ZONING IN THE ALKALI -FELDSPAR MEGACRYSTS FROM THE SĂVÂRŞIN SHOSHONITIC GRANITE, DROCEA MOUNTAINS, ROMANIA

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The Săvârşin shoshonitic granite, in which the zonal structure in the alkali-feldspar megacrysts occurs, represents an island arc intrusion. The zonal structure consists of zones of orthoclase-anorthoclase alternating with zones of albite-oligoclase. The bulk composition of the alkali-feldspar megacrysts is one of orthocalse, the amount of plagioclase mentaining in it in the limits of its definition. In the composition of these alkali-feldspar megacrysts there occur also low contents of Ca, Ba and Fe. These minerals show a normal to high value of the K/Rb ratio. The formation of the zonal structure was controlled by two control factors, namely, the equal concentration of K_2O and Na_2O in the parental shoshonitic magma, which determined a rhythmical crystallization of the zonal alkali-feldcpar megacrysts, and the oscillating vapour tension in the magma, acting under orogenic conditions lacking of stress.

Key words: Shoshonitic granite; Alkali-feldspar megacrysts; Zoning; Composition; Origin.

INTRODUCTION

It was Săvârşin where I first met, in 1952, the geological formations of the Mureş ophiolitic suture. Since, I paid a special attention to the structure, geochemistry and origin of the granitoid massif of Săvârşin, presenting these aspects in different papers. In the light of these previous studies, now my intention is to describe the zoning process that manifested itself in the genesis of the alkali-feldspar megacrysts from the Săvârşin shoshonitic granite from the southern part of the massif, a phenomenon that was only shortly presented in two previous papers[1, 2]. It represents in this region an occurrence as strange as the shoshonitic granite itself, maybe more.

OCCURRENCE OF THE SĂVÂRŞIN SHOSHONITIC GRANITE AND ITS PORPHYRITIC TEXTURE

The Săvârşin granitoid massif is located in the basin of the Mureş Valley. There it is emplaced in the ophiolitic formations of the Mureş ophiolitic suture (see Savu *et al.*[3]; Savu[4]). The genesis of the granitoid massif was determined by the closing of the Mureş Ocean, due to a bilateral subduction of its ocean crust[5]. It was directly engendered by the subduction of Andean-type, that manifested itself along the island arc from the southern flank of the ophiolitic suture[4].

The Săvârşin granitoid massif consists of two twin intrusions, namely, the Temeşeşti diorite-granodiorite sphenolith, in the north, and the Săvârşin shoshonitic laccolith the south, the present paper is dealing with. The last intrusion is located on the Mureş River (Fig. 1), and it was strongly eroded by this river. As shown in Figure 1, the Săvârşin laccolith is an asymmetrical pluton, since its root is situated in its northeast extremity, where it is marked by a negative gravity anomaly. The parental shoshonitic magma was intruded through this funnel and extended toward southwest through the ophiolitic rock pile, there forming the shoshonitic laccolith, as the long arrow in Figure 1 shows (see also Savu[2]).

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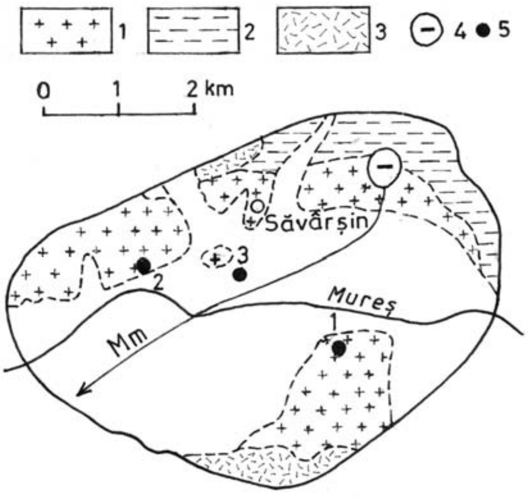

Fig. 1. Sketch-map of the Săvârşin shoshonitic laccolith: 1. large porphyritic granite; 2. granite in marginal facies; 3. contact zone; 4. negative gravity anomaly; Mm, general trend of the shoshonitic magma motion through the laccolith.

