LAMPROPHYRES FROM THE PRE-VARISCAN SOUTH CARPATHIAN GRANITOID PROVINCE, ROMANIA: GEOCHEMICAL DATA AND ORIGIN

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The lamprophyre dykes from the South Carpathian granitoid province are represented mostly by spessartites, malkites and kersantites, and rarely by camptonites and minettes. According to their chemical composition they belong to the tholeiitic and alkaline, rarely calc-alkaline-types. As regards the tectonic setting, these rocks show an ambiguous character, occurring at the same time – on different diagrams – either in the field of island arc rocks, or in the within plate rock field. The initial magma (pyrolite) resulted from a metasomatic mantle plume by partial melting. This pyrolite reacted with the residual magma from the magma chambers of the precursor syn-orogenic granitoids, still present in the host metasomatic upper mantle, thus getting contaminated. From this contaminated pyrolite lamproitic magmas differentiated, lamprophyres of different varieties derived from.

Key words: Lamprophyres; Petrography; Geochemistry;Tectonic setting; Origin.

INTRODUCTION

As usually, the acid plutonic activity is followed by a dyke system, among which dykes of basic rocks – the lamprophyres – are present. Likewise, after the emplacement of the numerous orogenic granitoid plutons in the Pre-Variscan South Carpathian granitoid province[1] a suite of dykes of different composition occurred. Among these dykes the lamprophyres represent a characteristic rock-group. Since these rocks essentially differ from the forerunner granitoid rocks, I tried in the present paper to show, as much as the existent analytical data allowed me, the geochemical aspects of these dyke-rocks and, by consequence, their tectonic setting and origin.

OCCURRENCE, PETROGRAPHY AND CLASSIFICATION

Within the Pre-Variscan South Carpathian granitoid province dykes of lamprophyres occur in association with some granitoid plutons present in both the Danubian Autochthon and the Getic Nappe. As it was reported, such rocks occur in connection with the following granitoid pluton areas: Muntele Mic, Cherbelezu and Sfârdin, Motru dyke-swarm, Şuşiţa, Parâng and Cărpiniş-Novaci from the Danubian Autochthon and Sicheviţa in the Getic Nappe. These granitoid plutons have been emplaced during two magmatic phases from the Pre-Variscan tectono-magmatic cycle, which lasted about 250 Ma (see Soroiu *et al.*[2], Stan *et al.*[3] and Savu[1]).

The lamprophyre dykes the thickness of which is no more than 3 meters, cut the granitoid plutons on different directions, corresponding to the main joints like Q, L and S from the plutons. More often the lamprophyre dykes have been affected by autometamorphism, so that their classification sometimes became difficult.

Danubian Autochthon. In the Muntele Mic granitoid pluton from this structural unit the lamprophyre dykes cut even the hydrothermal quartz veins, which shows that these rocks are the

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last Pre-Variscan igneous rocks[4]. They occur as green and aphanitic rocks (malkites), which sometimes show a flow structure and consist of brown hornblende (c ^ Ng = 5°), chlorite, albite, epidote, calcite and granules of secondary iron oxides and leucoxene, a mineral assemblage that indicates autometamorphic lampronite rocks (according to the mineralogical classification of Hatch *et al.*[5] and IUGS). They resulted from pyroxenitic magmas[4].

Within the area of Cherbelezu and Sfârdin granitoid plutons lamprophyres are of two varieties: spessartites and minettes. As shown by Stan *et al.*[6], the rocks from the first category exhibit a fine texture and consist of hornblende, plagioclase, clinopyroxene and accessory minerals like biotite, sphene, apatite and opaque minerals. The minette dyke observed in the south of the Cherbelezu pluton contains large biotite phenocrysts, included in a fine dark matrix consisting of biotite, augite, orthoclase, apatite, calcite, sphene and accessory iron oxides.

In association with the Motru dyke-swarm Berza and Seghedi[7] reported dykes of lamprophyres showing a porphyritic texture and consisting of clinopyroxene and red-brown hornblende phenocrysts included in a groundmass of variable granulation (0.03 to 0.3 mm). They seem to be rocks of camptonitic composition. In the groundmass there are to be found microcrystals of the same brown hornblende, plagioclase and sometimes pyroxene. Their parental magma was of lamprosomaitic to gabbrodioritic-type.

The Şuşiţa granitoid pluton was cut by lamprophyre dykes too, which belong to the spessartite-type[8]. Such a lamprophyre from the Sadu Valley consists of a groundmass of fine granulation, in which brown hornblende phenocrysts (2 to 3 mm long) do occur, The groundmass consists of fine granules of zoisite, albite, and brown hornblende. Both the phenocrysts and the groundmass present a common orientation. The parental magma was a lamprodioritic one.

