

MESOZOIC ALKALI BASALTS/LAMPROPHYRES FROM THE WESTERN CARPATHIANS

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Abstract: The products of intraplate-alkali Mesozoic (Cretaceous) volcanic processes are known from External and Central Western Carpathians (WC). Mineral composition of Cretaceous alkali volcanics in the External and Central Western Carpathians are similar. The main phases here are olivines (FO_{85-87}), clinopyroxenes (diopside), amphiboles, (kaersutite), dark micas (phlogopite, Ti-rich biotite), less frequent feldspars and analcime. Cretaceous volcanics of the External Western Carpathians have a geochemical pattern close to intraplate alkali rocks. Based on alkali character of volcanics we suppose that it was in close connection to rifting processes.

Key words: mineralogy, petrology, alkali basalts/lamprophyres, rifting, Cretaceous, Western Carpathians

Introduction

Evidence of volcanic activity during the Mesozoic can be found in all the main West Carpathians geotectonics zones. Using the division of the Western Carpathians into three main units (Plašienka 1999): External, Central, Internal – each unit is characterized by a particular type of volcanic activity at various time. In the External Western Carpathians (teschinite-picrite association), the volcanites are more differentiated (from picrites to syenites), while mostly only basanite-type rocks (rarely picrites) or their volcanoclastics are found in the Central Western Carpathians. In the Internal Western Carpathians, rocks of this type (alkaline basanites) do not occur in the Mesozoic. Here they are tholeiitic basalt (MORB) Triassic volcanites of the Jaklovce development of the Meliata group.

Geology

In the External Western Carpathians Mesozoic volcanic are related in space to the upper part of the Tešín-Hradište Formation. This is a classic area of occurrence of the teschenite or teschenite-picrite association. It is supposed that the volcanic activity took place in several stages, and culminated in the Barremian to Albian. New geochronological data point to the age K/Ar approx. 110 Ma (Grabovský - unpublished data) or $^{40}\text{Ar}/^{39}\text{Ar}$ 122 Ma (Lucinska-Anczkiewicz et al. 2002). A characteristic feature of the whole association is the predominance of shallow subsurface sills and veins over effusive or volcanoclastic rocks. The volcanic activity reached its maximum in the upper Tešín Beds, and in sandstones through conglomerates of the Hradište type. The products of the volcanic activity are various types of intrusive, effusive and extrusive rocks (picrites, basanites, teschenites and monchiquites).

In the Central Western Carpathians, primitive Mesozoic alkaline volcanism is known from the Tatric (envelope) units, the Krížna and Choč Nappes (the occurrence of picrite at Poniky). Prevailing volcanic activity are situated in the Krížna nappe. The Krížna nappe represents the most typical Mesozoic tectonic unit of the Western Carpathians. The Krížna nappe rock sequences with volcanics are known from following mountain chains: the Malé Karpaty Mts., the Považský Inovec Mts., the Strážovská hornatina Upland, the Malá Fatra Mts., the Veľká Fatra Mts. and the Nízke Tatry Mts. The lithological character of the Triassic sedimentary members of the above mentioned tectonic unit is more or less uniform, whilst during the Jurassic-Lower Cretaceous period a wide range of sedimentation condition was established. Volcanic activity within the depositional basin took place in the Barremian-Albian within so-called "Zliechov development". Besides these, penetrations of basanite dikes into granitoid rocks have been also reported (Hovorka et al. 1982, Spišiak et al. 1991, Spišiak and Balogh, in press.). On the basis of stratigraphic data the age of volcanics under consideration is Barremian – Aptian, which is proved also by geochronological data (102 Ma, Spišiak and Balogh 2002). The products of the volcanic activity are low-differentiated rocks of basalt/basanite type, very rarely picrites; volcanoclastic rocks are represented in substantial amounts (hyaloclastites etc.).

