DYKE ROCKS RELATED TO THE GRANITOID PLUTONS FROM THE SOUTH CARPATHIAN GRANITOID PROVINCE, ROMANIA*

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The present paper is referring to the dyke rocks related to the granitoid plutons from the South Carpathian granitoid province, which includes Late Precambrian to Early Paleozoic intrusions The dyke rocks usually inherited the geochemical characteristics of the granitoid plutons they are related to. They form a calc-alkaline series with a weak alkaline tendency. The parental magmas of the dyke rocks originated in the same magma chambers the parental magmas of the related granitoid plutons derived from. The dyke rocks occurred in the granitoid province after the intrusion of the granitoid plutons, when the host crystalline schists and the granitoid plutons had cooled off, and in the consolidated area different types of joints and initial fractures had occurred, along which the dyke rocks intruded.

Key words: Dyke rocks; Occurrence; Petrography; Classification; Geochemistry; Tectonic setting; Origin.

INTRODUCTION

The granitoid plutons and the lamprophyres from the South Carpathian granitoid province (SCGP) have been studied in some previous papers (Savu [1–3]), in which their petrology, geochemistry and origin have been presented. But, for a full characterization of this petrographic province, there must be studied the dyke rocks related to the granitoid plutons, too. On this purpose I presented in this paper a short but thorough description of these rocks, based mostly on the available geochemical data from the geological literature.

OCCURRENCE, PETROGRAPHY AND CLASSIFICATION

The dyke rocks from the SCGP occur in both the related granitoid plutons and in the Late Precambrian crystalline schists of the Danubian Autochthone and the Getic Nappe – the host of the granitoid plutons; the composition and distribution of these plutons on a general map were presented before[1]. But most of the dyke rocks are located in the granitoid plutons. Therefore, they inherited the main features of these plutons, such as those of common rocks, trondhjemitic and shoshonitic characteristics. Crossing the host crystalline schists there are few occurrences of dyke rocks, among which remarkable is the dyke swarm from the springs of the Motru River, described by Berza and Seghedi[4] as the Motru dyke complex[4].

Inside the granitoid plutons the dyke rocks are located along the open initial fractures oriented parallel to the main joint systems like Q, L and S, especially on the first two systems, and along the joints themselves. The general dyke thickness is of 0.5 to 3 meters, rarely more.

More spectacular are the dyke rocks from the Motru dyke swarm. There the dykes and sills are usually oriented parallel to the crystalline schists

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structures, *i.e.* on the ENE-WSW direction. The dyke swarm extends along a visible area of 2 kilometers wide and 25 kilometers long. But, according to the quoted authors, it could extend over a length of about 50 kilometers, because it is running under the Mesozoic deposits from the south of the region. There, the dyke thickness varies from a few decimeters up to several hundreds of meters.

Sometimes the dykes underwent the effects of the autometamorphism process, which partly altered their initial minerals. Moreover, they have been affected by the Variscan deformations along the shearing zones from the areas of the Şuşiţa and Parâng plutons and of the Motru dyke swarm

The age of these dykes, as for instance of those from the Motru dyke swarm, is Pre-Sillurian (Berza and Seghedi[4]). As a rule, they occurred after the emplacement of the granitoid plutons, the age of which is of 600–500 Ma[5]. It is strange that Balintoni *et al.*[6] recently obtained, on the same granitoid plutons, ages around 350 Ma. Thus during the Early Paleozoic in the SCGP area the granitoid plutons and the host crystalline schists cooled off, and there started occurring different systems of joints and initial open fractures, along which the dykes intruded[1].

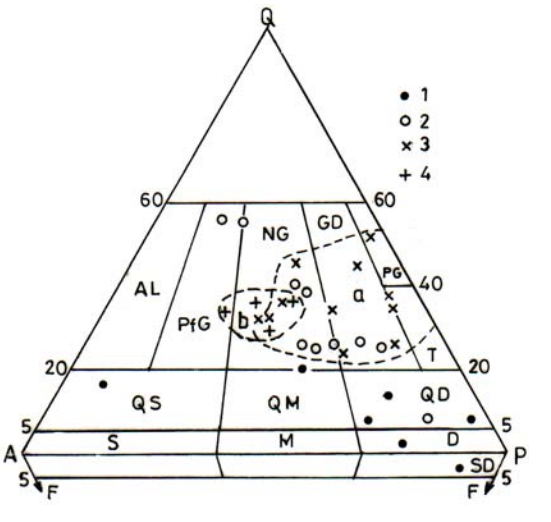

Fig. 1. Plot of the dyke rocks on the QAP diagram. Fields according to Streckeisen[7]: AL, alaskite; PfG, potash-feldspar granite; NG, normal granite; GD, granodiorite; PG, plagiogranite, trondhjemite; T, tonalite; QS, quartz syenite; QM, quartz monzonite; QD, quartz diorite; S, syenite; M, monzonite; D, diorite; SD, syenodiorite. 1, intermediate dyke rocks; 2 and field a = acid (leucocratic) dyke rocks; 3, trondhjemitic dyke rocks; 4 and field b = shoshonitic dyke rocks.