Between Sadu Valley and Parâng Peak the granitoid pluton was also cut by dykes of lampropyres, mostly located on S-joints, they being parallel to the pluton elongation[9]. They consist of a felt-like groundmass, formed of a fibrous amphibole, zoizite, albite and magnetite, in which nests of a secondary amphibole, which substituted a primary melanocratic mineral, are present. This rock represents a strongly autometamorphic spessartite. Its parental magma was a gabbroid-pyroxenitic one[9].

A more detailed description of the lamprophyres from the South Carpathian granitoid province was performed by Savu *et al.*[10] on the lamprophyres related to the Cărpiniş-Novaci granitoid pluton, rocks which belong to the spessartite-group. The texture of these rocks usually is porphyritic, but there also occur rocks showing a doleritic texture (malkites). The fresh porphyritic rocks consist of a microcrystalline groundmass in which phenocrysts of clinopyroxene, hornblende and plagioclase, as well as pseudomorphoses of chlorite formed on a melanocratic mineral – most probably an olivine – occur. The groundmass consists of fine clinopyroxene and browm hornblende micro-crystals included in a mass of sericite, chlorite and albite, probably formed on some fine feldspar crystals. Rarely, there occur albitized and dim microcrystals of plagioclase. Hornblende crystals exhibiting a variable size, usually are prismatic and oriented parallel to the magma flow. They represent a brown variety of amphibole with the following optical properties: Ng = brown, Nm = dark brown., Np = light brown – yellowish; c ^ Ng = 17°. The plagioclase phenocrysts are altered and partly filled with secondary minerals. The pyroxene phenocrysts of 0.25 to 0.50 mm long sometimes gather in groups of 2-3 crystals, working a glomeroporphyritic texture. This mineral is colourless, shows polisynthetical twins and exhibits the following optical properties: c ^ Ng = 39°; Ng – Np = 0.023.

The lamprophyres with dolerite texture consist of altered plagioclase, clinopyroxene and numerous magnetite crystals, mass in which pseudomorphoses of chlorite substituting the phenocrysts of a melanoctatic mineral – likely an olivine – do occur. The pyroxene crystals exhibit the following optical properties: c ^ Ng = 45°; Ng – Np = 0.029, which indicate an augite.

Getic Nappe. The only granitoid pluton from this structural unit in which so far lamprophyres have been described is the Sicheviţa pluton. Stan *et al.*[3] shortly presented these lamprophyres as dykes of dark-green rocks which show a porphyritic texture. Usually, they are altered and cut by calcite veins. In the groundmass there occur phenocrysts of olivine, pyroxene and green hornblende.

Concerning the Pre-Variscan age of lamprophyres so far there are not radiometric data. Therefore, it was presented here as a relative age, based on the relationships of these dykes with the geological formations and the tectonic processes. Thus, at the beginning of the second chapter, there was shown that lamprophyres related to the granitoid plutons from the first phase are the last Pre-Variscan igneous rocks in the South Carpathian granitoid province, since they cut even the hydrothermal quartz veins from the granitoid plutons. But the peremptory argument that these rocks belong to the Pre-Variscan tectono-magmatic cycle, is the fact that the lamprophyre dykes occurring within the Variscan deformation zone from the Şuşiţa-Parâng granitoid pluton were also deformed by these processes, there occurring a secondary foliation (cleavage) that passes through both the country rocks and the lamprophyre dykes on the direction of N72°E/35°N (Fig. 1)[11]. According to the data of Soroiu *et al.*[2] this tectonic deformation took place at about 296 to 219 Ma ago (see also Savu[1]).

As regards the age of the lamprophyres related to the Sicheviţa pluton, it could be younger because according to Stan *et al.*[3], on the rocks of this pluton there were obtained ages of 350 to 250 Ma. Considering as the real age of the granitoid pluton that of 350 Ma (U/Pb), it results that the pluton and the associated lamprophyres belong to the Late Caledonian magmatic phase of the Pre-Variscan cycle, The younger ages determined by means of K/Ar method are consistent with those of the Variscan deformation.

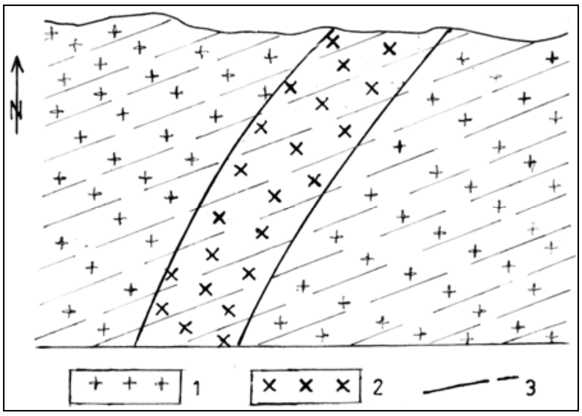

Fig. 1. Lamprophyre dyke cutting the Şuşiţa granitoid pluton in the Variscan deformation zone: 1, granitoid rock; 2, lamprophyre dyke; 3, Variscan foliation (Data from Savu[11]).

