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PETROLOGY OF THE WESTERN CARPATHIANS CRETACEOUS PRIMITIVE ALKALINE VOLCANICS

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Abstract: In several Mesozoic tectonic units (Silesian, Tatric and Fatric ones) of the Western Carpathians, different alkaline effusive and rarely also intrusive rocks of the Cretaceous age (approx. 100 Ma) are known. Olivines, clinopyroxenes and less frequently also amphiboles form phenocrysts, and glomerophyric accumulations of them occur in places. Fine-grained devitrified matrix (up to 40 vol. %) is another constant rock component. The nature of Cpx phenocrysts documents a rapid ascent of the melt which was contaminated by the resorption (mostly of carbonates) of xenoliths. The variable composition of these rocks is mainly a result of fractional crystallization and xenolith assimilation. According to their chemical composition these rocks correspond to alkaline basalts/basanites, locally even picrites. The presence of primitive alkaline volcanics is a consequence of extending volcanic activity in their respective units.

Key words: Western Carpathians, Cretaceous, primitive alkaline volcanics, petrology, geochemistry.

Introduction

The products of Mesozoic volcanic activities of various types occur in several tectonic units which are parts of the outer, central and inner tectonic zones of the Western Carpathians. They have calc-alkaline, tholeiitic and alkaline characters. Alkaline volcanics occur in the outer and central zones. Extending volcanism took place in a relatively short time-period in the Cretaceous. The main products of the volcanic activity are lava flows, dykes and mostly hyaloclastite flows and hyaloclatites. The thickness of individual volcanic bodies varies from several meters to tens of meters.

In this paper we deal with Cretaceous alkaline basalts, basanites and picrites. The geological position of the products of Mesozoic volcanic activity as well as their diversity in space and time, have already been described in detail (see Hovorka & Spišiak 1989, 1993). All the available analytical data (Mahmood 1973; Bujnovský et al. 1981; Hovorka & Spišiak 1988; Kudělásková 1982) have been used for geochemical interpretation.

Geology

In the Outer Western Carpathians the area of the Moravskosliezske Beskydy Mts. and the adjacent areas, both in the Czech Republic and Polish territories, are classical occurrences (Teschen/Těšín = type locality) of volcanics of the teschenite, or teschenite-picrite association (Hohenegger 1861; Tschermak 1866). The volcanic activity had a polystadial character; its maximum was in the Barremian-Albian (Table 1). The prevalence of shallow subsurface sills over effusives or their volcaniclastics, is the characteristic feature of the whole province. Volcanic activity was located in a longitudinal zone parallel to the axis of the Silesian nappe basin. There was no continuous (“line” type) penetration of magmatic melts on the bottom of the basin. Volcanic activity, however, had the character of mutually isolated fissure and sill penetrations of magma on the water-covered surface as well as of seamounts of alkaline basalt type.

Alkaline basalts/basanites occur in the cover Mesozoic units (in the Malé Karpaty Mts., the Tatry Mts. and the Nízke Tatry Mts.) as well as in a unit of nappe position (the Krížna Nappe). In all cases volcanic activity took place in the Aptian to Middle Albian. The majority of volcanics in the above mentioned units of the central zone have the character of hyaloclastites. In several cases volcanics occur in the form of dykes, in the Middle Triassic carbonates.

The alkaline basalts have sharp contacts with the host rocks. In some places only low-temperature mostly hydrothermal effects on the neighbouring rocks can be observed. Seismic effects due to volcanic activity on not yet consolidated sediments (Pl. I) have been described (Hovorka & Sýkora 1980).

Concluding the geological problems of the alkaline basalts of the Central Western Carpathian zone it should be stressed that the cover units on one side, and the Krížna Nappe on the other one, represent spatially clearly different tectonic units. Their alkaline basalts are more-or-less identical.

Besides alkaline basalt/basanites there are also picrites in the central zone. They are known from the area of Banská Bystrica as hidden bodies, found in boreholes. These picrites appear in two tectonic units — the Krížna and Choč nappes — we suppose the emplacement of the picrites after the settlement (Upper Cretaceous) of these geological units in their present position.

Table 1: Survey of the Western Carpathian Mesozoic volcanic activity.

	OUTER WESTERN CARPATHIANS	CENTRAL WESTERN CARPATHIANS		
Tectonic Unit	Silezic Unit	Tatric "envelope" Units	Križna Nappe	Choč Nappe
Association	Teschenite-Picrite Association	Alk. Basalts	Alk. Basalts Picrites	Picrites
Age	Berriasian-Aptian	Berriasian-Aptian	Valanginian-Albian	volcanics within the Mesozoic sequences
Magma Series	Alk	Alk	Alk	Alk(?)
Volcanic Products	Sills, Lava Flows, Hyaloclastites	Sills, Hyaloclastites, Lava Flows		Sills(?)
Geotectonic Position	WP	WP	WP	WP(?)
Lithostratigraphic Unit		Vývrať M. Mlynná Dolina Valley AB; Kamenný Žľab M.	Sasková AB; Beckov Castle; Hyaloclastites; Košeca M.; Jedľovina M.; Nolčovo M.; Zemianska Dolina Valley M.; Horný Diel Picrites	Stráže Picrites

M - members, AB - Alk. Basalts

Petrology and mineralogy

The alkaline basalts/basanites of the outer as well as the central zones occur in the form of massive lava flows, volcanic (chimney) breccias and hyaloclastites. Olivines, pyroxenes and less frequently amphiboles form phenocrysts; locally glomerophyric accumulations of these phases are present. Most lava flows have a fine-grained devitrified matrix, forming as much as 40 per cent of the rock.