According to their main features the dyke rocks have been separated into two general division, namely, intermediate and acid (leucocratic), each of them including common rock, trondhjemitic and shoshonitic dyke rocks, depending on the granitoid plutons they are related to (see Savu[1]). This classification is supported by the position of the rocks on the diagram in Figure 1, and by their chemical composition presented in Tables 1, 2 and 3.

a **The intermediate dyke rocks**. Albeit the intermediate dyke rocks are very rare, yet they occur in association with all the three group-types of granitoid plutons from the SCGP and in the host crystalline schists from the Getic Nappe and the Danubian Autichthone. From west to east, such dyke rocks occur in both the Poneasca[8] and Sicheviţa[9] granitoid plutons from the Getic Nappe, and in the Cherbelezu, Sfârdin[10] and Cărpiniş[11] granitoid plutons from the Danubian Autochthone. There they are represented by diorite porphyrites.

1. *Dyke rocks related to the common rock granitoid plutons*. In the Cărpiniş[10] granitoid pluton, for instance, there occur diorite porphyrites the texture of which is determined by plagioclase phenocrysts included in a groundmass consisting of plagioclase, deformed quartz and biotite. The plagioclase was altered into a fine mass of sericite including granules of albite and epidote. As a melanocratic phase there occurs a biotite in fine lamellae, partly substituted by chlorite. The accessory minerals are sphene, pistacite, allanite, apatite and magnetite.

2. *Dyke rocks related to the trondhjemitic granitoid plutons*. In the Cherbelezu trondhjemitic pluton also occur dykes of intermediate rocks, represented by porphyritic quartz diorites[11]. These rocks consist of plagioclase, quartz, green hornblende and biotite. As accessory minerals there occur apatite, zircon, sphene and magnetite.

3. *Dyke rocks related to the shoshonitic granitoid plutons*. The Novaci shoshonitic intrusion[10] was cut by a dyke of diorite porphyrite with zoned hornblende phenocrysts of 3 to 5 centimeters long, which are oriented parallel to the dyke walls. Besides, altered phenocrysts of plagioclase occur as well. These are included in a microgranular groundmass formed of partly altered granules of plagioclase, hornblende and biotite and accessory minerals like sphene, apatite and magnetite. It is of note that, sometimes, allanite shows a thin rim of pistacite

In the Motru dyke swarm, which could be considered as occurring after the intrusion of the Frumosu syn-orogenic granitoid pluton, the inermediate dyke rocks are represented by microdiorite and diorite porphyrites[4]. The microdiorite and quartz microdiorite porphyrites consist of a very fine groundmass, formed of plagioclase, hornblende, eventually quartz and biotite. The more important dykes consist of porphyritic diorites, which are also formed of plagioclase, hornblende, biotite, apatite, and a little quartz. The last rocks contain autoliths formed of hornblende, plagioclase and biotite.

b. **The acid (leucocratic) dyke rocks**. These are the most numerous dyke rocks in the SCGP, and are also associated with all the three group-types of granitoid plutons from this petrographic province, as well as in the host crystalline schists.

1. *Dyke rocks related to the common rock granitoid plutons* In this category were included most of the acid dyke rocks from the SCGP (Fig. 1 and Table 2), which occur both inside the related granitoid plutons and in the crystalline schists around these plutons.

Inside the granitoid plutons there are characteristic, among others, the dykes from the Poneasca[8] and Sicheviţa[9] plutons from the Getic Nappe and those from the Cărpiniş granitoid pluton[10] from the Danubian Autochthone. There occur granodiorite and granite porphyries, aplites, pegmatoid granites and quartz porphyries. The granodiorite porphyries consist of a microgranular groundmass in which zoned phenocrysts of plagioclase (An_{5-8}), green hornblende (c ^ Ng = 24^{o}) and biotite, partly substituted by chlorite, occur. The granite porphyries also consist of a groundmass formed of quartz, plagioclase (An_{8}), biotite and accessory minerals like apatite and zircon. In this groundmass there occur phenocrysts of potash feldspar with perthitic structure. It is worth mentioning that these phenocrysts include small lamellae of biotite oriented parallel to some imaginary zones.

Very numerous among the leucocratic dyke rocks from all of the granitoid plutons from the SCGP are the aplitic dykes. More characteristic are those from the Cărpiniş granitoid pluton[10]. These rocks consist of a microgranular granitic groundmass formed of xenomorphic quartz granules with rolling extinction, plagioclase (An_{8}), potash feldspar and biotite. If such a rock was affected by autometamorphism, the plagioclase was transformed, like that from the massif rocks themselves, into an association of sericite, kaolinite, epidote and albite. In such cases biotite was substituted by chlorite and in the altered rock tourmaline occurred, sometimes.

