50 years University of Mining and Geology "St. Ivan Rilski"
Annual, vol. 46, part I, Geology and Geophysics, Sofia, 2003, pp.19-24

PETROLOGICAL CHARACTERISTIC OF ALKALINE BASALTOIDS FROM THE REGION OF ST. SPAS BAKADJIK, YAMBOL DISRICT

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ABSTRACT
The alkaline basaltoids are spread in the northern and western slopes of St. Spas Bakadjik and near Pobeda village, Yambol district. They have the form of small sub-volcanic bodies and dikes located among the Upper Cretaceous pyroclastites of the Bakadjik formation and are also found as lithoclasts in the agglomerates in the region. The alkaline basaltoids are built by clinopyroxene and olivine phenocrysts and pseudoleucite subphenocrysts. Pseudoleucite is idiomorphic in the form of single crystals with well preserved primary morphology or in the form of groupings. It is composed of analcime (on places with zones of clinopyroxene inclusions) and K-feldspar. The main mass is composed of clinopyroxene and plagioclase microlites, olivine, pseudoleucite, K-feldspar. The accessory minerals are magnetite, titanomagnetite (in the form of complex framework-nucleation crystals) and apatite. Volcanites are undersaturated in SiO_2, olivine and nepheline, normative. They are with increased potassium alkalinity (K_2O/Na_2O - 1.01-1.47) and shoshonitic series. The index of hardening (SI - 38-42) and the index of differentiation (D.I. -18-23) are close to those of the primary weakly differentiated magma.

INTRODUCTION

The alkaline basaltoids are relatively rare rocks in nature. Their specific, in some cases, exotic mineral composition catches the attention of many researchers. In Eastern Srednogorie these rocks are distributed predominantly in Tamarino Bakadjik, where they have been subjected to specialized investigations (Stanisheva, 1968, 1969). The alkaline basaltoids in St. Spas Bakadjik are of more restricted distribution and are not so well studied. The alkaline basaltoids from the region of Pobeda village (Yambol region) are described by Stoinov (1955) as melanocratic shoshonites. Later, these rocks have been defined as analcimic basalts (Stanisheva, 1968). On the base of normative composition calculated following the system of Rittmann they have been nominated as tephrites (Popov & Antimova, 1982). The interest towards these volcanites is provoked both by their unclear classification and nomenclature position as well as by the supposition stated for the first time by Stoinov (1955) that analcime in them is at the expense of leucite. The paper presents the results of the petrologic investigations of the alkaline basaltoids from the volcanic and explosive facies as well as first the first evidence for the composition and genesis of psedoleucite in the volcanites from the region of St. Spas Bakadjik.

GEOLOGICAL SETTING

The alkaline basaltoids crop out in restricted areas to south of Pobeda village (Tepeto site) and along the northern and western slopes of St. Spas Bakadjik. They are in the form of small subvolcanic bodies and dikes located among the Upper Cretaceous pyroclastites of Bakadjik Formation. These rocks are also found in the products of the explosive facies, which is widely spread in the region. The pyroclastites in the region of Bakadjiks have been related to different lithostartigraphic units. According to Petrova and Simeonov (1989) they belong to the Bourgas Group while the volcanites - to the Michurin Group. Popova and Antimova (1982) relate the rocks from Bakadjiks to the Novopanicharevo Formation. Later, the same rocks have been related to the Bakadjik (Popov et al., 1993) and Draganovo (Savov and Filipov, 1995) Formations.

PETROGRAPHIC CHARACTERISTIC

The alkaline basaltoids of the volcanic facies are black with porphyric texture and massive structure. They are built by pyroxene, olivine, pseudoleucite, plagioclase, K-feldspar, analcime, magnetite, titanomagnetite, and apatite. The phenocrysts (50-55%) are of pyroxene and olivine. Clinopyroxene (30-35%) is light green, fresh, short-prismatic or isometric (2-5 mm), and with a clear zonal structure. Contains inclusions of olivine and magnetite and on places is magmatically corroded as a result of interaction with melt enriched in potassium. In these case the peripheral part of olivine are densely contoured by pseudoleucite crystals (Fig. 1a). Olivine (15-20%) is relatively fresh (in many cases with regular crystal forms) and with peripheral serpentinization locally penetrating the central parts of the crystal along fissures. The subporphyric generation is represented by pseudoleucite, clinopyroxene, and olivine. The pseudoleucite aggregates (0.08 to 0.12 mm) are composed of analcime with a peripheral stripe of K-feldspar (Fig. 1b) and form pseudomorphoses after leucite with not preserved relics. The aggregates comprise 15% of the rock volume and are irregularly distributed. The pseudoleucite subphenocrysts are in the form of single crystals or are groupings of several individuals. They are with a well preserved primary morphology - isometric, rounded, and on places with zonings of clinopyroxene inclusions (Fig. 1c). The groundmass is fully crystalline and is composed of disordered crossing relatively large plagioclase microlites. They are without clear contours and are partially altered to K-feldspar. The interstitial space is occupied by a great quantity of prismatic clinopyroxene microlites with square sections, rare olivine grains, K-feldspar,