The Săvârşin shoshonitic laccolith consists mostly of large porphyritic granite and a northern marginal zone, consisting of the same shoshonitic granite, but occurring in a marginal facies, as a porphyritic microgranite. The large porphyritic granite from which the alkali-feldspar megacrysts – this study is referring to – have been collected, is a pale-pinkish rock, which consists of quartz, alkali-feldspar megacrysts, plagioclase, green hornblende, biotite and accessory minerals. The alkai-felspar megacrysts are pinkish in colour and their size varies from 2 to 3 cm, rarely 4 cm. The groundmass of the granite contains reduced amount of alkali-feldspar. In the rarely occurring pegmatoid granites quartz forms graphic intergrowths with the alkali-feldspar, especially around the megacrysts. Plagioclase is represented by hypidiomorphic crystals showing a zonal structure and polysynthetic twins. Its composition varies from the core where is nearly an andesine (An_{30}), toward the margin where it reaches, in the last zone, the composition of albite (An_{10}). Hornblende is a common green variety, which forms small elongate crystals. Often, it is associated with biotite lamelae, a mineral that is prevalent in some rock samples. In the interstices between these minerals xenomorphic quartz granules do occur.

The average modal composition of the large porphyritic granite is as follows: 28 % quartz, 27.57 % up to 44 % alkali-feldspar, 20 % plagioclase; 5.5 % hornblende, 1.5 % biotite and 2.8 % accessory minerals, like sphen, apatite, zircon and magnetite or haematite.

According to its composition, the Săvârşin shoshonitic granite resulted from a juvenile magma[6] and belongs to the subsolvus–type of granites (see Tuttle and Bowen[7]).

The average chemical composition calculated from four analyses from Savu and Vasiliu[1] is as follows: 70 % SiO_2; 0.34 % TiO_2; 15.27 % Al_2O_3; 1.20 % Fe_2O_3; 1 % FeO; 0.04 % MnO; 0.82 % MgO; 1.12 % CaO; 4.18 % Na_2O; 4.47 % K_2O; 1 % P_2O_5; and 0.82 % H_2O^+. This average chemical analysis shows that the contents of Na_2O and K_2O are almost equal. This equality represents, in fact, the peremptory argument for some volcanics to be considered as shoshonitic rocks (see Cullers and Graf[11]). But the clear shoshonitic character of the Săvârşin granite results from the diagram in Figure 2, on which most samples of the granite plot in the shoshonitic field.

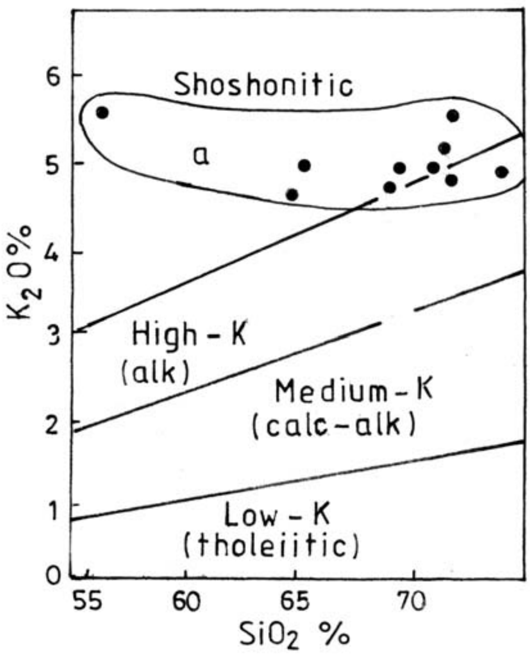

Fig. 2. Plot of the chemical analyses of the Săvârşin shoshonitic granite on the K_2O *vs* SiO_2 diagram. Fields according to Peccerillo and Taylor[8], Rickwood[9] and Laméyer and Bonin[10].