The quartz porphyries consist of an aplitic groundmass formed of deformed quartz, albite and potash feldspar, most of the last two minerals being substituted by the following mineral assemblage: sericite-kaolinite-zoizite-albite; biotite partly chloritized is also present. In this groundmass quartz phenocrysts do occur.

In this context it is noteworthy to mention the geodes from the Cărpiniş granitoid pluton. These geodes usually have been formed at the intersection of two joints or initial faults. They are upholstered by idiomorphic quartz crystals of 1 to 3 centimeters long[10].

The dykes of pegmatite and pegmatoid granite are more characteristic in the Poneasca pluton[8]. These rocks belong to the *feldspathic-type* category, being constituted mostly of microcline or microcline-perthite and albite with mirmekitic intergrowths with quartz; muscovite and biotite are also present. The normative composition of the potash feldspar from these rocks is Or_{78-84}, Ab_{14-20}, An $_{0.8-11}$. Sometimes, it forms graphic intergrowths with quartz.

In the crystalline schists there are characteristic the acid dyke rocks from the Motru dyke swarm, which are represented by porphyritic microgranite consisting of a fine groundmass, in which phenocrysts of quartz, plagioclase, orthoclase and albite of 2 to 5 millimeters long occur. With the dyke rocks from the dyke swarm there are also associated dykes of porphyritic microgranodiorites, which consist of a fine groundmass in which phenocrysts of plagioclase (An_{33-26}) showing a normal zoning, green hornblende, eventually quartz, biotite and accidentally clinopyroxene occur[4].

2. *Dyke rocks related to the trondhjemitic granitoid plutons*. Among this rock-type the most characteristic are the dykes related to the Cherbelezu trondhjemite pluton, which are represented by porphyritic granodiorites and aplites[11]. The first rocks consist of plagioclase, quartz, green hornblende and biotite and accessory minerals like apatite, zircon, sphene and magnetite. The effects of autometamorphism are very evident in these rocks, which consist in the alteration of plagioclase into sericite and calcite and of the mafic minerals into chlorite. In the extreme cases of alteration the entire rock mass, including phenocrysts, was transformed into a fine aggregate of sericite, chlorite and calcite, in which sometimes remnants of the original minerals are present.

Aplites are light colored rocks with a saccharoid texture. They are formed of quartz, albite-oligoclase, potash feldspar, rarely muscovite, biotite and opaque minerals.

3. *Dyke rocks related to the shoshonitic granitoid plutons.* The aplites from the Tismana[19] shoshonitic granitoid pluton are the most representative in this group. These rocks are represented by numerous dykes, which cut the

pluton on different directions. They are massive equigranular rocks, which consist of potash feldspar (microcline or microclin-pertite), quartz and plagioclase (An_{5-10}).

GEOCHEMISTRY OF THE DYKE ROCKS

The chemical composition of the dyke rocks was presented in Tables 1, 2 and 3. In these tables the rocks have been separated into the two main categories above presented, namely, intermediate and acid (leucocratic) rocks, each of them including dyke rocks related to the common rock granitoid plutons as well as to the trondhjemitic and shoshonitic plutons.

In the intermediate rock-group (Table 1), in which rocks of dioritic composition are included, the SiO_2 content varies from 52.18 to 63.09 %. The oxides of iron and magnesium (FeO* and MgO) are the highest in the entire dyke rock-series. The first oxide increases from 2.72 to 6.89 % and the second from 2 to 5.93 %. The alkalies are relatively low in the most rocks, their sum varying from 5.26 to 7.45 %.

According to their main major elements, these rocks are calc-alkaline in composition, so that on the diagram in Figure 2 they plot within the upper part of the calc-alkaline array, thus showing a higher iron content in comparison with the other rock-groups from the SCGP.

The acid (leucocratic) dyke rock-group, which is related to the common rock granitoid plutons (Table 2) includes terms of granodioritic and granitic composition, in which the SiO_2 content varies from 64.80 up to 75.96 %. FeO* and MgO are low. The sum of alkalies varies in high ranges situated between 6 and 8.88 %. According to the mentioned characteristics, on the diagram in Figure 2 the acid rocks plot along the left branch of the calc-alkaline array, too, but gathered in two distinct fields, which mark the composition of the granodioritic and granitic dykes.