The picrites have pronouncedly phyric (Ol, Phl) fabrics. Their matrix is fine-grained passing gradually to the originally glassy fabric. Generally a fresh appearance of picrites in thin sections is characteristic.

There are common amygdaloidal types with amygdales filled up with carbonates, chlorites and zeolites. Apart from amygdales, there are varying amounts of assimilated xenoliths (especially of carbonate rocks). For petrological and geochemical interpretations we have chosen rock types not affected by assimilation and metasomatism, i.e. without amygdales and xenoliths (all the analysed samples have been microscopically checked).

Olivines in phyric form are present especially in picrites and basanites (more magnesian). They are strongly altered and in most cases only olivine pseudomorphs have been preserved; they are filled up with serpentine-group minerals, chlorite and saponite. In the olivines there are rare Cr-spinel enclosures (they mostly occur in picrites). $Mg/Mg+Fe^{2+}$ ratio in the olivine varies in a narrow range from 0.86 to 0.87, which corresponds to the olivines from equivalent rocks (Dobosi 1987; Bédard et al. 1988; Trommsdorff et al. 1990).

Clinopyroxenes are quantitatively the most abundant and genetically the most significant minerals in all rock types. Beside phenocrysts of variable shape and size they also form microlites in devitrified matrix. Phenocryst forming clinopyroxenes are characteristic for sector and oscillatory zoning. Sector zoning (hourglass structure) is expressed through two very different sectors: pyramidal and prismatic. They differ optically (the pyramidal one has a higher birefringence and a lower refraction index) and chemically (Table 2). Pyramidal sectors (011, 111) are rich in Mg, Si and depleted in Fe, Al, Ti, as opposed to prismatic sectors (100, 110). Genetically, sector zoning is related to different speed of the growth of individual crystal planes and to partial balance between the crystal surface and the melt (Hollister & Gancarz 1971; Leung 1974; Nakamura 1974). Oscillatory zoning is common. Rims enriched in Ti, Al^{IV} and Fe and depleted in Mg, Al^{VI} are abundant. Sometimes there are Fe-enriched rims around Ti-augite crystals (Fe-augite, Mahmood 1973). The composition of Cpx microlites corresponds to that of phenocrysts rims. Following Cpx classification (IMA**;** Morimoto et al. 1988) these Cpx correspond to diopside (Fig. 1); the differences in composition are expressed by appropriate different adjectives (titanian, aluminian, calcian, ferroan, etc.). According to Poldervaart & Hess (1951) most clinopyroxenes correspond to salite. Cpx from picrites have lower Ca and/or higher Fe

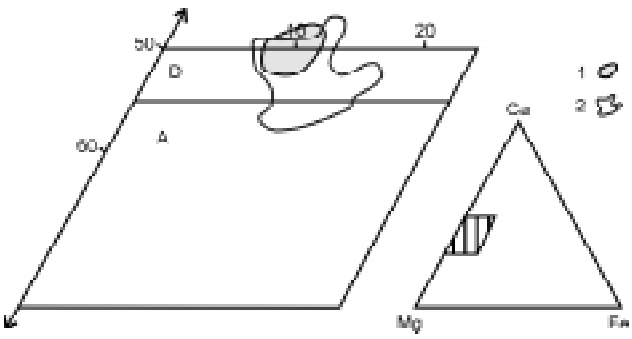


Fig. 1. Classification diagrams of clinopyroxenes (Morimoto et al. 1988). 1 — analyses of clinopyroxenes from basanites, Outer Western Carpathians, 2 — analyses of clinopyroxenes from basanites and picrites, Central Western Carpathians; A — augite, D — diopside.

Table 2: Selected analyses of clinopyroxene.