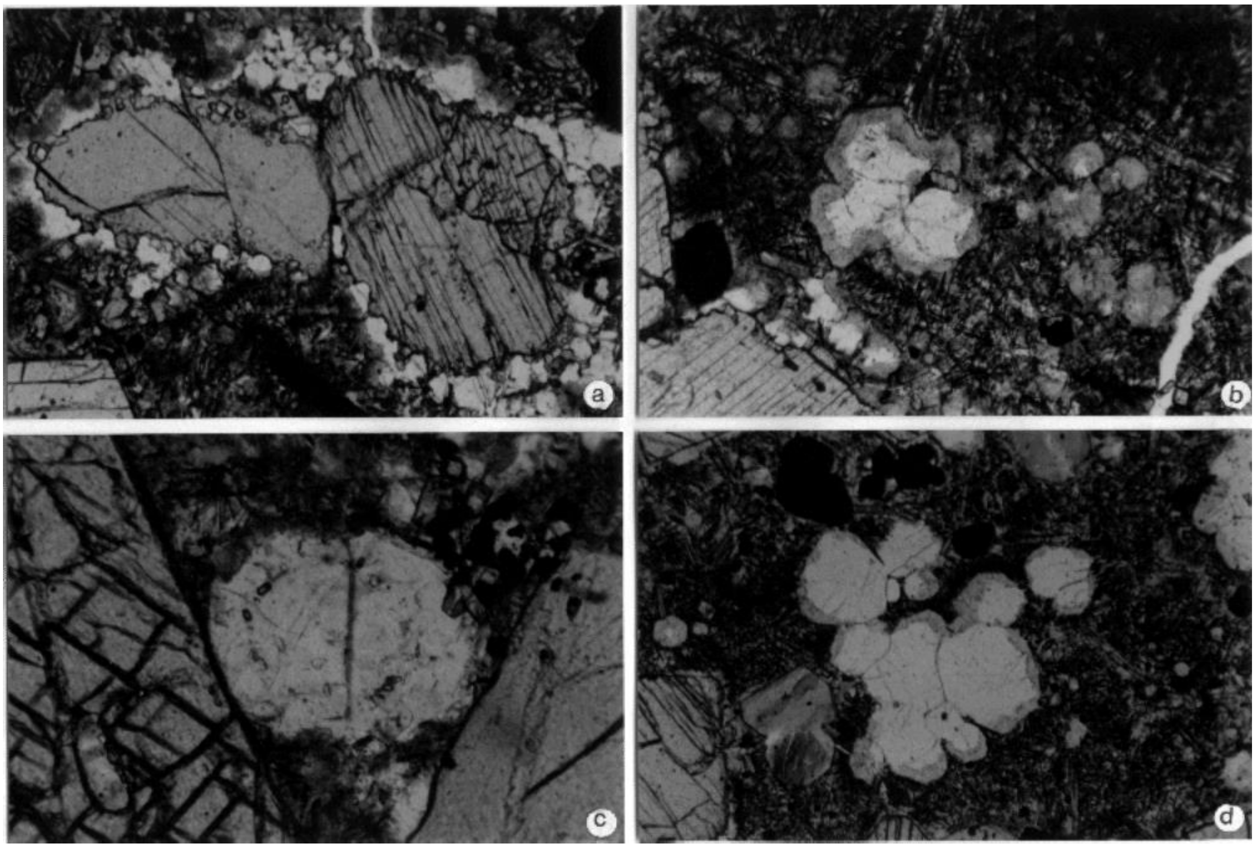

Figure 1. Microphotographs of pseudoleucite aggregates from alkaline basaltoids from the St. Spas Bakadjik: a - magmatically corode diopside with pseudoleucite crystals are disposed on the periphery; b - pseudoleucite aggregates of analcime with a peripheral stripe of K-feldspar (in the center) or entirely replaced by K-feldspar (to the right); c – psedoleucite subphenocryst with zonal inclusions of clinopyroxene; d - pseudoleucite aggergates of analcime with a peripheral stripe of K-feldspar. Figures a÷d II N. Base of figures a, b and d – 1.46 mm, figure c – 0.55 mm