Table 1

Chemical composition of the intermediate dyke rocks*

Number	1	2	3	4	5	6	7	8
SiO_2 %	63.09	58.16	59.99	52.18	53.50	56.65	58.11	60.96
TiO_2	0.42	0.50	0.79	1.25	1.0	0.80	1.25	0.85
Al_2O_3	16.01	15.71	15.75	18.44	19.21	19.0	17.72	16.42
FeO*	2.72	4.69	5.37	6.89	6.37	5.12	5.67	5.15
MnO	0.07	0.09	0.10	0.13	0.10	0.11	0.11	0.05
MgO	2.0	5.93	4.36	4.40	3.60	3.50	2.70	2.30
CaO	3.50	4.56	4.29	7.28	7.0	5.04	5.46	5.18
Na_2O	4.85	3.85	3.92	3.98	3.53	2.96	3.85	4.20
K_2O	2.93	3.60	3.23	2.31	2.31	3.30	2.12	2.60
P_2O_5	0.40	0.28	0.18	0.27	0.29	0.29	0.29	0.15
Loi	3.69	1.94	2.32	2.32	2.65	3.01	2.10	1.98
Total	99.95	100.01	99.63	99.76	99.92	99.78	99.89	99.87
Pb ppm	24	20	12	–		–	–	–
Cu	10	21	46	–	–	–	–	–
Ga	22	20	25	–	–	–	–	–
Sn	2	2	2	–	–	–	–	–
Ni	18	95	55	–	–	–	–	–
Co	5 .5	20	13	–	–	–	–	–
Cr	13	190	123	–	–	–	–	–
V	42	120	65	–	–	–	–	–
Sc	4.5	17	11.5	–	–	–	–	–
Y	0.6	0.8	1.4	–	–	–	–	–
Yb	0.6	0.8	1.0	–	–	–	–	–
La	60	42	58	–	–	–	–	–
Zr	130	100	150	–	–	–	–	–
Be	3	3	2.9	–	–	–	–	–
Nb	10	10	10	–	–	–	–	–
Ba	2100	1700	1300	–	–	–	–	–
Sr	3000	1000	970	–	–	–	–	–
Li	18	32	12	–	–	–	–	–

* The analyses in the Table represent: 1–3, Cherbelezu-Sfârdin quartz diorite porphyrites and monzodiorite porphyrites[11;] 4–8, Motru dyke swarm monzodiorite porphyrites[4]. FeO*, represents the total iron oxides.

The dyke rocks related to the trondhjemitic plutons are characterized by their high contents of SiO_2 and Na_2O, as the diagram in Figure 3 suggests. On this diagram most of these rocks plot within the field D. Their SiO_2 varies between 64.69 and 75.78 % and Na_2O between 4 and 4.65 % (Table 3). These data are consistent with the values established by Savu and Dobrescu[22] for the igneous rocks from the trondhjemitic plutons of the SCGP. On the diagram in Figure 2 most of these rocks plot within the granodioritic area of the calc-alkaline array.

Table 3

Chemical composition of the acid (leucocratic) dyke rocks related to the trondhjemitic (1–6) and shoshonitic (7–10) granitoid plutons*

Numb	1	2	3	4	5	6	7	8	9	10
SiO_2	68.68	70.44	74.40	75.09	73.40	75.78	74.02	75.32	69.83	71.68
TiO_2	0.40	0,28	–	0.08	–	0.60	0.05	0.05	0.52	0.94
Al_2O_3	14.40	15.51	14.92	14.96	14.30	14.26	13.58	14.30	14.49	15.56
FeO*	2.74	2.01	0.65	0.70	1.80	0.46	0.98	0.54	3.38	0.91
MnO	0.06	0.04	0.02	0.04	0.02	0.03	0.03	0.02	0.05	0.11
MgO	1.30	0.98	0.50	0.17	0.50	0.08	0.29	0.36	0.78	0.34
CaO	1.96	2.54	1.06	1.30	1.50	0.55	0.69	1.20	1.03	1.15
Na_2O	3.86	1.92	2.85	4.08	3.50	3.98	6.16	4.27	5.02	6.29
K_2O	3.86	1.92	5.45	3.78	4.40	3.98	6.16	4.77	5.02	6.29
P_2O_5	0.10	0.12.	0.03	0.06	–	0.08	0.62	0.01	0.16	0.03
Loi	1.75	1.35	0.88	0.62	0.80	0.37	0.71	0.36	1.31	0.45
Total	99.46	99.85				99.72	99.13	100.2	99.85	99.84
Pb	–	15	–	40	–	35	35	14	20	7
Cu	–	2.5	–	7.5	–	6	–	2.5	15	7
Ga	–	1.5	–	13	–	26	15	20	4.5	27
Ni	–	7	–	2.5	10	–	1		35	5
Co	–	6	–	2	–	2	22	–	–	5
Cr	–	1	–	3.5	–	3	7	1	2	5
V	–	2.3	–	4.5	–	5	5.6	2	16	8
Sc	–	2.5	–	2	–	2	–	–	–	–
Y–	–	6	–	5.5	–	5	28	–	–	–
Yb	–	0.5	–	0.5	–	0.5	–	–	–	–
La	–	30	–	30	–	30	–	–	–	–
Zr	–	175	–	130	–	18	90	40	410	–
Be	–	1.8	–	1.8	–	8.5	–	1.0	3.2	2.7
Nb	–	–	–	10	–	12.5	4.0	–	–	–
Ba	–	450		1100	—	38	683	390	1050	1000
Sr	–	280	–	220	–	40	165	230	240	290
Li	–	27	–	–	–	6.5	–	–	–	–