The emplacement of lamprophyres took place after the intrusion of granitoid plutons, when the area of the granitoid province became stable, the granitoid plutons cooled off and within the region, including the orogenic granitoids, the cooling joints (Q, L, S) occurred. It took place shortly after the age of 500 Ma, and before the sedimentation of the Silurian formations. More likely they occurred during the Cambrian period, in case of lamprophyres which were emplaced after the granitoid plutons from the first phase (600–500 Ma) of the Danubian Autochthone and at 350 Ma in case of those occurring after the second phase of granitoid intrusion, like those from the Getic Nappe. However, it must be shown that both the granitoid rocks and lamprophyres from the two magmatic phases are very similar one another. It is perhaps worth mentioning that a similar succession of phenomena occurred during the Alpine tectono-magmatic cycle in the western part of the Romanian territory. Thus, there occurred first the Late Kimmerian Săvârşin and Cerbia granitoids accompanied by shoshonitic granites, which were followed by lamprophyres and, then the intrusion of the Laramian granitoids from Banat and Apuseni Mountains took place also followed by lamprophyres.

GEOCHEMICAL DATA AND TECTONIC SETTING

The chemical composition of the lamprophyres was presented in Table 1. From this table it results that lamprophyres are intermediate to ultrabasic rocks, since their SiO_2 varies from 37.92 % to 54.46 %. The FeO_{tot} increases in these rocks from 5.47 % up to 10.51 % and MgO varies from 3.87 % to 8.41 %, underlining their predominant basic character. Suggestive is also the sum of alkalies that varies from 2.45 % up to 7.29 % indicating the presence of alkaline lamprophyres.

According to their composition, on the diagram in Figure 2, the plots of these rocks are gathering into two groups: one group includes the plots from the melanephelinite, basanite and basalt fields and the second one extends from the same melanephelinite field through the trachybasalt, and trachybasaltandesite fields, down to the basaltandesite field, which shows the high variability of the lamprophyres within their relatively restricted plot area.

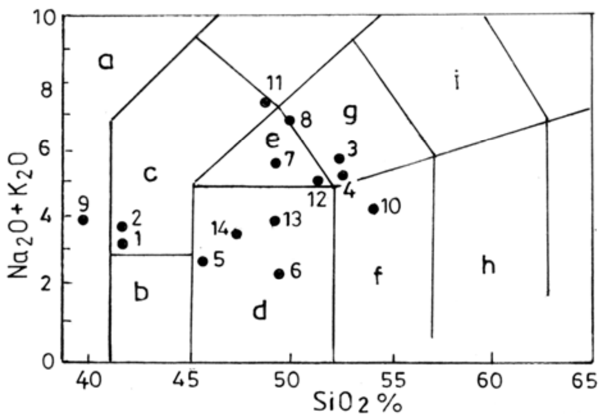

Fig. 2. Plot of lamprophyres on the Na_2O+K_2O *vs.* SiO_2 diagram. Fields according to Le Bass[12] (field a) and Le Maitre *et al.*[13] (fields b – i): a, melanephelinite; b, picrobasalt; c, basanite; d, basalt; e, trachybasalt; f, basaltandesite; g, trachybasaltandesite; h, andesite; i, trachyandesite.

