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Picrite Rocks in the Vicinity of Banská Bystrica (Krížna unit, Western, Carpathians)

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Abstract: In the Mesozoic of the Western Carpathians several characteristic volcanic formations occur: teshenite-picrite formation in Cretaceous of the Flysh Belt, alkali basalts/basanites formation in Cretaceous of the Cover Units and Subtatric Units and tholeiite formation in the Triassic of the ophiolite complex of the Meliaticum. In this study we present the results of the petrological research on the Mesozoic picrite formation in of the broader area of Banská Bystrica. Based on the clinopyroxene composition and on their rare elements composition, we assign the picrites into a formation of alkali basalts/basanites and they occur in the Cretaceous of the Cover Units and Subtatric nappes.

Key words: picrites, mineralogy, geochemistry, Cretaceous, Subtratric nappe, Western Carpathians

Introduction

Already in the past picrites were described in various geological units of the Western Carpathians. The Silesian Unit of the Western Carpathians Flysh Belt is the district with the most common occurrences of these rock bodies (hypabysal and surficial), where picrites are a part of the already classic, teshenite-picrite formation (Pacák 1926, Smulikowski 1929 in Hovorka- Spišiak 1988).

In the broader area of Vienna (Vienna basin) more of the picrite occurrences are known (Prey 1975). According to Tollmann (1985) more than 30 rock bodies are present there.

During oil-well exploration in the northern part of the Vienna basin near Gbely (Slávik 1930), and subsequently also near Kúty (Matějka in Budaj et al. 1963), picrite bodies were drilled. According to Benešová (1957), they metamorphosed the surrounding Albian sediments.

However the picrite described in detail by Ivan (1991) from the Strážny hill near Medzev occurs in the Gelnica Unit (Lower Paleozoic) and was metamorphosed to greenschist facies.

The process of gravitational differentiation is the typically process, that leads to the origin of picrites. Heavy olivine crystals accumulate and, due to the subsequent effusion and cooling, the origin of picrite and picrite basalt type of rocks occurs. As clinopyroxenes in basic effusive rocks, and consequently also in picrites, are highly informative value from all the present silicate phases (type and crystallisation conditions of magma), and in the case of the studied picrites they are and relatively well preserved, we focused on the study of their composition using an electron microprobe.

In the association with a review of Mesozoic volcanism products in the Western Carpathians, we focused on the study of picrites and alkali basalts/lamprophyres (Hovorka – Spišiak 1988, 1993, Spišiak – Hovorka 1997, Hovorka et al. 1999). Despite their rare occurrence, picrites have a high petrologic and geotectonic importance. As a shallow (hypabysal) rock, they offer complementary data not only about the character of the volcanism, but also about the type and composition of the upper mantle in the place of picrite magmas generation.

Generally is the idea still accepted, that picrite rocks in the Mesozoic of the Western Carpathians were either Triassic, or Neogene with the basaltic rocks (Hovorka - Slavkay 1966, Slavkay 1979). From casual view the picrites do not have any equivalent among the Lower Cretaceous alkali volcanic rocks of the Central Western Carpathians, but if the Mesozoic volcanism of the Outer and Inner Western Carpathians are compared in detail, the picrite rocks are an integral part of the whole volcanic province. Hence the resolution of the character and type of the volcanism was the main aim of this study.

The picrites were studied optically and geochemically (5 samples). Minerals were analysed using the electron microprobe CAMECA (Dipartimento di Mineralogia e Petrologia, Universita di Padova), or JEOL Superprobe (GS SR) at standard conditions. Petrogenic features and trace elements were analysed by XRF, or SPA at Geological Institute Sloval Academy os Sciences. Rare earths elements, or selected trace elements were analysed using ICP at the Ibaraki University (Mito, Japan).

Geology

Horný diel near Banská Bystrica

On the southern slopes of the Horný diel (ground elevation 1000 m above sea level) about 4 km north of Banská

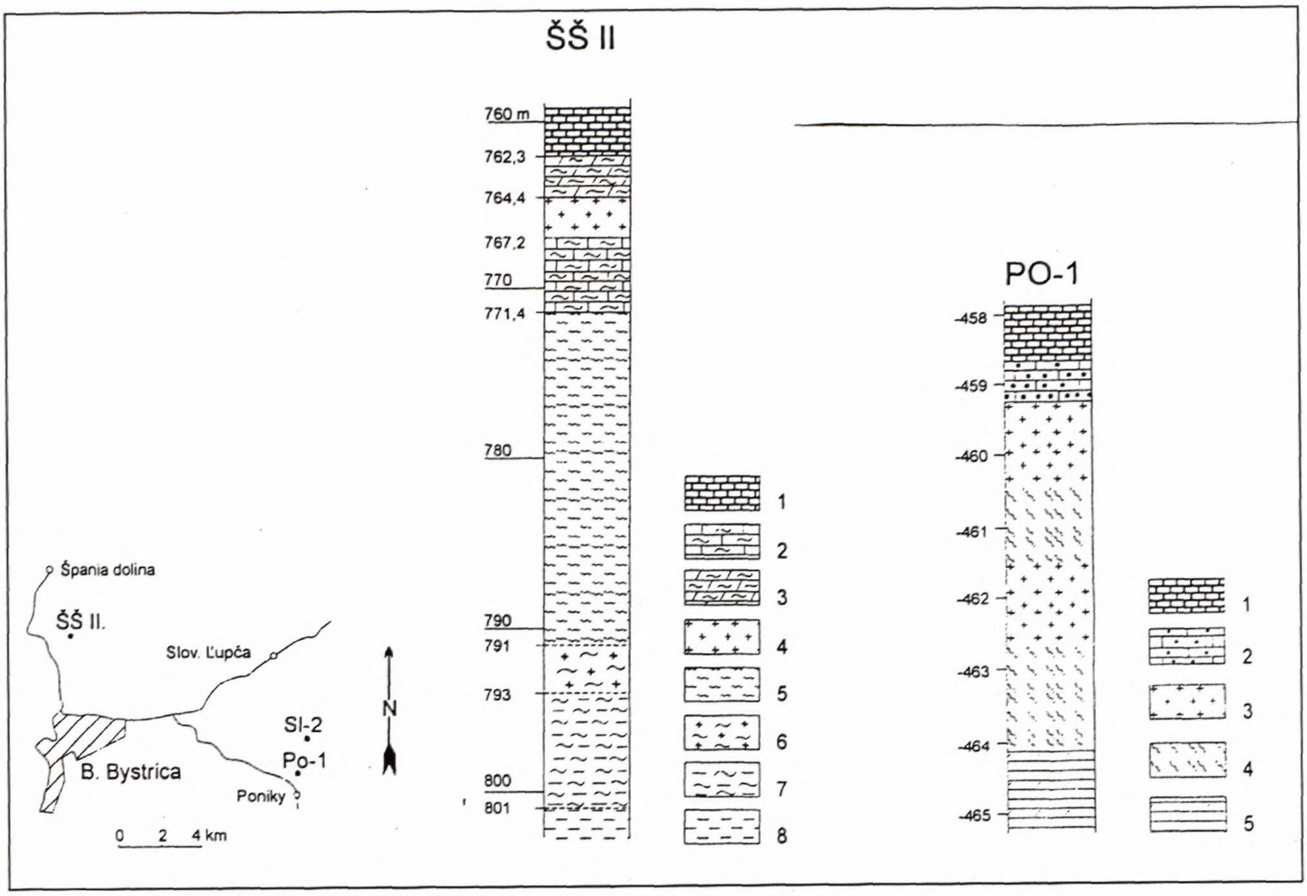


Fig. 1a. Schematic map of picrite occurrences locations (a) a part of the section of the drill hole ŠŠ-II (b) (according to Slavkay, 1979). 1 – grey limestones with interbedded fractured dolomites, 2 – grey, heavily broken limestones, 3 – tectonic breccia composed of dolomite, limestone and clay fragments, 4 – picrite, 5 – tectonic clay, fragments of limestones and claystones, 6 – heavily broken picrite from the tectonic zone, 7 – tectonic clay with fragments of violet–brown shales and sandstones, 8 – violet-brown shales, 1-3 – Middle Triassic, 5-7 – tectonic zone, 8 – Lower Triassic; Po-1, Sl-2 – indication of drill holes.

