — granodiorite containing micrographic intergrowths of quartz with K-feldspar, c — granodiorite with porphyric texture.

ples this trend can be observed in biotite phenocrysts. Biotite from the part of the intrusive granodiorite body which contains micrographic intergrowths of quartz with K-feldspar has such a reverse type of zonality in comparison with normal magmatic zonality trend. In this zone the processes taking place in the late magmatic stage could reach their gratest extent and intensity. Already not so unambiguous zonality trend can be observed in biotite phenocrysts from the part of granodiorite with hypidiomorphic uneven-grained texture. In this part of the body the conditions were not sufficient for all biotite phenocrysts to attain the same character from the viewpoint of element distribution. The insufficiency of these conditions affected most prominently the marginal part of the granodiorite body where probably due to faster cooling of magma with the formation of porphyric texture, an environment favourable especially for late magmatic processes did not originate. In this part of the intrusion, biotite phenocrysts have preserved their primary magmatic zonality, i.e. Ti content increases and Mg content decreases here in the direction from centres to the margins of the phenocrysts. Fe-Ti oxide is not developed to such an extent in the margins of the biotite phenocrysts as it was the case in the earlier mentioned parts of the intrusion.

From the above mentioned knowledge of the biotites from the HŠIK granodiorite it follows that in certain parts of the granodiorite intrusion (containing

Table 3

Copper contents (ppm) in biotite from the HŠIK granodiorite (for explanations see text)

biotite	Cu (ppm)
GRŠ-1	23
GRŠ-3	85
GRŠ-5	87

micrographic intergrowths of quartz with K-feldspars) the magmatic process had oxidation character — i.e. forming of Mg-richer margins of biotite phenocrysts, production of Fe-Ti oxide by the reaction biotite + melt. In the other zones of the granodiorite intrusion, i. e. in the zone with hipidiomorphic uneven-grained and porphyric texture, the magmatic process did not have such marked oxidation character.

On the basis of investigation of biotite from intrusive ore-bearing as well as barren rocks occuring in the New Guinea porphyry copper ores region, Mason (1978) came to the conclusion that for biotite of barren rocks the correlation $\Sigma Fe/(\Sigma Fe + Mg)$ to Al^{VI} is positive, while for ore-bearing intrusions is this relationship negative.

On Fig. 5, an analoguous relationship is plotted, constructed on the basis of chemical analyses of biotite from the HŠIK granodiorites. As it is obvious from this figure, the correlation $\Sigma Fe/(\Sigma Fe + Mg)$ Al^{VI} negative, what is typical, in the sense of Mason (1978), for biotites originating from ore-bearing intrusive rocks.

Let us now direct our attention to the copper contents in biotites from the HŠIK granodiorite (Tab. 3). According to Hendry et al. (1985), copper contents in biotite from barren intrusive rocks is in average 23 ppm Cu, while in mineralized intrusions a bimodal distribution of this element with maxima at about 7 and 100 ppm Cu can be observed. Due to the fact that the values presented in Tab. 3 have been obtained by AAS analysis from 0.5 g weight of separated biotite, these values represent only average copper contents in the biotites.

The sample GRŠ-1 represents biotite from granodiorite with hipidiomorphic uneven-granined texture. GRŠ-3 and 5, on the other hand, represent biotite originating from the zone of the granodiorite intrusion for which the presence of micrographic intergrowths of quartz with K-feldspars is characteristic.

From the copper contants in the biotite it follows that in the part of the granodiorite intrusion in which probably favourable conditions were created for biotite as a mineral phase to remain an open system up to the late magmatic stage, biotite with increased copper contents (GRŠ-3, 5) was formed in the conditions of slow temperature decrease and abundance of hydrothermal fluids. Lack of hydrothermal fluids, even if the conditions of slow cooling were fulfilled (GRŠ-1), caused that copper contents in such biotite did not increase.

Table 4

Chemical and modal composition of individual rock types of the HŠIK granodiorite: for more details see text

	granodiorite		
	GRŠ-1	GRŠ-3	GRŠ-4
	Contents of oxides (weight %)		
SiO_2	61.97	59.43	65.51
TiO_2	0.54	0.77	0.60
Al_2O_3	15.61	15.07	16.03
Fe_2O_3	2.01	1.85	2.08
FeO	1.89	3.19	1.78
MgO	1.85	3.10	2.18
MnO	0.08	0.13	0.07
CaO	4.84	5.95	4.65
Na_2O	6.73	5.55	2.04
K_2O	3.32	3.56	3.49
H_2O^-	0.28	0.43	0.36
H_2O^+	1.02	0.73	0.96
Sum	100.35	100.11	99.94
	Modal contents (vol. %)		
Aph + Bt	15	24	14
Plg	38	33	39
K-Fld	24	19	22
Qtz	20	18	23
accessory	3	6	2
Sum	100	100	100

Explanations: Aph — amphibole; Bt — biotite; Plg — plagioclase; K-Fld — K-feldspar; Qtz — quartz; accessory — accessory minerals (zircon, apatite, Fe-Ti oxides).

Table 5

Localisation of samples

GRŠ-1:	Roadcut on the road Žarnovica—Hodruša-Hámre, in the Kyslá region.
GRŠ-2:	Exposure in the lower part of the creek flowing from under the Vlčia hill, on the beginning of the village Kohútov.
GRŠ-3:	Elevation point Kamenný Závoz.

Conclusion

As a conclusion it can be said that except primary magmatic biotite, secondary biotite is also present in lesser quantities in some parts of the intrusion (GRŠ-3) in the HŠIK granodiorite. The chemical composition of the individual primary biotite phenocrysts indicates an oxidation magmatic trend, which is most prominently developed especially in the part of the granodiorite intrusion where micrographic intergrowths of quartz with K-feldspars are present as well (GRŠ-3). Individual biotite phenocrysts are corroded along the margins — probably due to a decrease of pH_2O in magma, while after this corrosion no further growth of biotite took place. The presence of oxidation trend, together with the negative correlation of ΣFe ($\Sigma Fe + Mg$) to Al^{VI} and the increased copper contents (~ 87 ppm Cu) — favourable indications of ore content — can be nevertheless observed only in biotites from some parts of the HŠIK granodiorite.

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