Table 1

Chemical composition of Lamprophyres*

Pluton	1	2	30	4	5	6	7	8	9	10	11	12	13	14
SiO_2	41.85	43.91	54.03	54.32	46.11	49.86	51.0	49.16	37.92	54.46	48.34	56.27	48.62	46.86
Al_2O_3	14.90	14.79	16.03	15.78	16.04	13.77	15.15	13.86	13.0	15.59	17.0	17.85	16.0	13.59
Fe_2O_3	4.36	4.01	1.86	1.34	4.79	3.42	4.50	2.80	5.54	1.81	2.53	3.0	5.35	4.08
FeO	6.70	6.87	5.07	5.50	7.39	8.76	4.10	3.34	4.60	3.85	4.82	5.81	2.80	3.30
MnO	0.19	0.15	0.13	0.09	0.16	0.16	0.15	0.13	0.15	0.12	0.04	0.17	0.14	0.11
MgO	7.59	8.0	7.42	7.30	6,95	8.49	6.73	3.87	1.14	3.89	7.10	5.40	9.0	9.33
CaO	10.53	10.22	5.61	5.99	10.33	9.29	6.04	9.0	14.24	6.57	8.12	7.84	8.80	10.92
Na_2O	1.70	1.75	3.53	2.75	2.11	1.89	3.05	1.85	0.56	-	1.64	3.23	3.0	2.47
K_2O	1.66	2.13	2.02	2.41	0.83	0.56	3.87	5.35	3.55	4.24	5.54	1.47	0.80	1.04
TiO_2	3.32	2.97	1.0	0.96	2.02	1.16	0.98	1.20	4.07	0.89	1.10	1.60	0.65	0.11
P_2O_5	1.14	0.62	0.17	0.26	0.25	0.17	0.54	1.52	0.56	0.24	0.19	0.42	0.11	0.16
CO_2	1.92	1.37	0.57	0.40	-	Tr	0.33	5.52	2.25	4.21	0.40	0.28	0.30	2.82
S	0.34	Tr	-	Tr	0.02	Tr	0.09	0.14	0.18	0.04	0.16	0.26	-	-
H_2O^+	3.74	3.05	2.50	2.90	3.0	2.47	1.40	2.44	2.97	4.94	2.83	2.14	-3.90	-5.0
Total	99.94	100	99.94	100	100	100	99.94	100	99.98	100	99.83	99.74	99.53-	-99.79
Mg#	91.81	95.45	96.46	96.84	94.23	95.19	95.82	94.85	77.08	95.17	96.50	94.63	96.95	97.59
Pb	6.5	3.0	6.5	3.0	3.0	5.0	14	38	10	3.0	-	-		5.0
Cu	42	51	42	51	28	155	22	26	40	45	-	-		50
Ga	16.5	22	10.5	22	17	14	18	18	16.5	15	-	-		10
Ni	180	270	180	270	85	140	78	75	110	65	-	-		210
Co	-	-	-	-	37	40	38	16	48	18	-	-		32
Cr	230	200	230	200	130	235	280	105	180	220	-	-		730
V	90	160	99	160	155	175	190	110	300	105	-	-		200
Sc	-	-	-	-	-	-	25	1.4	39	19				36
Zr	-	-	-	-	145	130	140	175	230	145	-	-		80
Y	-	-	-	-	-	-	23	19	20	12	-	-		36
Yb	-	-	-	-	-	-	2.9	0.8	1.5	1.7	-	-		1.1
La	-	-	-	-	-	-	44	65	62	34	-	-		30
Be	1.9	1.7	1.9	1,7	1.0	1.0	3.2	1.3	1.3	7.0	-	-		-
Nb	-	-	-	-	-	-	10	10	23	10	-	-		10
Ba	220	440	220	440	210	90	2200	4000	2700	340	-	-		500
Sr	215	195	215	195	700	190	2200	3150	1700	120	-	-		1100
Li	42	39	42	39	27	8.0	56	48	50	140	-	-		0
Sn	-	-	-	-	-	-	2.0	4.5	2.0	2.0	-	-		3.5

* The analyses in the table are from the following granitoid pluton areas: Danubian Autochthone: 1, 2, Muntele Mic (Savu *et al.*[4]); 3, 4 Şuşiţa (Savu *et al.*[8]); 5, Parâng (Savu *et al.*[9]); 6, Cărpinş-Novaci (Savu *et al.*[10]); 7, 8, 9, 10, Cherbelezu and Sfârdin (Stan *et al.*[6]); 11, 12, Motru dyke-swarm (Berza and Seghedi[7]).; Getic Nappe; 13, 14, Sicheviţa (Stan *et al.*[3]).

As shown in Figure 3, most of the lamprophyre dykes are tholeiitic rocks, as they fall within the field of this rock-type. The alkaline lamprophyres are represented on the diagram only by the alkali-richest rocks.

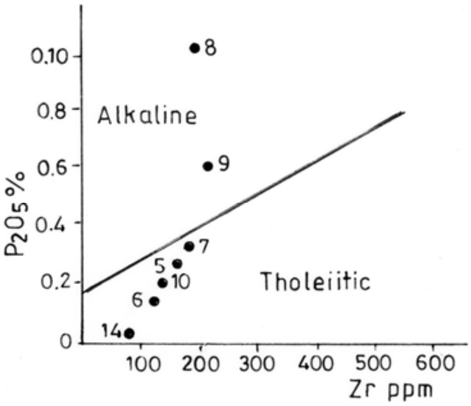

Fig. 3. Plot of some lamprophyres on the P_2O_5 *vs*. Zr diagram. Fields according to Floyd and Winchester[14].

On the diagram in Figure 4 the high variability of lamprophyres is further detailed. So, the tholeiitic rocks are represented by the lamprophyres from the Muntele Mic, Parâng and Cărpiniş-Novaci granitoid plutons. Alkaline lamprophyres occur in relation with the Şuşiţa, Cherbelezu and Sfârdin plutons. The most alkaline rock from the last area (No. 9) is very rich in iron, so that it plots on the diagram in the tholeiitic field, but nearer to the FeO_{tot} – Alkalies side of diagram.