Fig. 1b. A part of the section of the drill hole PO-1 (according to Hovorka–Slavkay 1966). 1 – broken grey to dark-grey dolomites (fissures filled by calcite), 2 – broken dolomites with clastic fragments of picrite, 3 – biotitic picrite, 4 – broken biotitic picrite, 5 – broken grey dolomites alternating with layers of heavily broken bioititic picrite

Bystrica a picrite body was drilled in the drill hole ŠŠ-II (Fig. 1a) in the interval 764.4-767.2 m (Slavkay 1979). The surrounded rocks consist of Middle Triassic limestones of the lower sub-plate of the Krížna nappe (l.c.). The contact zones with ambient rocks were not obtained using the related core run due to the extensive tectonic fracturing therefore, the mode of deposition of the picrite body and its relationship to the surrounded carbonates is unknown.

Poniky district

North of the Poniky, about 8 km SE from Banská Bystrica in Middle Triassic dolomites of the Choč nappe (Bystrický 1964, in: Slavkay 1965), volcanic rocks of the picrite type were found in two drill holes. Their basic characteristic is described in studies of Hovorka & Slavkay (1966) and Slavkay (1979). In the drill hole Po-1, located about 250 m W of the northern margin of the village Poniky at a depth of about 460 m (fig. 1b), a volcanic rock body was discovered with an apparent thickness nearly of 5 m, occurring in grey dolomite breccia. Along veinlets of carbonate, pyrite and gypsum were present. Carbonates and pyrite represent a product of the overprinting hydrothermal processes. Gypsum probably is a product of migration from the overlying Lower Triassic Drienok sequence, in which layers of gypsum and anhydrite occur. Based on the presence of small glassy fragments of picrite in the superposed dolomites and based on the missing or still nodetermined contact-thermal influence of picrite on the surrounded dolomites. Hovorka and Slavkay (1966) proposed that the body represents a product of the submarine volcanic activity in the surrounding carbonate sediments. However the number of fragments decreases slowly in direction from the contact. It is not possible to determine the relationship of the picrite to the overlying dolomites from the drill core. The picrite from the immediately underlying part of the core is extensively fractured, and the tectonite is cemented by carbonates.

In the drill hole St-2, situated close to the hill Stráž (697 m) about 2.5 km north of from Poniky (approximately 2 km from the drill hole Po-1). It is a body with a consistent geological position and consistent petrographic character as the body in the drill hole Po-1 was discovered (Slavkay 1979).

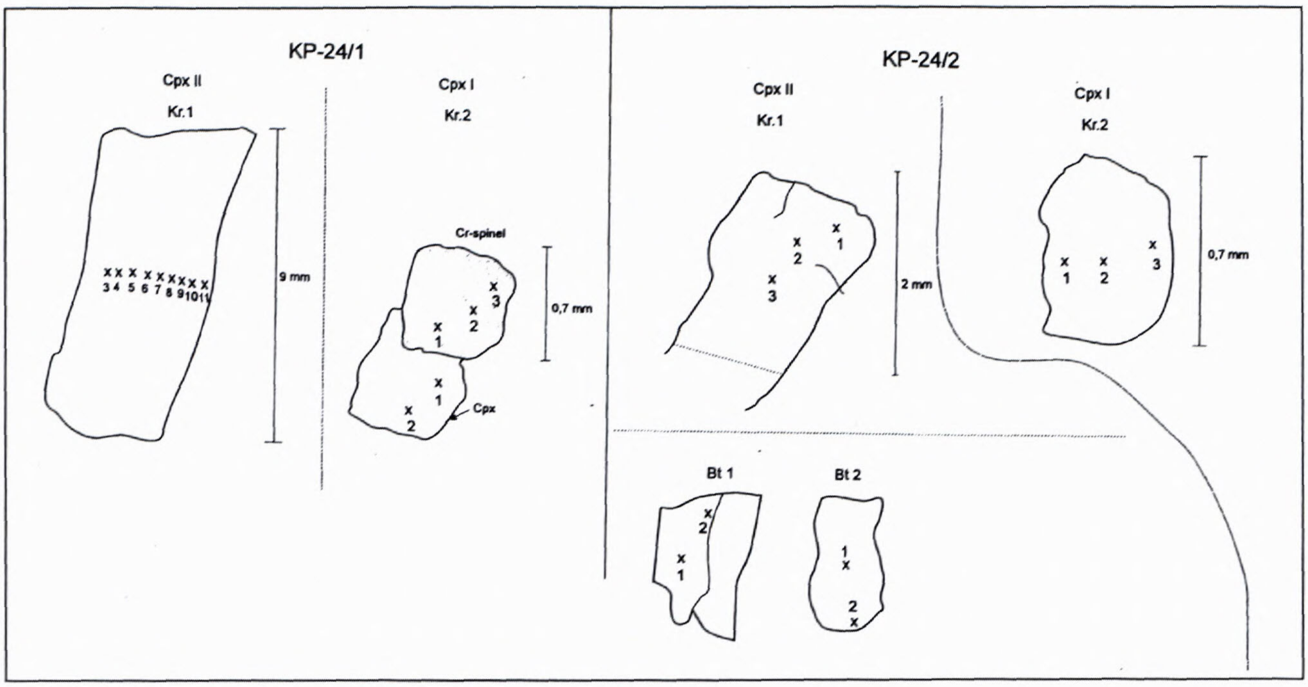


Fig. 2. Diagram of the analysed clinopyroxenes.

Petrology

The basic rocks from the drill hole sections are represented by fragments of centimeter size. The freshest rocks are dark-green, but the tectonized ones are pale green. These rocks contain pale-green porphyric olivines (2-6 mm) of lens-like sections, short (2-5 mm) dark columns of clinopyroxenes, leaves of dark mica (2-3 mm) and products of younger hydrothermal (pyrite, carbonate). The groundmass of the volcanic rocks is deep-green and macroscopically aphanitic. Locally, textures of poikilitic mutual intergrowths of pyroxene, amphibole and dark mica of II. generation are clearly visible.

The rocks contains phenocrysts od more abundant olivine and less abundant clinopyroxene.