From the average chemical analysis there was calculated the average normative composition of the shoshonitic granite, that is as follows: 29.47 % q; 27.77 % or; 32.32 % ab; 4.72 % an; 1.5 % di; 1.75 % hy; 0.82 % c; 0.34 % hm; 0.40 % il; 0.12 % pr. Due to the large porphyritic texture of the shoshonitic granite, an accurate modal or chemical (normative) analysis of these rocks is very dificult to perform (see also Chayes[12] and Vorma[13]). Between the modal and normative analyses, presented, above there occur differences, especially in case of K_2O and Or (orthoclase), respectively. It is of note that, according to its texture and to the above analyses the Săvârşin shoshonitic granite is consistent with some old rapakivi granites from Finland, I visited in 1973, east of Helsinki. (see the chemical data in Vorma[13]). The K/Ar age of Săvârşin granite is of about 30 Ma.[14]

ZONING IN THE ALKALI-FELDSPAR MEGACRYSTS

The light pinkish alkali-felspar megacrysts do not always show any crystallographic faces, since their albitic margins are crenelated by the groundmass small crystals. More often the Karlsbad twin occurs in the megacrysts structure, which marks their monoclinic symmetry of high temperature (> 700^0 C). Otherwise, Savu and Vasiliu[1] determined by means of the bifeldspatic geologic thermometer the crystallization temperature of the Săvârşin granite at about 710^0 C.

But the most important feature of the alkali-feldspar megacrysts from the Săvârşin shoshonitic granite is their rhythmical zonal structure. It was observed under microscop as far back as in 1953 (Savu, unpubl. rep.). This structure consists of concentric zones that fit the crystallographic faces of the mineral (see also the microphotograph in Savu and Vasiliu, Pl. II, Fig. 1)[1].

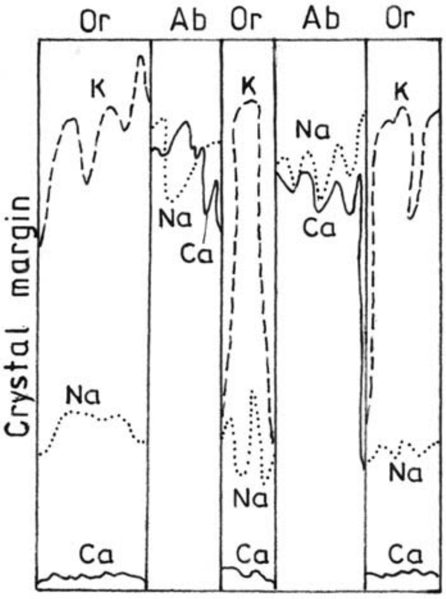

Fig 3. Diagram showing the variation of K, Na and Ca in some marginal zones of a zonal alkali-feldspar megacryst, determined by means of a Cameca microanalyser.

The composition of the zones from the magacryst clearly results from the data of a microanalysis presented in Figure 3. In this figure the results of a cross-section analysis made by means of a microanalyser on a polished megacryst sample from the granite in the Cetăţuia Hill are presented. It shows that, according to the K, Na and Ca patterns, in the megacryst structure zones of orthoclase-anorthoclase alternate with zones of albite-oligoclase. Even inside of these zones there are variations of the three chemical elements, marking very thin zones from the cryptic microstructure of the thick zones. The thickness of the large zones is variable. In the orthoclase-anorthoclase zones Ca is always present, yet in very small contents. Otherwise, Winchell and Winchell[15] established that, in the orthoclase network Ca, Ba and Rb participate with 1 mol per cent.

CHEMICAL COMPOSITION OF THE ALKALI-FELDSPAR MEGACRYSTS

The chemical composition of three alkali-feldspar megacrysts was presented in Table 1. This table shows that, in spite of the fact that the samples of alkali-feldspar megacrysts have been collected at long distances from one another, their composition is very close. It indicates that the parental shoshonitic magma of the granite laccolith was very uniform in composition.