* The analyses in the Table represent: 1. Ogradena microgranodiorite porphyry[17]; 2, Buta aplite[18]; 3–5, Sicheviţa aplites[9]; 6, Cherbelezu aplite[11];7, Tismana aplite[19] (besides the data from the table this rock contains: 27;La; 64 Ce; 25 Nd; 50 Sm; 1.06 Eu; 3.1 Gd; 0.58 Tb; 3.03 Dy; 3.16 Er; 4.61 Yb; 0.79 Lu ppm); 8–9, Novaci aplites[10]; 10, Poneasca aplite[26] FeO* represents the total iron oxides.

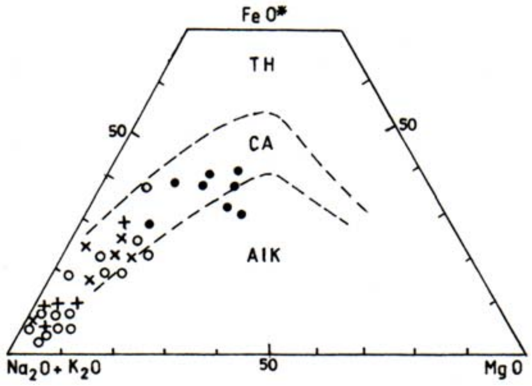

Fig. 2. Plot of the dyke rocks on the FeO* – $Na_2O + K_2O$ – MgO diagram. Fields according to Irvine and Baragar[20] and Hutchinson[21]: TH, tholeiitic; CA, calc-alkaline; Alk, alkaline. Legend as in Figure 1.

Like the massif rocks from the shoshonitic granitoid plutons the related dyke rocks are rich in SiO_2 and alkalies, especially K_2O (see Savu[1,3]). Thus their SiO_2 varies from 69.83 to 75.26 % (Table 3). The sum of alkalies is higher in comparison with most of the granitoid dyke rocks from SCGP. It increases up to 6.16 %. Iron and magnesium oxides are very low, the first oxide varying from 0.2 to 0.11 % and the second between 0.03 and 0.78 %. On the diagram in Figure 2 the shoshonitic dyke rocks plot in the lowest part of the calc-alkaline array, together with some alkali-rich granitoid dykes. It is of note that by extreme differentiation of the calc-alkaline granitoid magma there resulted dyke rocks that got the composition of the shoshonitic rocks, as shown by Table 3 (sample 10) and Figure 4.

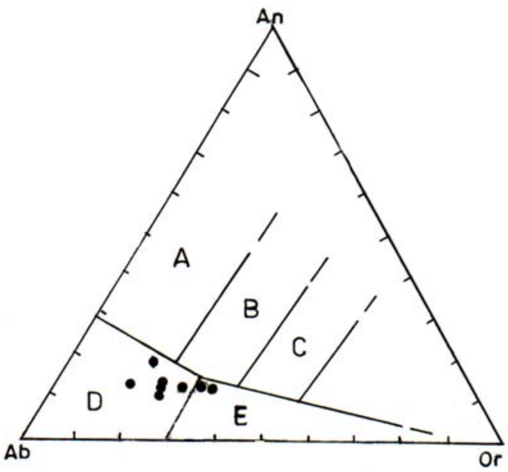

Fig. 3. Plot of the dyke rocks related to the trondhjemitic granitoid plutons on the An-Ab-Or diagram. Fields according to O'Connor[23] (see also Streckeisen[7]): A, tonalites (dacites); B, granodiorites (dacites, rhyolites); C, quartz diorites, quartz monzonites; D, trondhjemites (quartzkeratophyres); E, granites (rhyolites).

The shoshonitic character of these rocks is very well evidenced by the diagram in Figure 4, on which most of these rocks plot in the shoshonitic field, at high values of SiO_2, and partly in the field of the high-K granitoid rocks.