Olivine (20-50 % by volume) is present in form of pyrphyritic phenocrysts only. It is extensively serpentinised, and isaccompanied by typical loop-like structures (Photo 1). The cores of the individual loops are formed by serpentinised olivine, as well as talc, calcite and low birefringent to isotropic serpentine of the chrysotile-lizardite group. The middle part of the "channels" is filled by fine-grained ore pigment or by a pale to colourless type of serpentine. Olivine could not be analysed due to the high degree of alteration.

Clinopyroxene is present in the form of columns of three generations or types:

- *Clinopyroxenes I* are made up of tiny columns 1 - 3 mm in size. They occur closely associated with olivine or with Cr-spinel (they are in direct contact with them, Fig. 2, Photo 2). They do not show any optical or chemical zoning.
- *Clinopyroxenes II* - porfyric phenocrysts (up to 10 mm in size) are of idiomorphic appearance. They are pink-violet to brown-violet with a distinct pleochroism (Photo 3, 4). The basic optical properties are the following: Z/c = 54-56°, 2V = 48-50°. Part of the porphyric clinopyroxene phenocrysts are zonally structured and are marked by the gradual ("undulatory") extinction of crystals in the sections perpendicular to the c axis. Oscilatory and sectional zoning is characteristic for the Cpx. Oscillatory zoning is produced by an increase of TiO_2, Al_2O_3, Cr_2O_3, or by reduction of SiO_2, MgO and Na_2O in direction from the centre to the margins of the crystals (Table 1, Figs. 2, 3). The crystal structure of the zoning is a disequilibrium state and is formed during a quick ascent of a melt i.e. change in PT conditions - predominantly pressure.
- *Clinopyroxenes III* - clinopyroxenes of the groundmass. They form tiny 0.1 to 0.4 mm columns or clusters of irregularly confined grains. They have similar optical and chemical properties to the margins of the porphyric phenocrysts.

The composition of clinopyroxenes in picrites was studied by an electron microprobe (Table 1, Fig. 2). In the classification diagram (Fig. 4) these clinopyroxenes project into the diopside field, while the clinopyroxenes I. are shifted in direction of the lower Fe content and higher Mg content. The Cpx II from the picrites have a similar composition to those of the alkali basalts from the Cover Units and of the Krížna nappe (Hovorka – Spišiak 1988). Clinopyroxenes from the picrites are chemically more homogeneous than the clinopyroxenes of the alkali basalts from the Cover Units.

In the clinopyrexenes the Al^{IV} and Ti contents have a close mutual association. Yagi and Onuma (1967) infered, that ions of these elements are present in a hypothetical molecule of Ti-pyroxene $CaTiAl_2O_6$, whose solubility in diopside is markedly decreased at high pressures. Tracy and Robinson (1977) obtained similar results too.

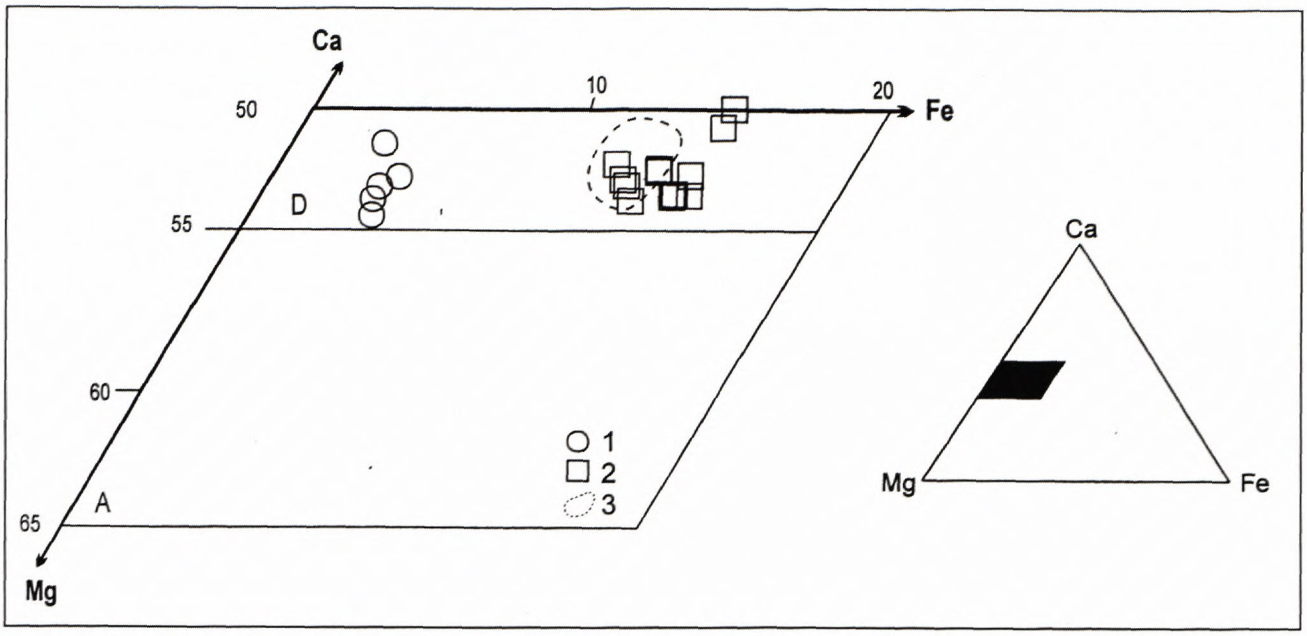


Fig. 3. Linear section with TiO_2, Al_2O_3 and Na_2O contents in the clinopyroxene II grain (kr. 1)