Petrology and geochemistry

Mineral composition of Cretaceous alkali volcanics in the External and Central Western Carpathians are similar. In the External WC the main phases here are olivines (Fo_{85-87}), clinopyroxenes (based on the IMA classification – diopside), amphiboles, (kaersutite), dark micas (phlogopite, Ti-rich biotite). From among less frequent light minerals there are namely feldspars and analcime. Cretaceous volcanics of the External Western Carpathians have a geochemical pattern close to intraplate alkali rocks (Tab 1). The rocks are typically alkali, and compositionally resemble basanites in terms of Zr/TiO_2 vs Nb/Y . Typical is high contents of P_2O_5 , TiO_2 , alkalis and incompatible trace elements such as light REE, Zr, Nb, Y, Ba and Sr and by High Ti/V (50) and chondrite –normalised $(La/Yb)_n$ (8-25) ratios. Major elements composition and trace elements patterns and Nb-Sr isotopic values indicate that the this magma was derived from a mantle source (Dostal and Owen 1998). We can compare Cretaceous alkali volcanics in the External WC to Late Cenozoic alkali volcanics of Central as well as Western Europe. They are also similar to Mesozoic alkali volcanics from various parts of Europe (North-Pyrenean rift zone – Azambre et al. 1992, Northern Calcareous Alps - Trommsdorff et al. 1990 etc.). We suppose the Upper Mantle source material close to HIMU. This suggestion has been proved also by Sr and Nd isotope studies (Dostal and Owen l.c.).

The majority of Mesozoic alkaline rocks from the Central Western Carpathians (with the exception of picrites) are characterised by the presence of a fine-grained devitrified matrix (up to 40 %). Olivines, pyroxenes and to a lesser degree amphiboles form phenocrysts and locally they accumulate into glomerophyres. Clinopyroxenes (Cpx) are the determining and dominant minerals in all rock types. Besides phenocrysts of various shape and size, they form also microlites in the devitrified matrix. A characteristic feature of the clinopyroxenes is sector and oscillation zoning. Cpx microlites have a composition corresponding to the rim of phenocrysts. According to the IMA pyroxene classification they correspond to diopside. On the basis of various discrimination diagrams (Le Bas 1962, Leterrier et al. 1982 etc.) the studied clinopyroxenes correspond to pyroxenes from alkaline rocks. Amphiboles are zonal too and correspond to kaersutite or low-silicium kaersutite. From other minerals, there are rarely present phlogopites, feldspars, spinels, apatite analcime, pseudoleucite, spinel, ore minerals and others.

The geochemical patterns of Central Western Carpathians Mesozoic volcanics are very close to those of the External Western Carpathians. Characteristic features of these rocks are low SiO₂ (cca 4l %) and high TiO₂ and P₂O₅ contents (3,2 and 0,8 % respectively), 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) is detected. On the other hand, the contents of : Y (24 ppm) and HREE are relatively low. Different discrimination diagrams (Pearce and Cann 1973, Mullen 1983, Meschede 1986 etc.) assign these rocks to alkaline basalts (WPA, OIA; Hovorka and Spišiak 1988, Spišiak and Hovorka 1997). In this rock types numerous carbonate xenoliths (some of which could be immiscible carbonate ocelli have been found). The gradual transition from xenoliths with well-preserved faunal remnants (Hovorka – Spišiak 1988) to intensively recrystallized ones, has been described.

Based on alkali character of volcanics under consideration we suppose that Cretaceous volcanism of the External as well as Central Western Carpathians was in close connection to rifting processes. Such processes lasted for a short-time, and in the following time-period compressional processes took part, which blocked communication paths of magma. So the origin of alkali magma is bound on deep-seated transcrustal faults, which acted during the Cretaceous basins formation.

This study represents a partial output from the grants No. 2/7091/00 VEGA.

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Tab. 1 Selected analyses of the Cretaceous alkali rocks of the External and Central Western Carpathians