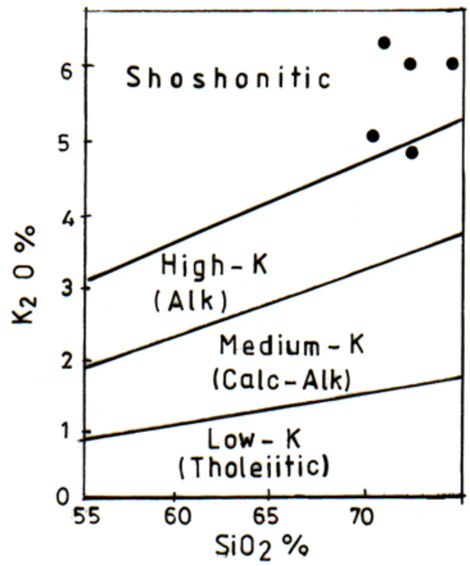

Fig. 4. Plot of the dyke rocks related to the shoshonitic granitoid plutons on the K_2O *vs*. SiO_2 diagram. Fields according to Rickwood[24]. Data from Table 3.

The general features of the calc-alkaline dyke rocks from the SCGP show that all of them belong to the ferriferous granitoid series. As it results from the diagram in Figure 5, except for a few more melanocratic intermediate dyke rocks, most of the acid (leucocratic) dyke rocks plot on this diagram in the ferriferous rocks domain, like the rocks of the granitoid plutons they are related to (see Savu[3]).

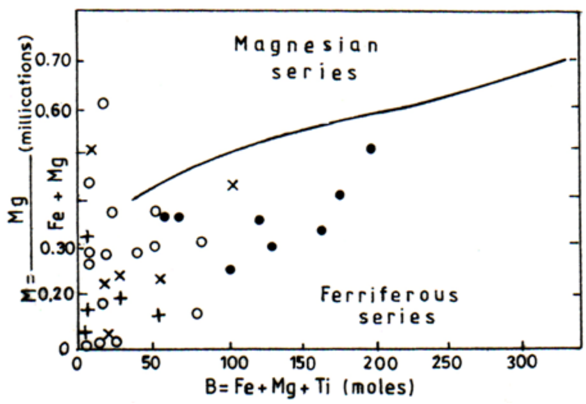

Fig. 5. Plot of the dyke rocks on the Mg / Fe* + Mg *vs*. Fe* + Mg + Ti diagram. Fields according to Debon and Le Fort[25]. Legend as in Figure 1. Fe* as total iron cations.

The trace elements from the dyke rocks of the SCGP (Tables 1 to 3), although in incomplete sets, are contributing to the completion of the geochemical characteristics of the dyke rocks from this petrographic province. Thus, elements such as Pb Cu, Ga and Sn show generally low or very low contents in all of the rock-groups. Among these elements Ga presents the highest contents and Sn the lowest. Low contents show Be and Li, too. But the most remarkable elements for their high contents along the entire dyke rock-series are Sr and Ba.. Both of them show high contents, especially in the intermediate rock-group.

The siderophile elements like Ni, Co, Cr, V and Sc show higher contents in the intermediate rocks, too, because these rocks are the richest rocks in iron and magnesium major elements, in the position of which these trace elements enter into the network of different melanocratic minerals. The lowest contents of these elements occur in the more leucocratic shoshonitic rocks. Other trace elements like U, Th Zr, Hf, Nb and Rb have been rarely determined. Amid these elements Zr was more often determined, and it shows the highest contents. Higher values of Zr occur in the dyke rocks related to the shoshonitic granitoid plutons.

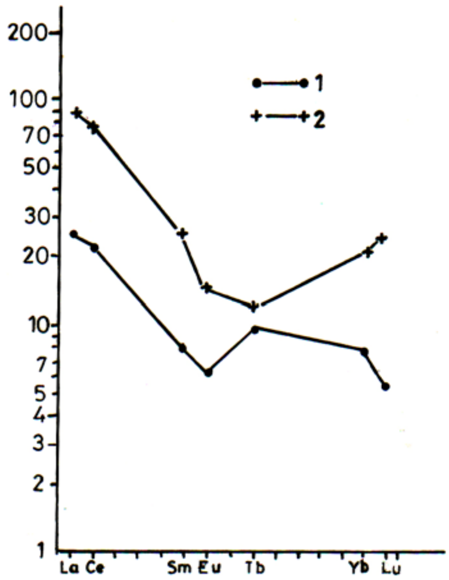

Fig. 6. Chondrite-normalized REE patterns of two aplites from the SCGP. Data from Tables 2 and 3. 1, Poneasca acid (leucocratic) aplite[26]; 2, Tismana shoshonitic aplite[19].

The rare earth elements (REE) have been determined in two aplites, only: one from the Poneasca common rock granitoid pluton[26] and other from the Tismana shoshonitic pluton[19]. What is interesting in these two rocks, is the fact that their chondrite-normalized REE patterns (Boynton normalizing values[27]) are almost parallel in the LREE segment, from La to Eu, and are diverging in the HREE segment (Fig. 6). It is also of note that the Poneasca aplite shows a strong Eu negative anomaly and the Tismana aplite a Tb negative anomaly.