SAMPLE	1Pr	2Pr	3c	3r	4m	5m	6r	6c	7c	7r	8r	8c	9Pr	9Py
rock	P	P	F	F	B	B	B	B	B	B	B	B	B	B
SiO_2	39.84	40.80	46.68	41.43	46.77	46.68	41.67	43.98	45.29	41.95	45.90	49.15	42.72	46.35
TiO_2	5.01	4.31	2.49	5.39	2.84	2.71	5.45	4.31	2.85	4.00	3.22	1.94	5.50	3.63
Al_2O_3	10.39	9.81	5.87	10.09	5.17	4.98	9.95	9.25	6.46	8.99	6.57	4.70	11.51	7.65
Cr_2O_3	0.00	0.00	0.00	0.00	0.00	0.03	0.04	0.05	0.65	0.41	0.00	0.00	0.00	0.00
FeO*	7.52	7.75	6.17	7.35	7.31	7.25	7.77	7.28	5.87	7.20	7.77	5.98	10.91	8.73
MnO	0.16	0.15	0.11	0.14	0.07	0.10	0.06	0.09	0.05	0.10	0.18	0.08	0.22	0.15
MgO	12.32	12.54	13.14	11.34	13.48	13.52	11.60	12.65	14.20	13.13	13.19	14.66	8.80	12.95
CaO	23.97	23.81	24.44	24.16	22.17	22.00	23.01	23.13	24.14	21.87	22.64	22.59	19.11	19.10
Na_2O	0.57	0.59	0.45	0.57	0.42	0.40	0.46	0.46	0.45	0.49	0.46	0.47	0.60	0.51
K_2O	0.21	0.22	0.34	0.34	0.00	0.01	0.00	0.00	0.00	0.09	0.00	0.00	0.05	0.30
TOTAL	99.99	99.98	99.69	100.81	98.23	97.68	100.01	101.20	99.96	98.23	99.93	99.57	99.42	99.37
Formula based on 6 oxygens														
Si	1.53	1.56	1.76	1.57	1.78	1.79	1.58	1.64	1.70	1.61	1.73	1.83	1.63	1.74
Al^{IV}	0.47	0.44	0.24	0.43	0.22	0.21	0.42	0.36	0.29	0.39	0.27	0.17	0.37	0.26
Al^{VI}	0.00	0.00	0.02	0.02	0.02	0.01	0.03	0.04	0.00	0.02	0.02	0.04	0.14	0.08
Ti	0.14	0.12	0.07	0.15	0.08	0.08	0.16	0.12	0.08	0.12	0.09	0.05	0.16	0.10
Cr	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.00	0.00	0.00
Fe^{3+}	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
Fe^{2+}	0.24	0.25	0.19	0.23	0.23	0.23	0.25	0.23	0.18	0.23	0.24	0.19	0.35	0.27
Mn	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.00
Mg	0.70	0.71	0.74	0.64	0.77	0.77	0.66	0.70	0.80	0.75	0.74	0.81	0.50	0.73
Ca	0.98	0.98	0.99	0.98	0.91	0.90	0.94	0.92	0.97	0.90	0.91	0.90	0.78	0.77
Na	0.04	0.04	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.04	0.03	0.03	0.04	0.04
K	0.01	0.01	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01

FeO* - total Fe as FeO, Pr -prismatic sector, Py - pyramidal sector, c - core, r - rim, m - microlites, P -pyroxenites, F - fourchites, B - basanites, l-3 - Outer Western Carpathians, 4-9 - Central Western Carpathians. Data sources: Kudělásková l982, Hovorka & Spišiak et al. 1991, original analyses.

and Mg content. There is a good correlation between Al, or Al^{IV} and Ti. Pyroxene phenocrysts from the studied basanite samples plot in both the "igneous clinopyroxene" and "inclusion in basalts" fields of the Al^{VI} versus Al^{IV} diagram (Aoki & Shiba 1973, Fig. 2). Cpx zoning (rimward enrichment in Al^{IV}, Ti and Fe and Mg and Al^{VI} depletion) may be explained in three ways (Bédard et al. l988): (1) it represents a kinetic effect, (2) it reflects a differentiation of the melt as it cools and crystallizes, or (3) it reflects changes in pressure during crystallization. With regard to all possibilities and presented data (zoning character, Cpx composition, rock composition, etc.) we suppose that the dominant process of the Cpx generation were polybaric conditions and fractional crystallization (Fig. 3). Rimward Ti-Al^{IV} enrichment is a result of polybaric crystallization during the ascent of the magma. As pointed out by Wass (l979) data on solubility of Ti in Cpx in dependence on pressure and temperature are often controversial. A relation between Ti + Al^{IV}: Si ratio and pressure has been found, but fractionation trends can strongly influence the ratio. The ratio of Al^{IV} : Al^{VI} in Cpx seems to be the most suit-

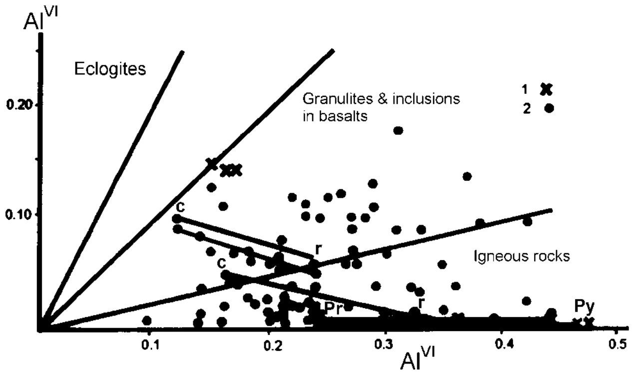
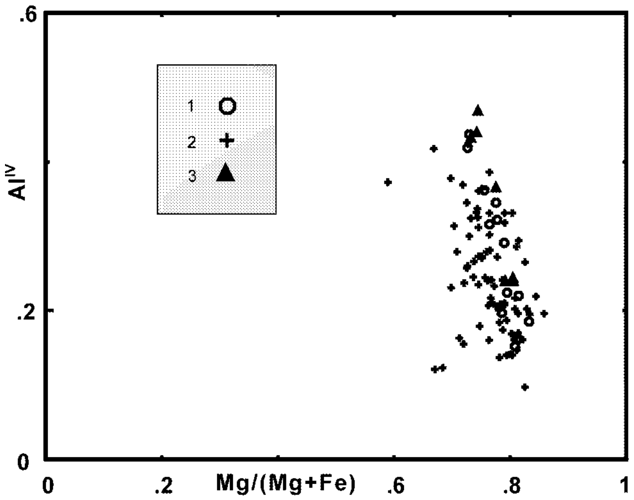