Table 1

Chemical compositiuon (%) of three alkali-feldspar megacrysts (data from Savu and Vasiliu[1])

Sample	1	2	3	Average
SiO_2	63.94	64.20	63.87	64.00
TiO_2	0.03	0.03	0.03	0.02
Al_2O_3	19.78	19.58	19.87	19.74
Fe_2O_3	0.23	0.23	0.26	0.24
CaO	0.39	0.35	0.37	0.37
BaO	1.05	0.81	1.03	0.96
Na_2O	3.27	3.13	3.04	3.14
K_2O	10.88	10.60	10.04	10.50
H_2O	0.20	0.26	0.27	0.20
Total	99.77	98.84	98.78	98.85

It results from this table that in the composition of the alkali-feldspar megacrysts K_2O is the main oxide. It forms the component orthoclase ($KAlSi_3O_8$), the amount of which is of 65.77 % (Table 2). Besides, there have been added components like $NaAlSi_3\ O_8$ about 30 %, $Ca_2Al_2Si_2O_8$ cca 1.36 %, and $Ba_2Al_2Si_3O_8$, 1.75 %.

The amounts of these components are situated in the limits estimated by Winchell and Winchell[15]. The content of Fe_2O_3 occurring in the analyses could be contained either in the component of K FeSi3O8 or in the possible inclusions of iron oxides in the alkali-feldspar megacrysts. Water is relayed to the caolinite, which occurs as a product of alteration.

The normative components of the alkali-feldspar megacrysts, calculated from the analyses in Table 1, have been presented in Table 2.

Table 2

The normative composition (%) of the alkali-feldspar megacrysts

Sample	1	2	3	Average
Or	67.60	66.32	63.40	65.77
Ab	28.43	30.19	33.26	30.62
An	1.83	1.77	0.48	1.37
Cn	1.87	1.48	1.92	1.75
Mt (Hm)	0.20	0.20	0.20	0.20
Total	99.93	99.87	99.26	99.71

According to the values of the components from Table 2, the three alkali-feldspsr megacrysts have been plotted on the Or-Ab-An diagram (Fig. 4).

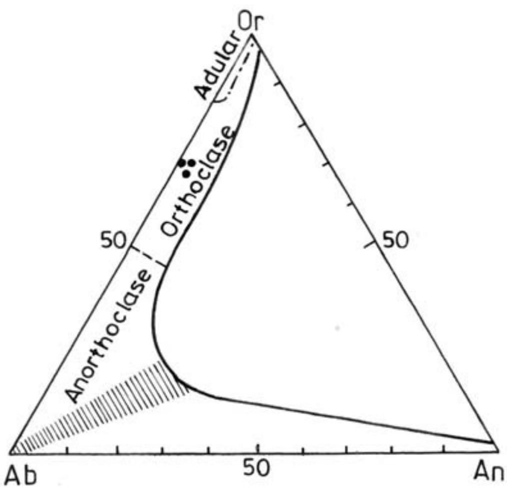

Fig. 4. Plot of the three alkali-feldspar megacrysts on the Or-Ab-An diagram. Fields according to Tröger[16].

On this diagram all of the megacrysts plot in the field of orthoclase. This fact shows that the alkali-feldspar megacrysts from the Săvârşin shoshonitic granite are represented by a variety of albite-rich orthoclase, in which a zoning process manifested itself during its crystallization.

The plot of these minerals on the diagram in Figure 5 shows that, they are normal or high K/Rb ratio alkali-feldspars. On this diagram they fall in the field of this type of alkali-feldspars, studied by Heier and Taylor[17] in 1959.

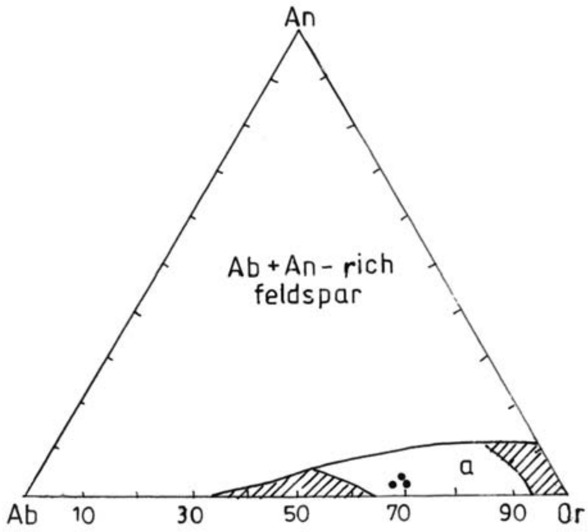

Fig 5. Plot of the three alkali-feldspar megacrysts on the Or-Ab-An diagram. Fields according to Heier[18]: a. field of the alkali-feldspar with normal or high value of the K/Rb ratio.