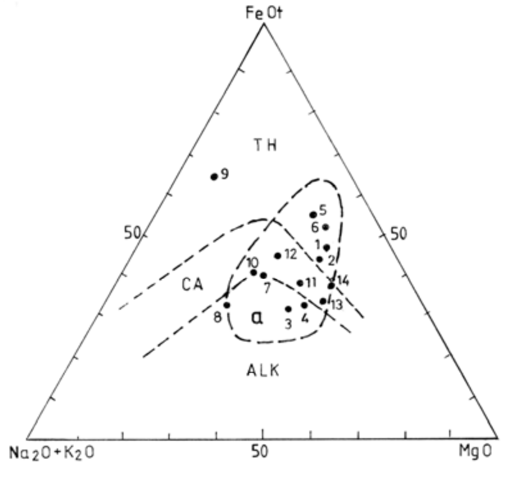

Fig. 4. Plot of lamprophyres on the FeO_{tot} – Na_2O + K_2O – MgO diagram. Fields according to Irvine and Baragar[15] and Hutchinson[16]: TH, tholeiitic; CA, calc-alkaline; Alk, alkaline; a, field of the Mureş rift Paleogene hotspot volcanics[17].

But the most important character of lamprophyres evidenced by this diagram is that they plot inside the field of the Paleogene hotspot volcanics from the Mureş rift[17], which are related to the Transylvania mantle plume[18].

In contrast, the lamprophyres associated with the Motru dyke-swarm and Sicheviţa pluton (Nos. 11 to 14) are clear calc-alkaline rocks, a character which could raise the question of their origin, namely, if they are real lamprophyres or basic differentiates of the calc-alkaline parental magma of the dyke-swarm and granitoid rocks. But the lamprosomaitic character of the parental magma established by Berza and Seghedi[7] for one of the two analysed rocks related to the dyke-swarm (Table 1) shows that this rock represents a lamprophyre. Similarly, the Niggli magmatic values of the Sicheviţa lamprophyres (Table 2) show the lamproitic character of their parental magma. And that, the more so as according to the different authors above quoted, lamproitic magmas of different varieties represent the parental magmas of other lamprophyres from the South Carpathian granitoid province.

Table 2

Niggli values of the Sicheviţa lamprophyres

Value	*si*	*al*	*fm*	*c*	*alk*
13*	132.6	25.7	48.5	25.7	0.07
14	110.2	18.7	46.5	27.5	7.16

* The order numbers according to Table 1

The trace elements, although in incomplete set, yet underline some characteristics of lamprophyres and contribute to elucidate the tectonic setting and origin of these rocks, Thus, from the Table 1 it results that the lamprophyres are generally rich in sideritic elements like Ni, Co, V and Sc. In the three alkaline lamprophyres from the Cherbelezu and Sfârdin area Ba and Sr exhibit very high contents. Moreover, in one of them the content of these elements is equal. The same alkaline lamprophyres present higher contents of Zr.

Some characteristic ratios of the major and trace elements from the South Carpathian lamprophyres (Table 3) mark the relationships of these elements and some features of the lamprophyres. So, the first ratios in the table show that Al2O3 is higher than CaO; FeOtot is also higher than MgO. The high content of Ba in lamprophyres clearly results from the K/Ba, Sr/Ba and Zr/Ba ratios. Within the sideritic trace element group Ni is prevalent over Cr and Co.

As regards the tectonic setting of lamprophyres, it differs from that of the granitoid plutons from this petrologic province, which are island arc granitoids[1]. On the contrary, the lamprophyres are within plate rocks, as it results from the diagram in Figure 5, based on low-content major elements. It is again of note that these rocks plot on this diagram in the field of the already mentioned Paleogene hotspot volcanics, except for the calc-alkaline lamprophyres, which fall in the volcanic arc basalt field. It results that the parental magma of the syn-orogenic granitoids and that of the lamprophyres were totally different and occurred under different tectonic conditions.