Fig. 2. Al^{VI} vs. Al^{IV} in pyroxenes. Field of "Eclogites", "Granulites & inclusions in basalts" and "Igneous rocks" are from Aoki & Shiba (1973). 1 — analyses of clinopyroxenes from basanites, Outer Western Carpathians, 2 — analyses of clinopyroxenes from basanites and picrites, Central Western Carpathians; c — core, r — rim. (Data sources: Hovorka & Spišiak 1988; Spišiak et al. 1991; unpublished data). Py — pyramidal sector, Pr — prismatic sector.



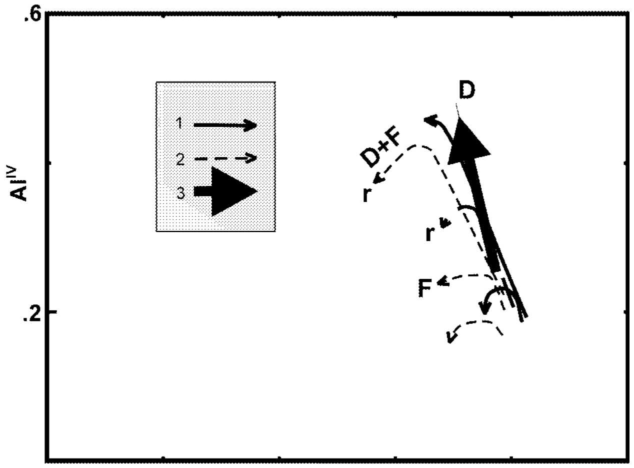


Fig. 3. Al^{IV} vs. Mg/(Mg + Fe) in pyroxenes from Western Carpathians Cretaceous alkali basalts/basanites. 1 — Cpx from basanites, Outer Western Carpathians, 2 — Cpx from basanites and picrites, 3 — Cpx from thin basanite dykes, 2, 3 — Central Western Carpathians, r — rims; D — decompression, F — fractionation. (Data sources: Hovorka & Spišiak 1988; Spišiak et al. 1991, unpublished data).

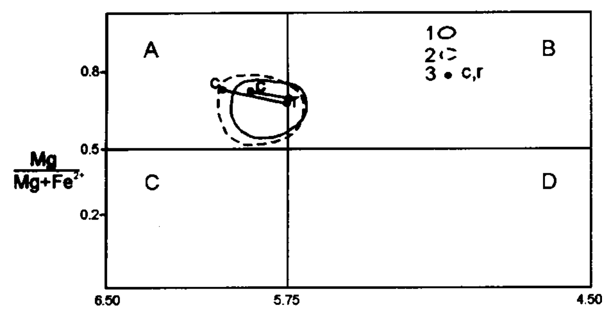


Fig. 4. Classification diagram of amphiboles (Amph; IMA, Leake 1978). 1 — Amph from basanites, Outer Western Carpathians, 2 — Amph from basanites, Central Western Carpathians, 3 — selected analyses, c — core, r — rim.

able indicator of relative pressure (Thompson 1974; Wass 1979). Following the Cpx composition in the Cretaceous alkaline basalts/basanites of the Western Carpathians we can summarize:

— the ratio of Al^{IV} : Al^{VI} in Cpx cores is close to 1, which indicates their crystallization originating under high pressures and high temperatures (ca. 20 kbar, 1300 °C);

— Cpx rims (with a high Al^{IV} : Al^{VI} ratio) crystallized under much lower pressures, i.e. during the ascent of the melt;

— the ratio of Al^{IV} : Al^{VI} in the matrix microlites is similar to that of phenocryst rims (the microlites crystallized during the magma ascent).

The preceding findings are also proved by the composition and the character of Cpx zoning in individual rock types. In the case of rock bodies of great thickness, or well-crystallized bodies, mineral zoning is insignificant and the Al^{IV}: Al^{VI} ratio low, close to 1. In thin dykes, Cpx zoning is well expressed, and the ratio (Al^{IV}: Al^{VI}) is high. On the basis of the position of the analyzed Cpx in various discriminant diagrams (Le Bas 1962; Leterrier et al. 1982) they have the character of the Cpx of the alkaline (peralkaline) rock types.