Some trace elements possible to be determined in the alkali-feldspar megacrysts, have been presented in Table 3.

Table 3

The contents (ppm) of some trace elements in the three alkali-feldspar megacrysts

Sample	1	**2**	**3**	Average
Pb	12	13	13.5	12.5
Ga	16	14	17	15.6
Li	2	5	2	3.0
Sr	3000	3000	3000	3000
Ba	9400	7200	9200	8600
Mn	80	80	80	80

This table shows that Ba and Sr participate in these minerals with high contents. Higher contents (14330 ppm) of Ba have been quoted by Heier[18] in some sanidines. These high contents can be explained by the close values of the ionic radius of the trace elements and that of some major elements, which enter in the composition of the alkali-feldspar, as the above presented formulae showed. For instance, the ionic radius of Ba is of 1.43 Å and that of K, in the position of which Ba is captured, is of 1.33Å. Sr the ionic radius of which is of 1.27 Å can be captured in the position of both K and Ca. Other trace elements like Pb, Ga, Li and Mn have been determined, too, which show normal contents in such minerals. It is worth noticing that Ni, Co, Cr, V, Be and Sn present undetermined contents.

ORIGIN OF THE ZONAL STRUCTURE OF THE ALKALI- FELDSPAR MEGACRYSTS

The zoning process in alkali-feldspar is rarely observed in the nature. Therefore, usually it is not described in the mineralogical treatises, yet it is an interesting phenomenon. About it Schermerhorn[19] showed that such zonal structure in alkali-feldspars indicates some variations of the Na_2O in the magma.

According to my observations in the present case and in case of the zoning process in plagioclase crystals from the volcanic rocks, in the zoning process manifested itself in the alkali-feldspar megacrysts from the Săvârşin shoshonitic granite acted two control factors. A first control factor could have been the almost equal concentration of K_2O and Na_2O in the parental shoshonitic magma. As shown above, the concentration in the shoshonitic magma of K_2O was of 4.47 % and that of Na_2O of 4.18 %. Under these conditions there could have occurred the rhythmical crystallization of the zones of different composition of the alkali-feldspar megacrysts, in which the K^+ and Na^+ ions from the magma have been included.

This rhythmical crystallization could have been controled by another factor, which, in fact, would alone have determined a zonal structure. This second control factor could have been the oscillating vapour tension in the parental magma[20] of the shoshonitic granite. But, it must be underlined that the two controlling factors of the zonal structure acted under orogenic conditions lacking of stress. If stress should have acted, probably the alkali- feldspar megacrysts would have crystallized as microcline or microcline-perthite, like the alkali-feldspar magacrysts from the late orogenic shoshonitic plutons in the South Carpathian granitoid proviunce (Savu, in press.) and from the shoshonitic rapakivi granites in Finland[13]. However, the most important factor that determined the lack of any zonal structure in the alkali-feldspar megacrysts from the last granitoids was the unequal contents of K_2O and Na_2O in their parental shoshonitic magmas, the first component being far higher than the second one.

CONCLUSIONS

The Săvârşin granite laccolith in which zonal alkali-feldspar megacrysts occur, is a shoshonitic granite, in the parental magma of which K_2O and Na_2O participated in almost equal amounts. Among the determined trace elements Ba and Sr are remarkable by their high contents.

The zonal structure of the alkali-feldspar megacrysts consists of alternating zones of orthoclase-anorthoclase and albite-oligoclase that show a variable thickness.

Two factors controlled the occurrence of the zoning process evolution in the alkali-feldspar megacrysts, which acted under orogenic conditions lacking of stress. The main control factor could have been the equal concentration of K_2O and Na_2O in the parental shoshonitic magma. It favoured the rhythmical crystallization of the alkali-feldspar megacrysts in the network of which the ions of K^+ and Na^+ have been rhythmically included. The second control factor could was the oscillating vapour tension in the parental shoshonitic magma.

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