Table 3

Some characteristic ratios from the South Carpathian lamprophyres*

Pluton	1	2	3	4	5	6	7	8	9	10	11	12	13	14
CaO/ Al_2O_3	0.70	0.69	0.35	0.37	0.64	o.67	0.53	0.69	1.09	o.42	0.47	0.43	0.55	0.80
MgO/ FeOt	0.71	0.74	1.10	1.08	0.59	0.71	0.82	0.66	0.11	1.07	1.0	0.62	1.11	1.34
K/Ba	0.006	0.004	0.007	0.004	0.003	0.005	0.001	0.001	2.26	0.50	-	-	-	0.001
Sr/Ba	0.97	0.44	0.97	0.44	3.33	2.11	1.0	0.001	0.62	0.35	-	-	-	1.83
Ti/Sc	-	-	-	-	-	-	0.02	5.07	0.06	0.04	-	-	-	0.001
Ti/V	0.02	0.01	0.01	0.002	0.008	0.003	0.003	0.006	0.008	0.005	-	-	-	0.03
Ti/Zr	-	-	-	-	0.008	0.008	0.004	0.004	0.01	0.003	-	-	-	-
Cr/Ni	1.27	0.74	1.27	0.74	1.52	0.16	3.58	1.40	1.63	2.09	-	-	-	3.47
Co/Ni	-	-	-	-	0.43	0.28	0.48	0.21	0.43	0.17	-	-	-	0.15
Zr/Ba	-	-	-	-	0.69	1.44	0.08	0.04	0.08	0.42	-	-	-	0.13
Zr/Y	-	-	-	-	-	-	6.08	9.21	11.50	12.0	-	-	-	2.22

* Same legend as in Table 1.

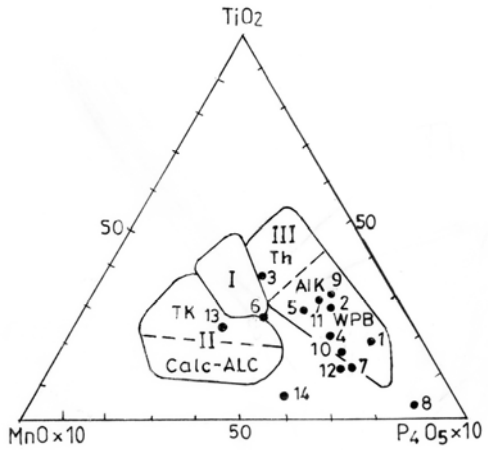

Fig. 5. Plot of lamprophyres on the TiO_2 – MnO – P_2O_5 diagram. Fields according to Mullen[19]: I, ocean floor basalts; II, volcanic arc basalts; III, ocean island basalts; WPB, continental within plate basalts.

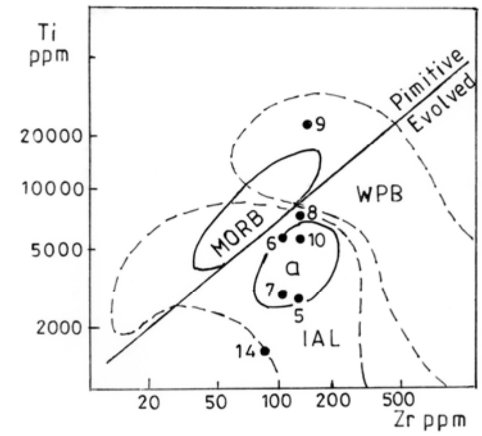

Fig. 6. Plot of some lamprophyres on the Ti *vs*. Zr diagram. Fields according to Pearce[20]: WPB, within plate basalts; MORB, mid-ocean ridge basalts; IAL, island arc lavas; field a, like in Figure 4.

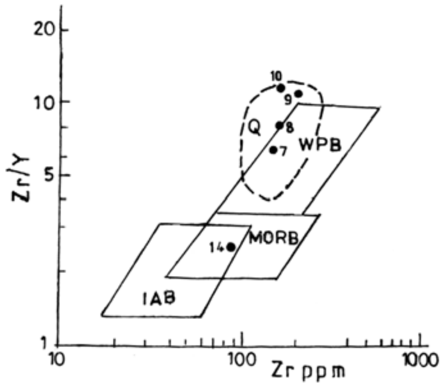

Fig. 7. Plot of some lamprophyres on the Zr/Y *vs*. Zr diagram. Fields according to Pearce and Norry[21]: WPB, within plate basalts; MORB, mid-ocean ridge basalts; IAB, island arc basalts; field a, like in Figure 4.

And, like the mentioned Paleogene hotspot volcanics, on the diagrams in the construction of which trace elements like Zr and Y beside Ti have been used (Figs. 6 and 7), the lamprophyres exhibit double characteristics. It is evidenced by the way their plots occur on different diagrams either in the island arc field (Fig. 6), or in the within-plate basalt field (Fig. 7). Thus they represent transitional rocks between the two tectonic settings, an aspect that could indicate a double origin of their parental magmas. But according to the ambient under which these rocks occurred, they must be considered as within plate rocks, the island arc character probably being a collateral inherited feature.

ORIGIN OF THE PARENTAL LAMPROITIC MAGMA

After the emplacement of the orogenic granitoid plutons within the South Carpathian granitoid province, when the Pre-Variscan tectonic movements, which determined the two phases of orogenic granitoid ceased, a distension period set up within this area after each granitoid phase. Consequently, in the metasomatic mantle wedge, weakened and lightened by the process of extraction by partial melting of substances needed to the genesis of the orogenic granitoid plutons, there took place the emplacement of one (or several) heavy mantle plume coming from the lower mantle. By reaction with the host metasomatic upper mantle this mantle plume was affected by metasomatism too.Under these new structural conditions there manifested itself a special magmatism with magmas of lamproitic character.