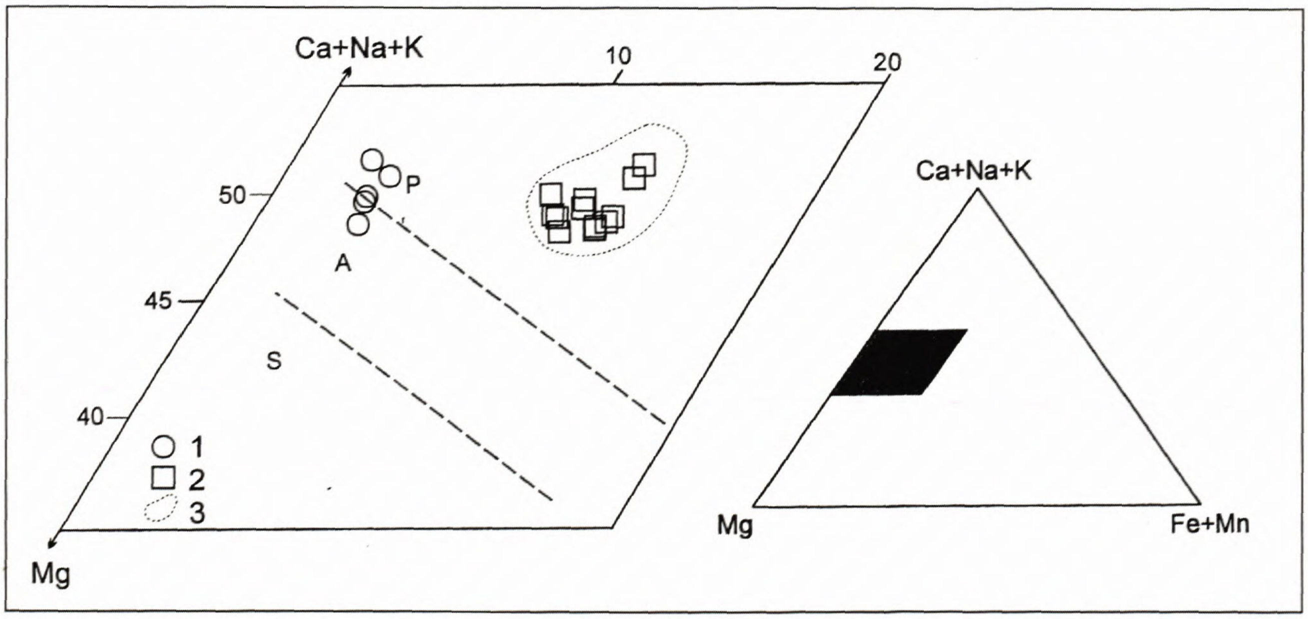


Fig. 4. Classification diagram of clinopyroxenes (according to Morimoto et al. 1988) from picrites from the Poniky area with the following marked fields: A – augite, D – diopside, 1 = clinopyroxenes II, analyses of clinopyroxenes from the figure 2 and table 1, 3 = field of analyses of clinopyroxenes from picrites of the Outer Western Carpathians.

Cpx zoning (rimward enrichment in Al^{IV}, Ti and Fe and Mg and Si and Na depletion) may be explained in three ways (Bédard et al. 1988): (1) it represents a kinetic effect, (2) it reflects a differentiation of the melt as it cools and crystallises, or (3) it reflects changes in pressure during crystallisation. With regard to all possibilities and the presented data (zoning character, Cpx and rock composition, etc.) we infer that polybaric conditions and fractional crystallisation were the dominant process of the Cpx zoning generation. Rimward, Ti-Al^{IV} enrichment is a result of polybaric crystallisation during the ascent of the magma. As pointed out by Wass (1979), data on the solubility of Ti in Cpx in dependence on pressure and temperature are often controversial. There was found a relationship between Ti + Al^{IV}: Si ratio and pressure, and fractionation trends can strongly influence the ratio. The ratio of Al^{IV} : Al^{VI} in Cpx seems to be the most suitable indicator of relative pressure (Thompson 1974, Wass 1979). Through a study of Cpx from the Upper Createaceous lamprophyres in Velence, Buda Mts. (Hungary, Dobosi and Horváth 1988) determined the presence of two types of Cpx: 1. High pressure Al-augites (with low

Photo 1. A spinel grain at the contact with Cpx I (lower left), Sample KP-24, 1N, magnification 54 x, Photo Oswald

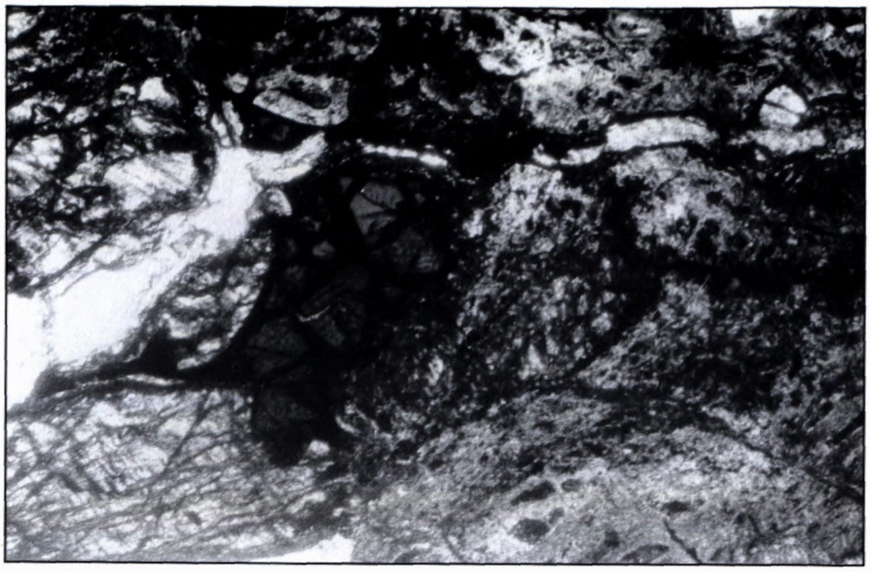
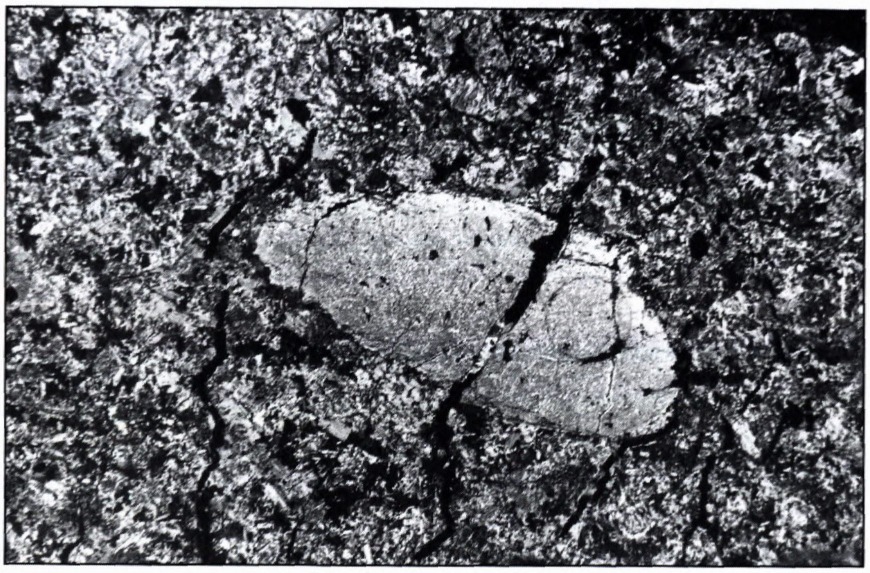


Photo 2. Cpx II phenocryst (in the middle) in the fine grained groundmass, sample KP-24, 1N, magnification 7,7 x, Photo Oswald



TiO_2 concentration and high Al_2O_3 and Na_2O concentrations) and 2. lower pressure zonal phenocrysts with margins enriched in TiO_2.

If applying these findings to the studied pyroxenes, than the clinopyroxenes I crystallised in the upper mantle at high pressures (together with olivine) and the margins of the clinopyroxene II probably represent a product of crystallisation at the mantle/crust boundary at relatively reduced pressure. At the Ti: Al diagram (Fig. 5) a marked differences can be seen between clinopyroxenes I (the association with olivine and Cr-spinel) and clinopyroxenes II. While for the Cpx I very low Ti concentrations are characteristic, Cpx II have higher Ti contents and the projection points are distributed along the line of Ti: Al ratio = 1:3, whereas there is also a positive corelation of these elements (with increasing Al concentration the increase of Ti content also occurs). The projection points of the clinopyroxene II analyses are located on the right from the T line, which indicates the maximal concentration of the presented elements in clinopyroxenes of tholeiite basalts, i.e. they are located in the field of alkali basalts.