Amphiboles. A number of amphiboles vary in different rock types, and/or depend on their evolution. The highest modal contents are in thin basanite dykes. Similar to Cpx, amphibole forms phenocrysts (usually smaller than Cpx) with observable zoning. Apart from rare sector zoning there is typical oscillatory zoning with increasing Ti, Al and Fe, and decreasing Si and Mg rimwards. The other elements do not show significant changes (K-depletion of the rims), or there is no zoning. Zoning in Cpx and Hbl is identical. The identical Hbl zoning has been described in similar alkaline rock types (Mokhtari & Velde 1987). Locally amphibole replacement of Cpx can be observed. The amphiboles under study have high Ti and low Si contents. In the IMA amphibole classification (Fig. 4, Leake 1978) they correspond to kaersutite, or subsilicic kaersutite. The composition of amphibole rims, or microlites, along with their occurrences (replacement of Cpx, concentrated occurrences in the spaces of resorbed xenoliths) point out their origin from the melt having been affected by xenolith assimilation (especially carbonatic rock).

Dark micas (flakes smaller than 1 cm) mostly occur in picrites - here their composition corresponds to phlogopites, and in thin basanite dykes, where they form tiny flakes of Ti-biotite. In dark micas, too, there is zoning with increasing Ti and Mg, and decreasing Fe and K from core to rim. The specific composition of the discussed micas reflects the compositions of the parental melt (high Ti, Mg, etc. contents).

In the matrix of primitive alkaline volcanics studied here, there are also other minerals according to the rock type namely: nepheline, analcime, plagioclase, leucite, ore minerals, spinel and others.

Geochemistry

Although the Cretaceous alkaline rocks of the central West-Carpathian zone show considerably different modal compositions, their chemical compositions are similar (Ta-

Table 3: Chemical composition of representative rocks types.

SAMPLE	1	2	3	4	5	6	7	8	9	10	11	12
Rock	P	T	F	F	B	B	B	B	B	B	B	B
SiO_2	39.12	39.54	38.80	38.90	42.55	39.72	40.36	37.51	38.96	38.97	39.35	36.82
TiO_2	1.6	2.3	2.49	1.5	3.46	2.84	3.47	2.8	3.4	3.38	2.89	2.58
Al_2O_3	11.99	14.16	13.27	12.48	12.83	13.19	13.32	10.88	12.61	12.57	14.08	9.81
Fe_2O_3	5.52	6.32	8.06	6.3	13.47*	10.77*	12..26*	10.83*	6.46	6.07	11.46*	1.97
FeO	5.57	4.55	5.53	4.16					7.22	7.43		8.66
MnO	0.13	0.01	0	0.05	0.13	0.11	0.17	0.14	0.2	0.19	0.17	0.15
MgO	16.55	6.13	6.53	12.55	7.99	9.75	7.45	8.28	7.71	7.97	5.77	8.57
CaO	14.13	13.36	16.87	15	11.49	10.66	10.49	13.92	8.41	8.63	11.82	15.01
Na_2O	1.4	3.29	3.02	1.76	3.21	1.46	2.59	2.66	2.17	2	2.1	2.64
K_2O	0.8	1.77	0.65	0.68	0.17	1.56	2.26	0.76	2.41	2.54	4.05	0.75
P_2O_5	0.45	1.54	0.62	1	1.12	0.58	0.99	0.78	0.097	0.99	1.02	0.76
LOI	2.65	7.58	3.19	5.71	4.1	9.2	5.5	11.5	9.76	9.47	6.7	13.3
TOTAL	99.91	100..55	99.03	100.09	100.52	99.95	98.86	100.06	99.407	100.21	99.41	101.02
Cr	460	3	4	320	193	343	180	316	106	177	57	288
Co	42	10	5		44	71	40	39	41	44	33	30
Ni	300	35	70	110	133	155	91	185	66	70	40	170
V	28	300	280	520	255	263	296	225	147	159	245	101
La	50		98	82	83	44	74	59	62.8	77.2	65	30
Ce	102		235	160	160	117	144	109	131	160.5	141	78
Nd	43		135	78	60	36	65	45	68.2	76.3	59	
Sm	7.3		22	13	9.2	5.4			11.8	14		5.6
Eu	2.6		7	4.4	3.2	2.5			3.9	4.9		2.5
Gd	12		20.6	10.6					10.2	12.5		
Tb	0.92		2.9	1.58	2.4	0.92						1.2
Ho	0.95		2.8	2.1					1.22			
Yb	2.2		3.8	0.35	2.7	2			2.07	3.17		1.9
Lu	0.31		1.3		0.32				0.28	0.4		0.22

* - total Fe as Fe_2O_3, P - picrites, T - teschenites, F - fourchites, B - basanites, 1-4 - Outer Western Carpathians, 5-12 - Central Western Carpathians. Data Sources: Kudělásková 1982, Hovorka & Spišiak 1988, Spišiak et al.1991, original analyses.