The genesis of the lamproitic magmas was discussed by many geologists, which advanced different hypotheses in this respect (see Cullers and Graf[22]). But, as it was shown above, the lamprophyres plot on the presented diagrams within the field of the Paleogene hotspot volcanics and like these rocks, they present a double character regarding the tectonic setting.

As the diagram in Figure 8 shows, the initial melt derived from the metasomatic mantle plume. It had the composition of a pyrolite that resulted by 1 % partial melting of the source, as it is shown by the first lamprophyres, which plot around the line of this composition (field a in the diagram). By reaction with the residual granitoid magmas from the magmatic chambers of the precursor syn-orogenic granitoids, still present in the host metasomatic upper mantle, this pyrolite was contaminated. From this contaminated pyrolite lamproitic magmas differentiated, from which different varieties of lamprophyres, including the alkaline ones, resulted (field b).

This genetic model is supported by the $Mg^{\#}$ vs SiO_2 diagram (Fig. 9), on which the plots of lamprophyres gathered into a restricted field. It shows that there was not a normal differentiation of the initial magma by olivine fractionation, but a contamination marked here, for instance, by the rock number 9. The high value of the Zr/Y ratio (Table 3) supports this conclusion too, suggesting that the high content of Zr in the lamproitic magmas, especially in the alkaline ones, occurred by contamination with the residual granitoid magmas. The evolution of this process, which led to the genesis of the lamproitic magma, explains also the ambiguous character of the lamprophyres as regards their composition and tectonic setting.

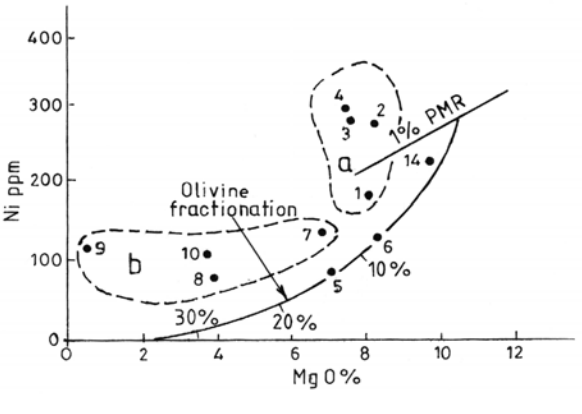

Fig. 8. Plot of lamprophyres on the Ni *vs*. MgO diagram showing the contamination of the initial pyrolite by the residual granitoid magmas. Olivine fractionation trend and the pyrolite line (PRM) according to Volker *et al.*[23].

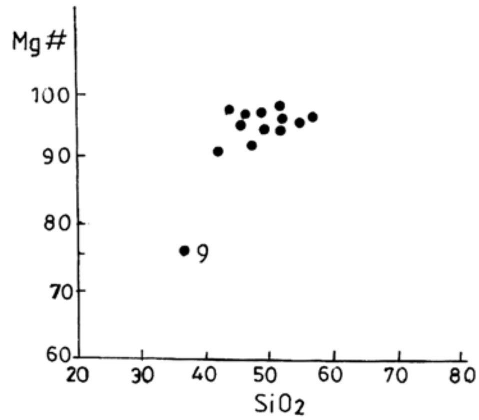

Fig. 9. Plot of lamprophyres on the $Mg^{\#}$ vs SiO_2 diagram, which shows the contamination of the initial pyrolite by the residual granitoid melts.

Unfortunately, there are not REE analyses needed for the direct determination of the mantle plume origin of lamprophyres. But it was inferred from the geochemical characteristics of the exotic blocks of ultrabasic rocks from the Tismana shoshonitic granitoid pluton; two of these xenoliths have been analysed by Duchesne *et al.*[24] These blocks represent mantle xenoliths (see also Savu *et al.*[25] – the chapter of discussions), as the diagram in Figure 10 shows. It clearly results from this diagram that the two ultrabasic xenoliths plot within the mantle peridotite domain, and there, just in the field of the mantle plume xenoliths from the young hotspot trachybasalts from the Perşani Mountains.

The ultrabasic character of the mantle xenoliths from the Tismana shoshonitic granite was established by the Niggli magmatic values from Table 4, which show that the xenoliths derived from hornblenditic and pyroxenitic magma-types. This was, in fact, the composition of the metasomatic mantle plume from which the xenoliths have been torn off by the granitic magma – originating in the same plume source (paper in preparation) – and entrained toward the surface.