Letterrier et al. (1977) used the dependency of clinopyroxene composition on the composition of melts, from those they originated, for the determination of the type of basalts (Fig. 6). At the diagram fields for Cpx of alkali basalts (A) and tholeiitic with alkali-calcareous basalts (TH + CALC) are selected. The projection points of clinopyroxenes II. from the studied picrites are present in the field A (alkali basalts) and a large part of the analyses overlap with the field of clinopyroxenes of the Mesosoic alkali basalts from the other tectonic units of the central zone of the Western Carpathians (the dashed field). This also results in the similarity of clinopyroxene composition of picrites and alkali basalts from this zone. The flat differences inside the given tectonic zone of the I. order are

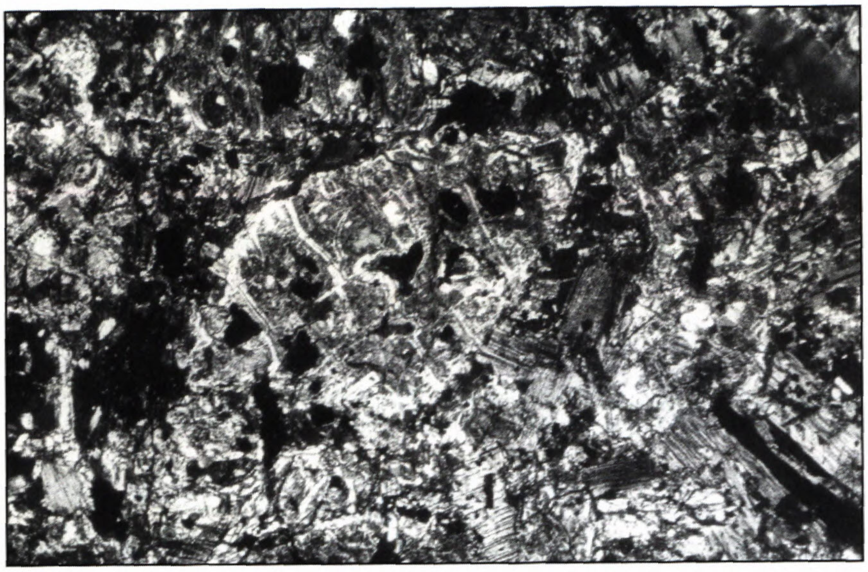


Photo 3. Pseudomorphousis after olivine (in the middle) filled with serpentine group minerals. Around – fine-grained matrix composed of phlogopite, carbonate, serpentine group minerals and ore minerals, sample KP-24, 2N, magnification 27 x, Photo L. Oswald

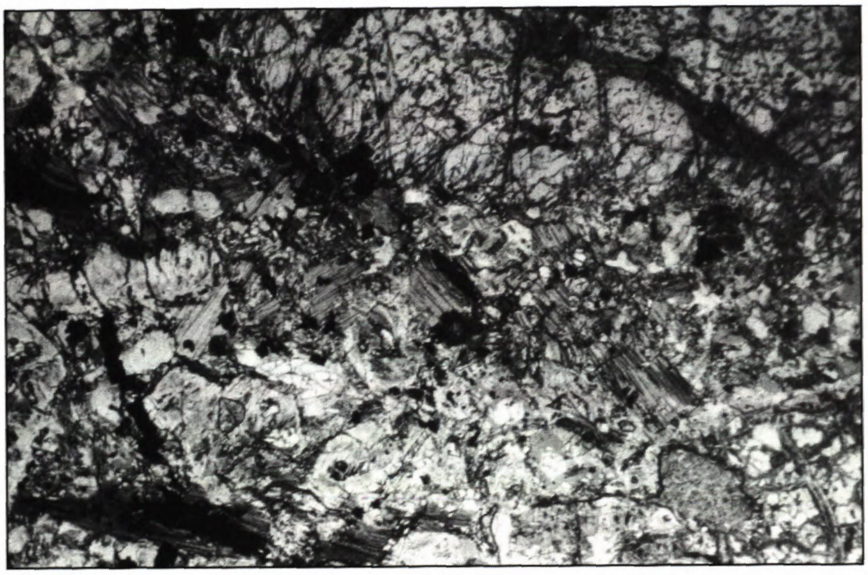


Photo 4. Cpx II phenocryst (at the top) in the fine grained matrix. Under Cpx phenocryst –tiny flakes of phlogopite, sample KP-24, 1N, magnification 27 x, Photo L. Oswald

conditioned by flat differences in the composition of the presented type of eruptives. Considering they have little Ti content, clinopyroxenes I. have markedly different position. Thus, finally we can state that the composition of clinopyroxenes II., as the terminative minerals of picrites from the vicinity of the Banská Bystrica, indicates their classification into the group of alkali basalts.

Dark mica – phlogopite, is represented by deep brown to brownish-red (Z) coloured leaves of the size 0.1 - 3 mm. Its distribution is uneven in detail - locally it forms irregularly confined leaf clusters. The dark mica content in the rock is as much as to 5 volumetric %. Near the hydrothermal veinlets with carbonate filling it gains more bright hue with a pleochroism of bright yellow-brown to green hue. According to the chemical composition (Table 2) the dark micas belong in the field of phlogopites (Fig. 7) in the classification diagram after Deer et al. (1962), and they have an identical position to the phlogopites from picrites of the outer Western Carpathians (Kudělásková 1982).

Apatite is a typical accessory mineral in picrites. It forms long columnar to acicular crystals with an elongation ration 1:25 and it reaches a length of 1.5 mm. Most of the apatite crystals are clear, only in the middle of some crystals is there a dark inclusion. Apatite does not occur among the minerals of the intratelluric phase (a part of the matrix) - it originated among the last phases of the given association.

Fine-grained amphibole (0.01 mm) is present in picrites in the amount of an accessory mineral. Its brown colour and extensive pleochroism are characteristic. It occurs very rarely and it forms idiomorphic columns, but mostly irregular crystals. The pleochroism varies between brown-yellow and brown hue. According to this colour, a