TECTONIC SETTING OF THE DYKE ROCKS

Before, there was shown that the common rock granitoid plutons from the SCGP belong to the island arc granitoids (IAG)[1], save the shoshonitic granitoid plutons the average chemical composition of which indicates intraplate granitoids (WPG)[3]. The dyke rocks related to the first granitoid plutons are also belonging to the island arc (syn-collision) granitoid category, as shown by the diagram in Figure 7. On this diagram even the aplite related to the within plate Tismana shoshonitic granitoid pluton fall in the syn-collision granitoid field. This situation shows that there is not always a strict correlation between the direct products of the parental magma and those of the highly differentiated fractions of this magma, like the aplitic rocks, for instance. .

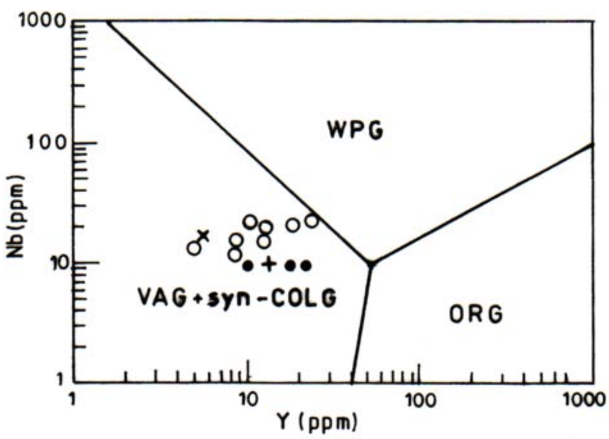

Fig. 7. Plot of the dyke rocks on the Nb vs. Y diagram. Fields according to Pearce *et al.*[28]: VAG + syn – COLG, volcanic arc granitoids + syn-collision granitoids; WPG, within plate granitoids; ORG, ocean ridge granitoids. Data are from Tables 1, 2 and 3. Legend as in Figure 1.

However, the relationships between the low-content major elements like Ti, Mn and P (Fig. 8) show that a few dyke rocks occur under the tectonic conditions of an island arc. Most of them are plotting in the within plate rock field and out of any characteristic fields. This discrepancy can be determined by the fact that the dyke rocks came from different granitoid magma chambers, the magmas of which had their own differentiation trend.

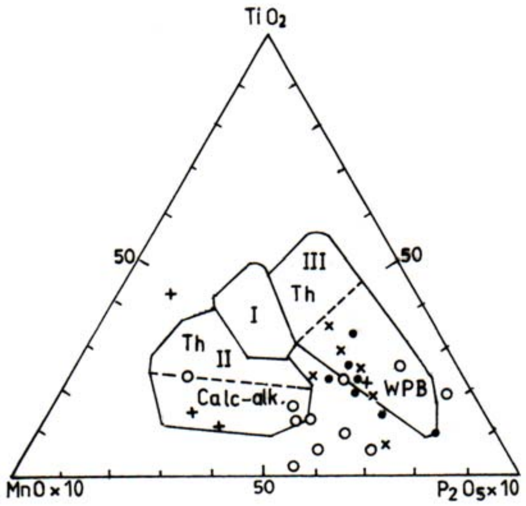

Fig. 8. Plot of the dyke rocks on the Ti–Mn – P diagram. Fields according to Mullen[29]: I, ocean floor rocks; II, arc calc-alkaline rocks; III, within plate rocks. Data from Tables 1, 2 and 3. Legend as in Figure 1.

The discrepancy between the dyke rocks from the SCGP are also manifest on the diagram in Figure 9, in which the relations FeO*/ FeO* + MgO *vs*. SiO_2 and TiO_2 *vs*. SiO_2 are taken into consideration. On the first diagram the dyke rocks plot at random within its different fields. A more clear feature of the dyke rocks results from the TiO_2 vs. SiO_2 diagram. On this diagram all of the dyke rocks plot in the CEUG field, in which rocks occurring under the continental epeiorogenic uplift conditions are usually situated.

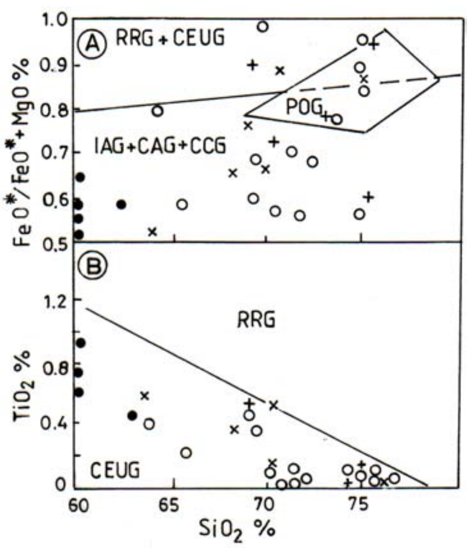

Fig 9. Plot of the dyke rocks on the FeO* / FeO* + MgO *vs* SiO_2 and TiO_2 *vs*. SiO_2 diagrams. Fields according to Maniar and Piccoli[30]: RRG, rift related granitoids; CEUG, continental epeiorogenic uplift granitoids; POG, post orogenic granitoids; IAG, island arc granitoids; CAG, continental arc granitoids; CCG, continental collision granitoids.