ble 3). In the Outer Western Carpathians there is a wider range of rock types (from picrites to syenites); in the Central Western Carpathians rock composition generally corresponds to basanites. In the TAS diagram the volcanics are concentrated in the field of basanites, and/or picrobasalts (Hovorka & Spišiak 1988). Following a more detailed classification of alkaline rocks (Le Bas 1989, Fig. 5; Rock 1987, Fig. 6) they correspond to basanites - melanephelinites, and/or alkaline lamprophyres. In general, the rocks have low SiO_2 (ca. 41 %) and high TiO_2 and P_2O_5 contents (3.2 and 0.8 % respectively). Characteristic features of these rocks are: elevated Cr (280 ppm) and Ni (190 ppm) contents; elevated contents of incompatible elements such as Ba (650 ppm), Sr (700 ppm) and LREE; also high Nb (78 ppm), V (245 ppm) and Zr (305 ppm) are detected. On the other hand, the contents of Y (24 ppm) and HREE are relatively low (all data in Hovorka & Spišiak 1988, Nb = unpublished data). Different discrimination diagrams (Pearce & Cann 1973; Mullen 1983; Meschede 1986 etc.) assign these rocks to alkaline basalts (WPA, OIA; Hovorka & Spišiak 1993). The standardized REE pattern (Fig. 7) shows a slight positive Eu anomaly. The REE contents and their normalized patterns are equal in similar alkaline rocks in Europe (Wedepohl 1985; Mertes & Schmincke 1985; Trommsdorff et al. 1990).

Several authors (e.g. Frey et al. 1978) calculated mantle sources for various basanite and nephelinite types on the basis of REE abundances. They conclude that a single source (lherzolite pyrolite) modal composition can yield the observed REE contents by 4–7 % melting provided that the source region was already relatively enriched in LREE prior to the partial melting event. Their findings are also proved by data on the abundances of other trace elements and at the same time support the assumption on similar mantle sources and similar melting characteristics for the alkaline rocks studied.

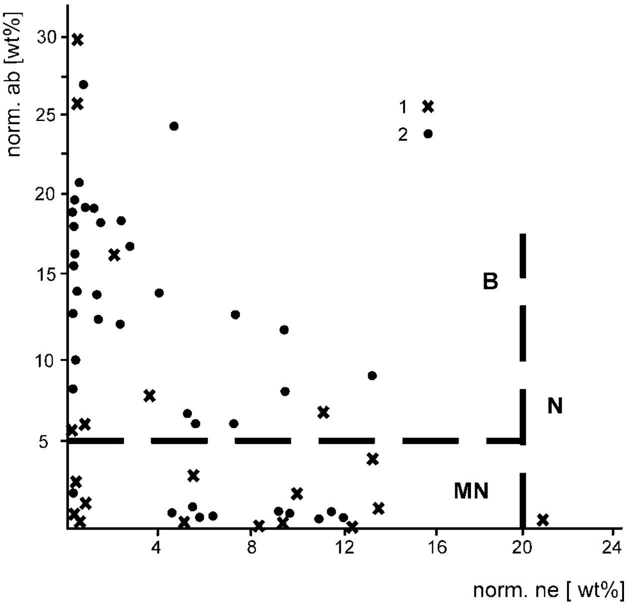


Fig. 5. CIPW normative *ne* vs. *ab* plot of the nephelinitic rocks and basanites (Le Bas 1989). 1 — basanites from Outer Western Carpathians, 2 — basanites from central Western Carpathians, B — basanites, MN — melanephelinites, N — nephelinites.

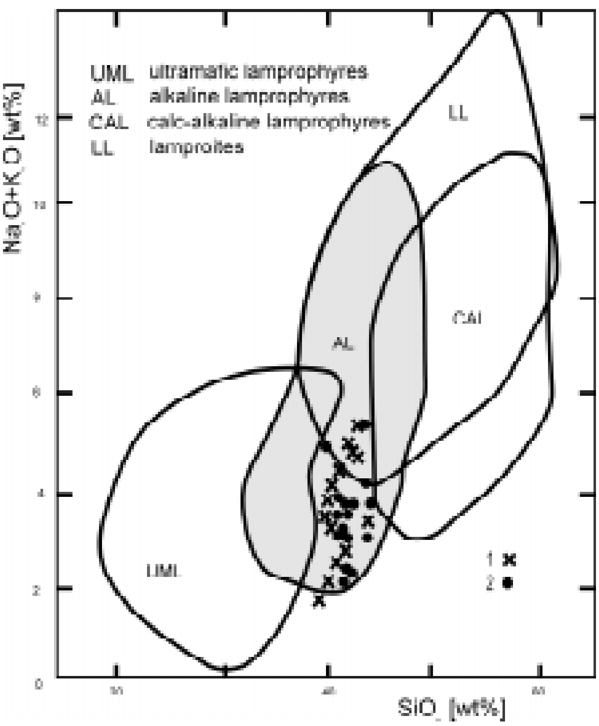


Fig. 6. (K_2O+Na_2O) vs. SiO_2 plot of the lampropyres. Field of lamprophyres according to Rock (1987). 1 — basanites from Outer Western Carpathians, 2 — basanites from Central Western Carpathians.