Tab. 1 Selected analyses of clinopyroxenes

Sample	KP-24/1											KP-24/2					
Place	kr. 1 CPx II									kr. 2 CPx I		kr.1 CPx II			kr. 2 CPx I		
Number	3	4	5	6	7	8	9	10	11	1	2	1	2	3	1	2	3
SiO_2	46,99	48,92	48,72	49,78	50,12	49,11	49,52	43,71	44,87	52,67	52,13	49,20	48,26	48,05	52,13	52,43	52,74
TiO_2	2,94	2,28	1,86	1,58	1,24	2,14	1,87	4,76	3,92	0,18	0,00	2,06	2,62	2,79	0,01	0,01	0,21
Al_2O_3	7,06	5,52	5,49	4,50	4,56	5,38	5,34	9,56	8,94	5,53	5,31	5,80	5,89	5,78	6,03	5,75	5,56
Cr_2O_3	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,15	0,14	0,71	0,62	0,01	0,00	0,00	0,85	0,74	0,67
FeO^+	7,46	6,87	7,47	7,53	7,74	6,41	6,84	7,12	7,21	1,89	2,53	6,02	6,81	6,56	2,50	2,30	2,32
MnO	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
MgO	13,05	13,37	13,51	13,64	13,35	13,84	13,27	11,67	12,03	15,34	16,43	13,56	13,99	13,86	15,44	15,88	15,89
CaO	22,04	22,16	22,03	22,14	21,97	22,17	22,08	22,11	22,09	21,98	21,50	22,04	21,93	22,11	21,50	21,58	21,24
Na_2O	0,33	0,71	0,55	0,52	0,78	0,55	0,50	0,31	0,38	1,15	1,06	0,73	0,55	0,59	1,35	1,09	1,18
K_2O	0,11	0,16	0,16	0,17	0,17	0,14	0,12	0,15	0,12	0,09	0,10	0,11	0,18	0,14	0,16	0,17	0,15
TOTAL	99,98	99,99	99,79	99,86	99,93	99,74	99,54	99,54	99,70	99,54	99,68	99,53	100,23	99,88	99,97	99,95	99,96
Formula based on 6 Oxygens																	
Si^{IV}	1,76	1,82	1,82	1,86	1,87	1,83	1,85	1,65	1,69	1,91	1,89	1,83	1,79	1,79	1,89	1,90	1,91
Al^{IV}	0,24	0,18	0,18	0,14	0,13	0,17	0,15	0,35	0,31	0,09	0,11	0,17	0,21	0,21	0,11	0,10	0,09
Al^{VI}	0,07	0,06	0,06	0,05	0,07	0,06	0,08	0,07	0,08	0,15	0,12	0,08	0,05	0,04	0,15	0,14	0,14
Ti	0,08	0,06	0,05	0,04	0,03	0,06	0,05	0,14	0,11	0,00	0,00	0,06	0,07	0,08	0,00	0,00	0,01
Cr	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,02	0,02	0,00	0,00	0,00	0,02	0,02	0,02
Fe^{2+}	0,23	0,21	0,23	0,23	0,24	0,20	0,21	0,22	0,23	0,06	0,08	0,19	0,21	0,20	0,08	0,07	0,07
Mn	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Mg	0,73	0,74	0,75	0,76	0,74	0,77	0,74	0,66	0,67	0,83	0,89	0,75	0,77	0,77	0,83	0,86	0,86
Ca	0,88	0,88	0,88	0,88	0,88	0,88	0,88	0,89	0,89	0,85	0,84	0,88	0,87	0,88	0,84	0,84	0,82
Na	0,02	0,05	0,04	0,04	0,06	0,04	0,04	0,02	0,03	0,08	0,07	0,05	0,04	0,04	0,09	0,08	0,08
K	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	0,01	0,01	0,01	0,01	0,01	0,01

FeO^+ = total Fe as FeO

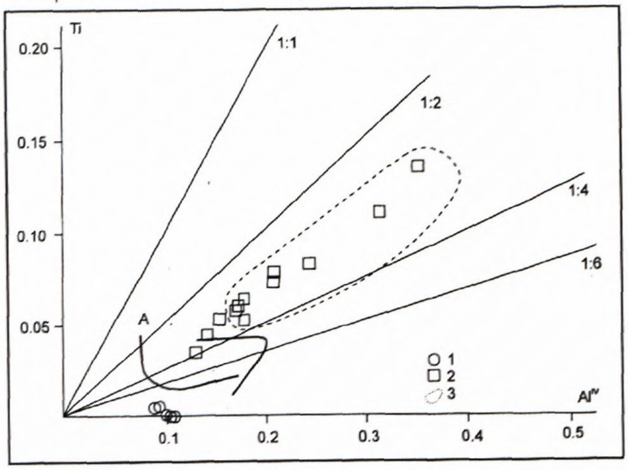


Fig. 5. Diagram Ti vs. Al^{IV} for clinopyroxenes with marked fields for: maximum Ti, Al contents in tholeiite basalts (T) and their minimum contents in alkali basalts (A) (fields according to Maruyama 1976, in: Takeda 1984); explanations as in figure 3.

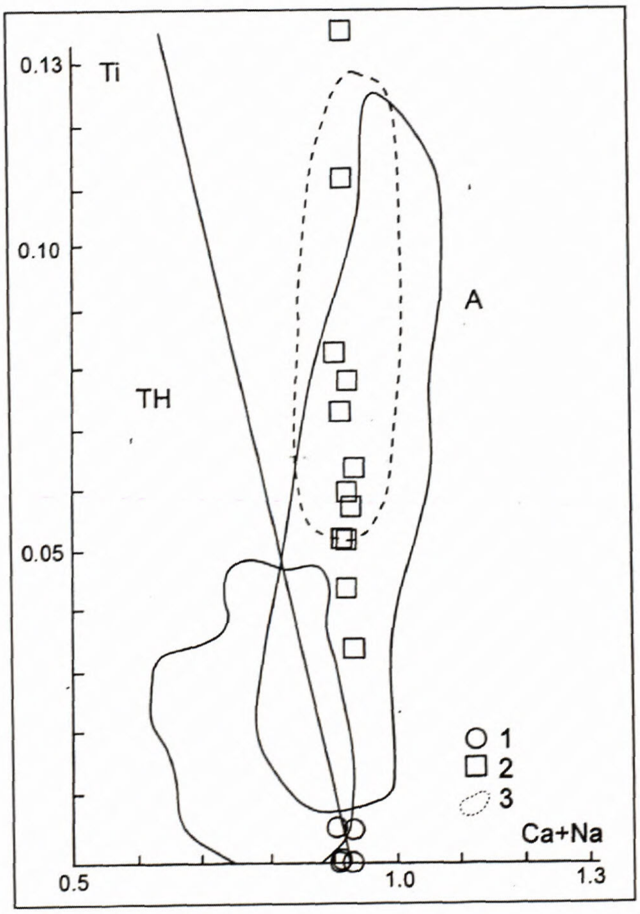


Fig. 6. Diagram Ti vs. Ca + Na for clinopyroxenes (according to Leterrier et al. 1982). A - field of clinopyroxenes from the alkali basalts, Th = field of clinopyroxenes from tholeiites and calc-alkaline basalts; explanations as in figure 3.

general mineral association, as well as according to the analogy with amphiboles from alkali basalts of the Krížna nappe, we are dealing with an amphibole of kaersutite type.

Fe-Al-Cr-spinel is a typical ore mineral of tobacco-brown colour. It has a sinus-like, skeleton and it is overall

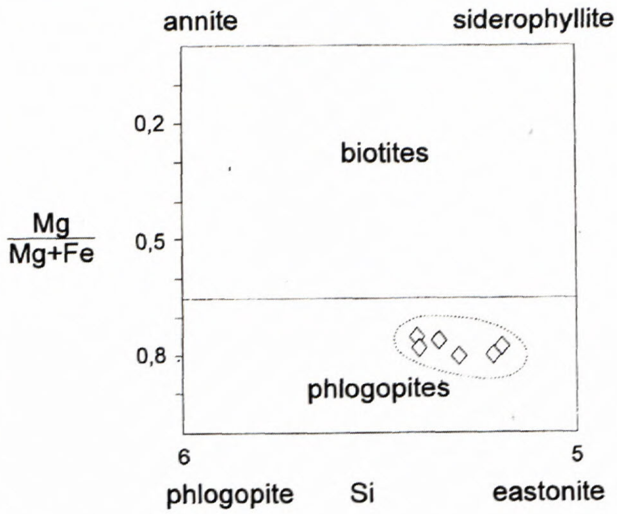


Fig. 7. Classification diagram of dark micas (according to Deer et al., 1962) from picrites from the Poniky area; analyses of micas from the table 2. Dashed field - phlogopite analyses from picrites of the Outer Western Carpathians (Kudělásková 1982)

very irregular confined. Most of the crystals of the spinel mineral group have at the margins tight rims formed by an opaque ore phase. It corresponds to Cr-spinel by its composition (Table. 2, Fig. 8).