The last observation is consistent with the observations obtained from the diagrams in Figures 7 and 8. All of them suggest that the dyke rocks intruded after the emplacement of the syn-orogenic and late-orogenic granitoid plutons, during the Late Precambrian to Ordovician period. Then the Pre-Carpathian framework was uplifted under the late-collision to post-collision conditions (see the model in Savu[31]).

ORIGIN OF THE DYKE ROCKS PARENTAL MAGMAS

The chemical composition (Tables 1 to 3) of the dyke rocks shows that they originated in calc-alkaline of mantle-source magmas. According to the data from these tables, in the dyke rocks the Al_2O_3 / CaO + Na_2O + K_2O ratio is higher than 1.1. The SiO_2 content varies between 62 and 75 % and the value of the K_2O / Na_2O ratio is usually very low. According to Chappell and White[32] all of these values indicate granitoid rocks originating in juvenile magmas. Besides, in the mineralogical composition of these rocks there occur mineral assemblages including green hornblende, sphene and magnetite; sometimes a clinopyroxene is present there. The presence of these minerals in the dyke rock composition shows, according to the same quoted authors, their origin in juvenile parental magmas *i.e.* mantle source magmas. This conclusion clearly results from the diagram in Figure 10.

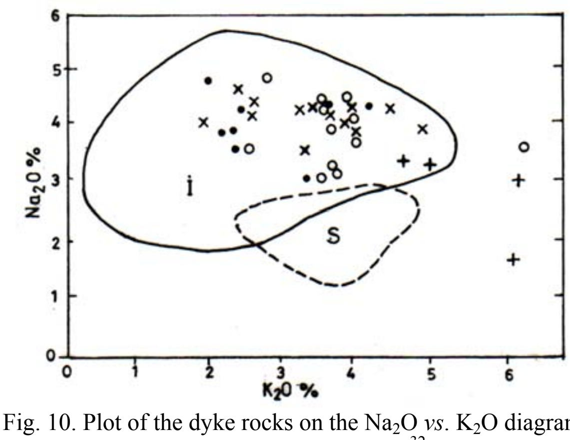

Fig. 10. Plot of the dyke rocks on the Na_2O *vs*. K_2O diagram. Fields according to Chappell and White[32]. I, magmas of juvenile origin; S, magmas resulted from sedimentary materials. Data are from Tables 1, 2 and 3. The same legend as in Figure 1.

The parental magmas of the dyke rocks were calc-alkaline magmas, which derived from a metasomatic mantle source (see Roden and

Murthy[33]), occurred over the subduction plane of the subduction system above mentioned[1].

It seems that in this metasomatic mantle numerous magma chambers were formed, because the dyke rocks associations derived from these calc-alkaline magmas are variable.

From these parental magmas there resulted both the common rock dykes and the trondhjemitic dykes, the compositions of which are very close to that of the rocks from the related granitoid plutons. It is of note that the features of the highly differentiated dyke rocks, such as some aplites, somehow differ from that of the parental magmas, as shown above.

The Tismana aplite (Table 3) related to the shoshonitic granitoid pluton, also shows shoshonitic characteristics, because its value of (Dy / Yb)N ratio of 0.21 and that of (Ce / Yb)N ratio of 3.6 would place this rock in the plume-source domain (see Savu[3]). In spite of all these observations, on the diagram in Figure 7 this aplite did not fall in the within plate field, thus differing from the average of the Tismana massif rocks.

CONCLUSIONS

Within the South Carpathian area dyke rocks occur all along the SCGP, but they are mostly located inside or around the granitoid plutons they are related to.

Depending on their general features, the dyke rocks have been separated into two main division, each of them including common rock, trondhjemitic and shoshonitic dyke rocks.

The chemical composition of the dyke rocks evidenced a general calc-alkaline dyke rock- series with a weak alkaline tendency.

The parental magmas of the first two groups above shown originated in a metasomatic mantle source, occurred above the subduction plane of the subduction system that generated the process of mantle metasomatism and the genesis of the calc-alkaline parental magmas. The Tismana aplite dykes are an exception, because they derived from a mantle plume-source, like the Tismana shoshonitic pluton itself.

The tectonic setting indicates syn-collision to post-collision intrusion of the dyke rocks, which were intruded within the SCGP area when the precursor granitoid plutons had cooled off and different types of joints and initial fractures had started to occur along which the dykes have been located.

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