Sample	1	2	3	4	5	6	7	8	9	10
SiO ₂	48.90	42.65	39.12	40.05	39.30	42.03	38.63	43.20	40.21	39.38
TiO ₂	2.59	3.04	1.60	2.40	2.95	3.53	2.76	3.30	3.72	3.28
Al ₂ O ₃	14.80	13.77	11.99	13.55	13.50	12.55	12.53	12.19	13.48	11.83
Fe ₂ O ₃			5.52	6.30	4.95					
Fe ₂ O _{3tot}	10.92	10.21				14.21	11.52	11.08	14.16	12.78
FeO			5.57	4.41	5.75					
MnO	0.17	0.13	0.13	0.17	0.17	0.14	0.11	0.12	0.18	0.19
MgO	6.81	6.58	16.55	8.00	7.80	8.10	9.29	7.12	7.30	10.93
CaO	6.10	12.17	14.13	13.14	11.20	10.55	11.79	11.45	7.63	12.34
Na ₂ O	4.63	1.70	1.40	2.10	2.15	3.29	0.28	3.78	2.34	1.45
K ₂ O	0.51	2.53	0.80	1.90	2.05	0.54	2.34	0.28	2.40	1.75
P ₂ O ₅	0.43	0.75	0.45	0.74	0.70	1.09	0.85	0.95	1.03	0.85
LOI	4.00	5.40	2.65	7.32	9.00	4.30	9.10	6.60	7.60	4.60
TOTAL	99.86	98.93	99.91	100.08	99.52	100.33	99.20	100.07	100.05	99.38
Cr	66	60	460	355	387	191.00	211	91	289	402
Ni	49	46	300	196	270	169.00	125	98	158	199
Co			42	39	40	56.00	48	33	47	51
V	216	292	28	85	25	268.00	269	238	247	273
Zn	113	107				179.00	101	115	125	115
Rb	17	65		66	85	15.00	61	51	19	58
Ba	275	1419		954	1350	125.00	958	900	696	1578
Sr	622	1028		655	950	760.00	1641	1036	1055	746
Nb	55.50	110.00		82.30		109.20	77.00	83.00	80.00	105.20
Hf	4.36	5.78		5.22	7.50	8.74	0.00	0.00	0.00	6.19
Zr	195	266		255		437.00	262	272	342	313
Th	4.11	9.45		6.45	6.60	10.40	10.00	10.00	8.00	6.06
La	37.10	60.30	50.00	51.20	82.00	81.69	54.00	69.00	79.00	67.30
Ce	71.00	117.00	102.00	109.00	160.00	163.93	91.00	132.00	149.00	129.44
Pr	8.07	13.30		8.80		19.18	0.00	0.00	0.00	14.79
Nd	32.40	50.90	43.00	49.80	78.00	73.64	39.00	53.00	55.00	56.86
Sm	6.75	9.88	7.30	8.01	13.00	13.68	0.00	0.00	0.00	10.31
Eu	2.22	2.97	2.60	2.87	4.40	4.14	0.00	0.00	0.00	3.17
Gd	6.56	8.49	12.00	7.77	10.60	11.47	0.00	0.00	0.00	8.27
Tb	0.95	1.12	0.92	1.24	1.58	1.38	0.00	0.00	0.00	1.10
Dy	5.18	6.15		5.55		6.64	0.00	0.00	0.00	5.76
Ho	0.93	1.07	0.95	0.99	1.80	1.20	0.00	0.00	0.00	1.03
Er	2.33	2.64		2.47		2.84	0.00	0.00	0.00	2.54
Tm	0.29	0.33		0.30		0.32	0.00	0.00	0.00	0.32
Yb	1.64	2.12	2.20	1.86	2.10	1.71	0.00	0.00	0.00	1.81
Lu	0.25	0.28	0.31	0.27	0.35	0.27	0.00	0.00	0.00	0.26
Y	23.00	27.00		28.00		30.00	27.00	25.00	28.00	25.00

1- Žermanovice EWC- basanite/alkali basalt; 2 - Repište EWC - nephelinites/basanites; 3- Staříč EWC - picrite;
 4 - Straník EWC - basanite; 5 - Kojetín EWC - monchiquite; 6 - Osobitá CWC - basanite; 7 - Polom CWC - basanite;
 8 - Rúbane CWC - basanite, 9 - L. Dúbrava CWC - alkali lamprophyres; 10 - Cajla CWC - alkali lamprophyres;
 EWC - External Western Carpathians; CWC - Central Western Carpathians; Data: 1-2 = Dostal-Owen 1988,
 3-5 = Kudělkásková 1987, 4, 6-10 = original analyses