The isometric ore grains are present in the form of poikilitic inclusions in clinopyroxenes of the I[st] generation also are, mostly - *magnetite* ± Ti-magnetite (Kevex). Furthermore, these minerals occur also separately closely associated with unaltered parts of olivines. The spaces between the mineral phases of the I. and II. generation are locally filled by brownish coloured, glassy groundmass (20 - 30 vol. %), in which locally the microspherulitic structure, irregular clusters of tiny ore minerals and clusters of *chlorite* leaves are evolved. Locally, in the glassy aggregate fine-foliacoeus, low-birefregent serpentine, probably lizardite, is present. The association *calcite, talk, pyrite, chlorite, limonite* is a product of various types of overprinted alterations.

Geochemistry

Despite the relatively high degree of alteration we studied also the chemical composition of picrites (Table 3). From the main elements, low concentrations of SiO_2, Al_2O_3 and relatively high contents of TiO_2, MgO and P_2O_5 are characteristic for the studied picrites. The high value of LOI is influenced by the strong alteration of rocks - predominantly by hydration. From the trace elements, high concentrations of Cr and Ni, i.e. elements typical of basic and ultrabasic rocks, are characteristic for picrites from the broader area of Banská Bystrica. For the geochemical evaluation we have used predominantly incompatible elements (mainly HFSE) and a group of rare earths elements. In the ternary Zr:Nb:Y diagram (Fig. 9) the picrites are located in the field of intra-plate alkali basalts (WPA). The identical position of the studied rocks

Table 2 Chemical composition of phlogopites and spinels

	phlogopites						spinels		
	1	2	3	4	5c	5r	1	2	3
SiO_2	36,32	37,17	35,30	37,16	37,96	37,60	0,09	0,00	0,00
TiO_2	4,49	3,89	6,38	4,89	3,99	4,88	0,00	0,14	0,00
Al_2O_3	16,17	16,23	16,36	16,02	16,48	16,32	52,52	50,06	52,09
Cr_2O_3	0,00	0,00	0,00	0,00	0,00	0,00	13,36	16,76	14,35
$Fe_2O_3^*$	0,00	0,00	0,00	0,00	0,00	0,00	3,37	3,25	4,10
FeO	10,29	10,98	9,26	9,49	9,71	9,76	11,20	11,51	10,80
MnO	0,00	0,00	0,00	0,00	0,09	0,12	0,00	0,00	0,00
MgO	18,39	18,59	18,24	19,01	21,83	22,13	18,99	18,74	19,37
CaO	0,00	0,15	0,00	0,10	0,02	0,11	0,00	0,00	0,00
Na_2O	0,00	0,00	0,00	0,00	1,11	1,23	0,00	0,00	0,00
K_2O	8,42	8,39	8,76	7,89	7,51	7,51	0,00	0,00	0,00
Suma	94,08	95,40	94,30	94,56	98,70	99,66	99,54	100,46	100,71
Formula based on 22 Oxygens									
Si^{IV}	5,35	5,41	5,19	5,40	5,30	5,21			
Al^{IV}	2,65	2,59	2,81	2,60	2,70	2,70	1,65	1,58	1,62
Al^{VI}	0,16	0,19	0,02	0,14	0,01	0,00			
Ti	0,50	0,43	0,71	0,53	0,42	0,51	0,00	0,00	0,00
Cr	0,00	0,00	0,00	0,00	0,00	0,00	0,28	0,35	0,30
Fe^{3+}	0,00	0,00	0,00	0,00	0,00	0,00	0,07	0,07	0,08
Fe^{2+}	1,27	1,34	1,14	1,15	1,13	1,16	0,25	0,26	0,24
Mn	0,00	0,00	0,00	0,00	0,00	0,00			
Mg	4,04	4,03	4,00	4,12	4,54	4,57	0,75	0,75	0,76
Ca	0,00	0,02	0,00	0,02	0,00	0,00			
Na	0,00	0,00	0,00	0,00	0,30	0,33			
K	1,58	1,56	1,64	1,46	1,33	1,32			

$Fe_2O_3^*$ - in the case of spinels the ferrous iron calculated based on structural formula
c = core of a grain, r = rim of a grain

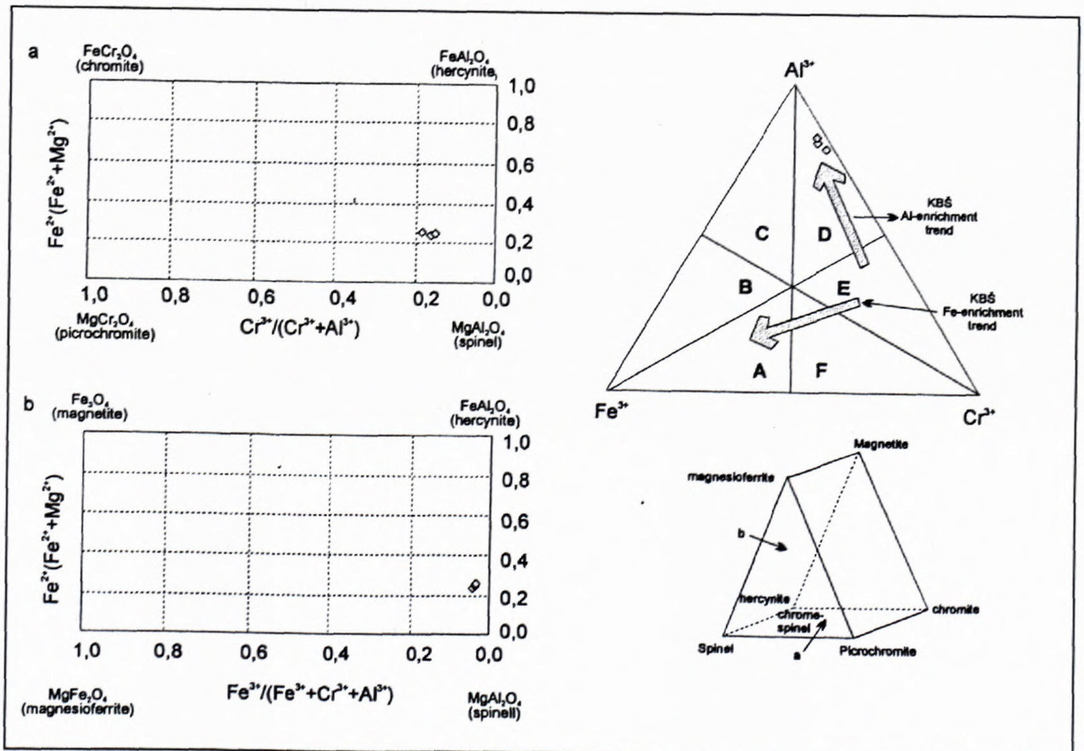


Fig. 8. Classification diagram of spinels (according to Stevens, 1944, Fe and Al - enrichment trend according to Henderson, 1975), analyses of spinels from table 2.