Experiments with basanite-like melts (Green 1973; Ulmer et al. 1989 in Trommsdorff et al. 1990) determined a rather narrow temperature and pressure ranges of their generation

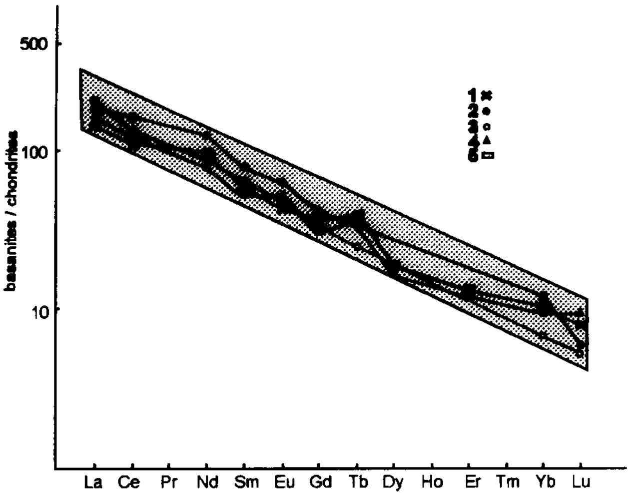


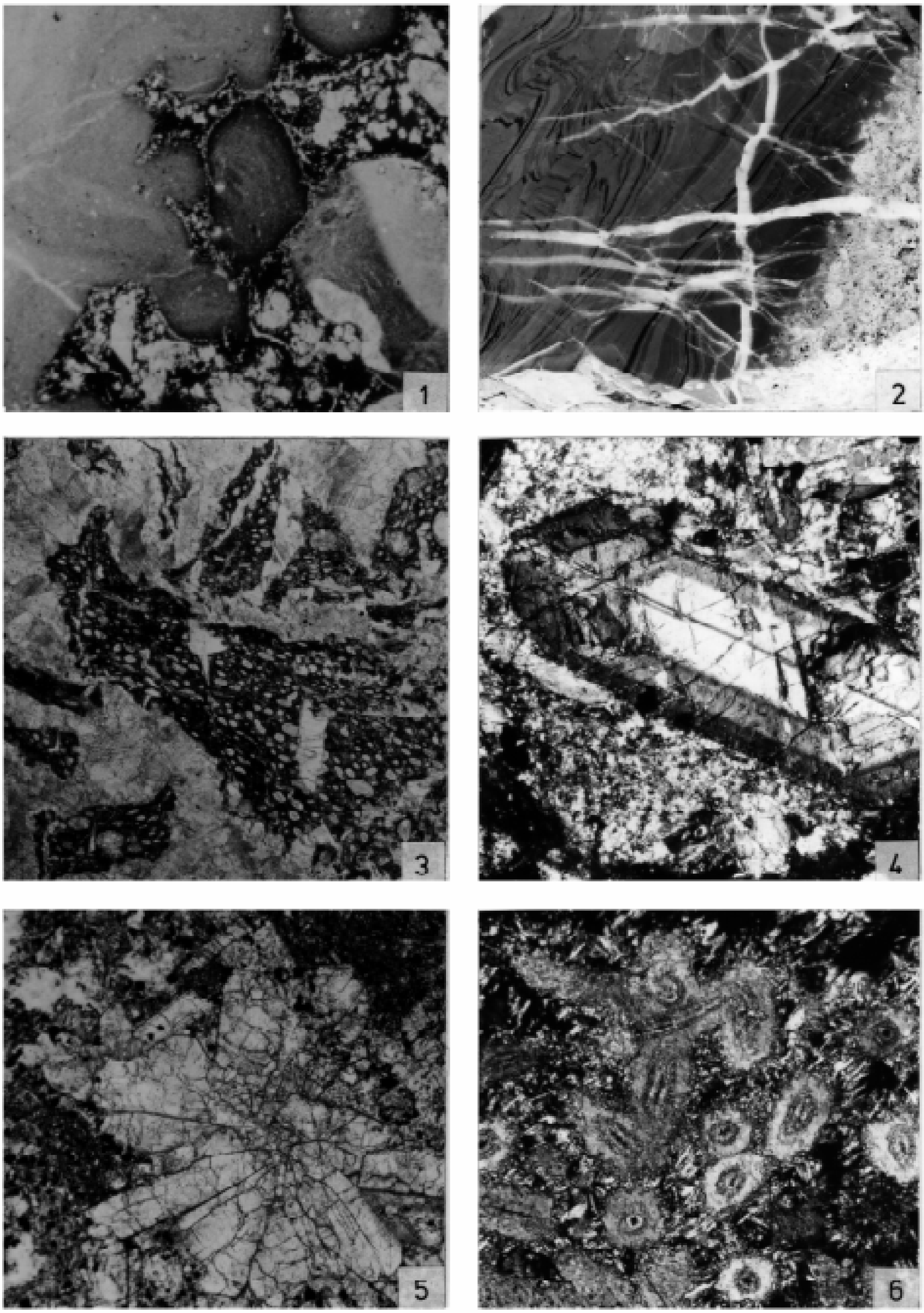
Fig. 7. REE pattern of the Western Carpathians alkali basanites/basalts normalized to chondrites (Haskin et al. 1968). 1 — basanites from Central Western Carpathians, 2 — basanites from Outer Western Carpathians, 3 — basanites (Ehrwaldite) from Northern Calcareous Alps (Trommsdorff et al. 1990), 4 — Average composition of the alkali basalts (Wedepohl 1975), 5 — composition of the basanites in Neogene European rift systems (Chauvel-Jahn 1984; Wedepohl 1985).