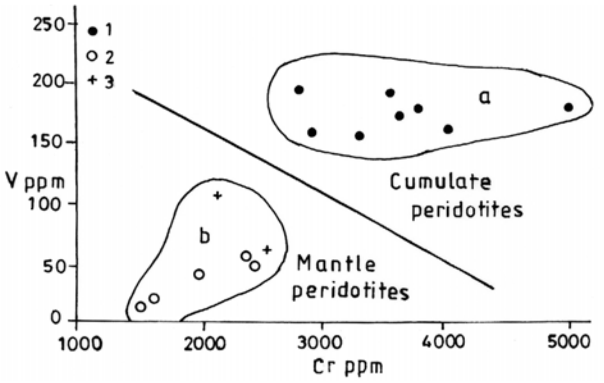

Fig. 10. Plot of some ultrabasic rocks from Romania on the V *vs*. Cr diagram. a, field of the cumulate peridotites; b, field of the mantle plume peridotites, 1, cumulate peridotites from the Mureş ophiolitic suture (data from Savu *et al.*[26)]; 2, mantle plume xenoliths from the Racoş-type young hotspot trachybasalts from the Perşani Mountains (data from Savu *et al.*[27]); 3, mantle xenoliths from the Tismana shoshonitic granitoid pluton (data from Duchesne *et al.*[24]).

Table 4

Niggli magmatic values of the two ultrabasic xenoliths from the Tismana pluton, analysed by Duchesne *et al.*[24]

Value	*si*	*al*	*fm*	*c*	*alk*
1.	164.6	3.25	50	29	17.
2.	130	27.2	49.5	21.7	10.5

According to the mineralogical composition of the ultrabasic xenoliths[24], the mantle plume from which they have been torn off was a metasomatic mantle plume.

The diagram in Figure 11 clearly shows the plume character of the source of the xenoliths, as the plots of these xenoliths are located at the right of the line of plume-source parental magmas.

Shortly, the processes leading to the genesis of South Carpathian lamprophyres evolved according to the following set up:

MMP ----→ MPPy ----→ MPPy + RGM-----
→LM-----→ normal lamprophyre trend.
\-------- → alkaline lamprophyre trend.

in which MMP = metasomatic mantle plume emplaced in the host metasomatic upper mantle beneath the South Carpathian granitoid province area; MPPy = mantle plume pyrolite; MPPy + RGM = mantle plume pyrolite contaminated by the residual granitoid magmas (RGM); LM = lamproitic magma from which different types of lamprophyres derived.

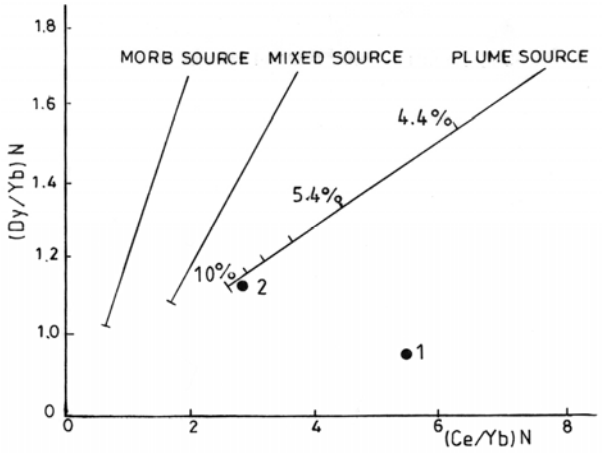

Fig. 11. Plot of the two mantle plume xenoliths on the (Dy/Yb)N *vs*. (Ce/Yb)N diagram. The magma source lines and melting rate values according to Haase and Devey[28].

The presence of a metasomatic mantle plume in the substratum of the South Carpathian granitoid province, in which the lamprophyres occur, and the geochemical likeness of these rocks with the young hotspot volcanics, allowed me to consider the lamprophyres from this granitoid province as derived from plume-source magma. In this respect it is worth mentioning that the East Carpathian Mesozoic lamprophyres also originate in mantle plume sources[29].

CONCLUSIONS

The Pre-Variscan lamprophyres from the South Carpathuan granitoid province occur as dykes emplaced after the intrusion of the orogenic granitoid plutons. They are represented by spessartites, malkites, and kersantites, rarely camptonites and minettes. According to their chemical composition, these rocks are represented by tholeiitic, calc-alkaline and alkaline lamprophyres. The rocks show an ambiguous tectonic setting, they occurring at the same time – on different diagrams – either in the island arc field, or in the within plate field. They originate in lamproitic magmas, which derived from metasomatic mantle plume sources. From the plume sources an initial magma (pyrolite) separated, which was contaminated by the residual granitoid magmas from the magmatic chambers of the synorogenic granitoids. From his contaminated pyrolite lamproitic magmas differentiated, the lamprophyre rocks of different varieties derived from.

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