Table 3 Chemical composition of rocks

sample	HD-1	HD-2	KP-24	KP-24/1	KP-27	MV-81	SVP
SiO_2	34,29	29,76	34,06		38,12	37,3	41,01
TiO_2	2,45	0,28	1,34		2,02	1,74	0,48
Al_2O_3	16,22	9,4	5,72		7,57	6,24	8,35
Fe_2O_3	3,63	3,21	6,75		6,52	*9,65	5,93
FeO	6,08	2,31	3,93		4,04		9,5
MnO	0,1	0,03	0,12		0,19	0,14	0,18
MgO	11,1	13,87	22,26		16,94	22,83	23,25
CaO	9,07	10,9	9,05		10,65	5,92	2,61
Na_2O	0,7	0,09	0,41		0,96	0,26	0,01
K_2O	0,79	3,44	0,92		1,02	0,94	0,01
P_2O5	0,67	0,08	0,74		0,85	0,65	0,14
H_2O^-	1,06	0,83	3,07		1,86		0,51
H_2O^+	13,36	25,04	10,87		8,15	*13,5	7,53
Total	99,52	99,24	99,24		98,89	99,17	99,51
La			53,85	39,17		33	1,05
Ce			101,21	72,94		75	
Nd			46,02	32,63		29	
Sm			10,3	7,27			0,52
Eu			2,61	1,75			0,154
Gd			6,82	4,83			
Dy			4,64	3,19			
Er			2,03	1,41			
Yb			1,33	0,96			0,31
Lu			0,18	0,13			
Y			18,85	12,83		14	
Ba			455	303		383	
Co			110	114	117	81	113
Cu			48	39	27		
Nb			71	53		50	
Ni			873	1232	1040	690	1290
Sc			18	15	21		
Sr			562	291		285	
V			173	138		150	
Zn			135	124	117	110	
Zr			209	159	224	163	
B			21,4		24,5		
Cr			680		710		1380
Ga			14		10		
U						1	
Th						8	

Samples HD-1, HD-2 and MV-81 = Predný diel, samples: KP-24, KP24/1, KP-27 = Poniky, SVP - picrite from Strážny vrch (Iván 1991), * = total iron as Fe_2O_3

and Mesozoic alkali basalts/basanites of the Central Western Carpathians suggests their geochemical relationship (dashed field). Alkali rocks have very specific REE contents (high concentrations of light REE and low concentrations of heavy REE). For a better interpretation we compared the composition of the studied picrites to the composition of the alkali basalts of the ocean islands and to an average teshenite (Fig. 10). The studied rocks have very similar character of the normalised curve with characteristic sharp incline in direction to the heavy rare earths and with a nearly invisible Eu anomaly. The composition of picrite from the Strážny vrch (Gemerikum, Ivan 1991) is markedly different.

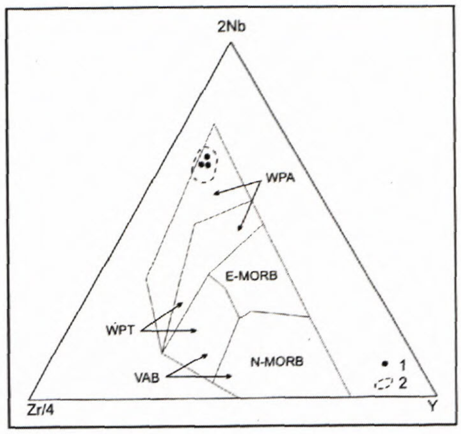


Fig. 9 Ternary diagram Zr:Nb:Y (according to Meschede, 1986) for various geotectonic types of basalts; 1 - analyses of the studied rocks from table 3, 2 - Mesozoic alkali basalts of the Central Western Carpathians (according to Hovorka-Spišiak 1988, Spišiak – Hovorka 1997, Hovorka et al. 1999).

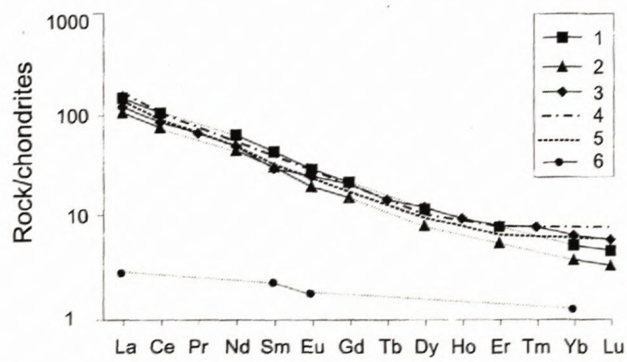


Fig. 10. Normalised curve of rare earths distribution in picrites from the Banská Bystrica area (1 - 3 analyses from the table 3). 4 = average composition of alkali basalts from the oceanic islands (OIB, Sun - McDonough 1989), 5 = average composition of teshenites (Rosi et. al. 1992), 6 = composition of picrites from the Strážny vrch (Iván 1991)

Discussion and Conclusions

– Picrites from the broader area of Banská Bystrica do not have equivalents among the basic volcanic rocks of the Mesozoic of the Western Carpathians. This results from their characteristic mineral composition, structures and chemical composition. Abundant olivine, present in the form of porphyric phenocrysts only, the presence of two Cpx generations, phlogopite and particularly the skeletal and sinus-like brown spinel are typical for these picrites.

– Despite the fact, that Hovorka and Slavkay (1966), based on the clasts of mainly volcanic glass in the overlying dolomites in the drill hole P-1, regarded the relationship of picrites and dolomites for a normal stratigraphic relationship, the discovery of picrites of identical composition also in the Krížna nappe from the study area (Slavkay, 1979) enabled new aspects of the problem to occur that in the time, when just picrite from the drill hole Po-1 was known, were not actual. Note, that picrites probably occur in two tectonic units of markedly allochtonous type. Those areas of sedimentation were separated from each other by tens to hundreds of kilometres. At the same time, there is a low likelihood of intrusions/effusions of nearly identical types of lavas into Mesozoic sedimentary sequences of the two basins. Thus there is a possibility to relate the penetration of picrite melts just after the moving of the Krížna and Choč nappes into their present-day position occurs, while their penetration was focused along the NS-oriented lineament - the Zázrivá-Revúca fault zone. Similar interpretation was already outlined by Hovorka (1976b) and Slavkay (1979) in their studies. Despite also taking into account the results of the study of Biely (1979) about the picrite occurrences area near Poniky (drill hole Po-1, Hovorka - Slavkay 1966), the insertion of dolomites with the associated picrites into the Choč nappe is not entirely clear. If the studied dolomites do not belong to the Choč nappe, but in the Krížna nappe, the above discussion would be not necessary. However, the existing data do not allow a definitive interpretation, therefore we do not regard this problem as entirely solved.

– Based on geochemical criteria the studied rocks from the broader area of Banská Bystrica belong to the alkali intra-plate basalts/basanites. Their composition is similar to the Mesozoic alkali basalts/basanites of the Central Western Carpathians and to the average teshenites.

– Picrites from the broader area of Banská Bystrica can be assigned to the province of the Mesozoic (Lower Cretaceous) alkali basalts/basanites.

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