(25–30 kbar, 1200–1300 °C). The composition and zoning of Cpx in the Cretaceous alkaline rocks of the Western Carpathians document similar conditions of the generation (approx. 23 kbar and approx. 1260 °C). A very low magma viscosity and suitable geotectonic conditions caused a rapid ascent of the melt and its further evolution.

The contents of the main and trace elements, including REE in the rocks under consideration, are specific and have no equivalent among the West-Carpathian volcanics. Their compositions, however, correspond very well to the compositions of the Mesozoic alkaline rocks of the Northern Calcareous Alps (Trommsdorff et al. 1990), and/or some Mesozoic alkaline rocks in Hungary (Bükk Mts., Mecsek Mts., Velence Mts., Buda Hills: Dobosi 1986; Dobosi & Horváth 1988).

As it was presented before, for geochemical interpretations we have chosen rock types without amygdales and xenoliths. The problem of composition of these rocks (especially low

Plate I. Fig. 1. Intimate contact of limy mud (aphanitic) with basaltic lava. The Veľká Fatra Mts. — Biely potok brook (Hovorka & Sýkora 1979). Enlarg. 27×. **Fig. 2.** Plastic deformation of unconsolidated limy mud by moving basaltic lava — filling of epigenic cracks by calcite. The Veľká Fatra Mts. — Biely potok brook (Hovorka & Sýkora 1979). Enlarg. 1.4×. **Fig. 3.** Hyaloclasts of alkali basalt in limestone. The Strážovské vrchy Mts. — Soblahov. Enlarg. 48×, || polars. **Fig. 4.** Compositionally zonal phenocryst of clinopyroxene in alkali basalt. The Nízke Tatry Mts. — Salatin. Enlarg. 95×, || polars. **Fig. 5.** Glomerophyric clinopyroxenes I with clinopyroxenes II on the rim of alkali basalt. The Strážovské vrchy Upland — brook near Mraznica. Enlarg. 30×/polars. **Fig. 6.** Xenolith (1 cm^3) of organodetritic limestone (Lassic ?) in alkali basalt. The Nízke Tatry Mts. — Ďumbier. Enlarg. 180×.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SiO_2 contents) has not been definitely solved yet. In the rocks (mainly dykes) there is often a high amount of differently resorbed crustal xenoliths (size usually 0.5 to 10 mm, Hovorka et al. 1982; Hovorka & Spišiak 1988; Spišiak et al. 1991). Carbonate rock xenoliths (some of them with fossil remnants) are most frequent. They are assimilated to various degrees and in the space of the original xenoliths originate kaersutites, in a few cases also Cpx, the compositions of which correspond to phenocryst rims (in this case Cpx and Hbl are only slightly zonal or even unzonal). The space of assimilated carbonate xenoliths show a lack of ore minerals that are abundant in the host matrix. Xenoliths of quartz-bearing rocks are rare. Beside xenoliths, blaebs of immiscible melt are likely to be contained in these rocks.

Considering the Cpx and rock composition and comparing them with their respective equivalents we suppose that the assimilation processes took part after the crystallization of Ol and Cpx phenocrysts, during the ascent of magma onto the (Earth's) surface. As the ascent was rapid, due to a low magma viscosity and extensional conditions, there were no considerable (except for SiO_2 contents) changes in chemical composition.

Conclusion

On the basis of the fabric and composition of rock-forming minerals (especially those of Ol, Cpx and Hbl) we could suppose their origin as follows:

— olivines most probably represent high-pressure phenocrysts;

— the central parts of phenocrysts, especially those of Cpx, crystallized under high pressure conditions as products of fractional crystallization;

— rims of Cpx and Hbl phenocrysts (but also partly dark micas) crystallized under substantially lower pressure during magma ascent. Under just the same conditions microliths in the matrix and Cpx and Hbl in the space of resorbed xenoliths also crystallized;

— the rims of Cpx and Hbl phenocrysts (partly also mafic micas) originated under a considerable pressure drop during the ascent of the melt. The same conditions were applied during crystallization of microliths in the matrix and Cpx and Hbl in resorbed parts of xenoliths;

— the composition and zoning of Cpx in the Cretaceous alkaline rocks of the Outer and Central Western Carpathians document the similar conditions of their generation (approx. 23 kbar and approx. 1260 °C, according Al^{IV}:Al^{VI} ratio). A very low magma viscosity and suitable geotectonic conditions caused a rapid ascent of the melt and its further development;

— the nature of Cpx phenocrysts documents a rapid ascent of the melt which was contamined by a resorption of xenoliths (mostly of neighbouring carbonatic rocks);

— the rocks are similar to Mesozoic alkaline rocks in the Northern Calcareous Alps and Cretaceous volcanics in the Mecsek Mts. Hungary in composition, occurrence and age;

— the occurrences of these rocks are conditioned by an extensional tectonic regime (embryonal rifting) in their respective units (Silesian, Tatric and Fatric units). The character of magmatism as well as its coincidence in the other parts of the Alpine - Carpathian region prove an extensional tectonic setting (rifting) in the whole mountain chain (Alpine — Carpathian segment of the Tethys).

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