and small biotite scales. Except as subphenocrysts pseudoleucite participates in the composition of the groundmass as well. It has irregular distribution and is most often in the form of irregular aggregates of isometric, rounded crystals with prevailing size of 0.03 to 0.07 mm. On places, between the separate individuals there are localized small biotite scales, which emphasize more clearly the morphology of the crystals. Opposite to the subphenocrysts the pseudoleucite aggregates of the groundmass are most often composed only of analcime or K-feldspar. In rare cases analcime is contoured by a peripheral stripe of K-feldspar. In the regions of greater concentration of pseudoleucite crystals the texture is ocellar. The accessory minerals are represented by magnetite, skeletal-nucleus crystals of titanomagnetite and markedly elongated needle-like apatite. The amygdales are relatively rare and are filled with zeolites.

The alkaline basaltoids from the explosive facies of the northern and western slopes of St. Spas Bakadjik are of analogous composition. They are black, fine porphyric, and with a massive structure. Built are by clinopyroxene and olivine phenocrysts and subphenocrysts, pseudoleucite, plagioclase, analcime, K-feldspar, magnetite, and titanomagnetite. The phenocrysts are about 35-40% of the rock volume. Clinopyroxenes are the prevailing ones (25-30%). They are fresh and with a zonal structure type sand watch with inclusions of serpentinized olivine and magnetite. In some cases corrosion bays are observed in the peripheral parts of pyroxenes being probably a result of interaction with the melt. Olivine (8-10%) is sized 0.7-0.8 mm and is replaced along the periphery and the fissures by serpentine. On places it is fully altered in serpentine. Pseudoleucite (0.08-0.30 mm) is predominantly subphenocrysts and clearly idiomorphic with fully preserved primary morphology in the form of single isometric rounded crystals or groups of several individuals (Fig. 1d). It is replaced by analcime having a reaction stripe of K-feldspar. The groundmass is composed of thin-prismatic to needle-like clinopyroxene and poorly shaped plagioclase microlites, crystallites, and a great quantity of skeletal-nucleus crystals of titanomagnetite forming a dense network. The crystallization row of the minerals from the porphyric and subporphyric generation of both facieses (determined by crystal morpholgy and mineral relations) is: magnetite - olivine - clinopyroxene - pseudoleucite. The row of crystallization in the groundmass is first olivine then clinopyroxene, pseudoleucite, apatite, titanimagnetite, and finally plagioclase.

The mineral composition of the pseudoleucite alkaline basaltoids of volcanic and explosive facies is close but displays some differences. Most of all they can be related to quantitative relations (gerater quantity of olivine and pseudoleucite in the volcanites, with psedoleucite being mainly in the groundmass while in the lithoclast it is mainly in the form of subphenocrysts) of the rock forming minerals and to textural features (degree of crystallinity) of the rock. Probably, the textural differences between the alkaline basaltoids of the two facieces are due to different crystallization conditions. It can be proposed that the coarse porphyric and with fully crystalline groundmass volcanites near Pobeda village had been formed in subvolcanic conditions while the alkaline basaltoids of the explosive facies - in conditions characterized by much more intense crystallization.

MINERAL CHEMISTRY

The clinopyroxenes are magnesium rich **(**Mg# – 74.3-81.6) with the value of Mg# being higher in the lithoclasts. According to the classification of Morimoto (1988) the clinopyroxene of the volcanic facies is diopside and from the explosive one – mainly augites and diopsides. The clinopyroxenes are zonal. The composition of their central parts if $Wo_{43-50}En_{38-45}$ and of the peripheral zones is $Wo_{46-50}En_{36-42}$. In a chemical aspect there is observed an increase in Fe content and a decrease of Mg content from core to rim of the crystals (Table 1). The alkaline oxides mark a weak increase towards the periphery.

The olivines are magnesium rich ($Fo_{76-83}Fa_{17-24}$) and the content of the forsterite molecule in the olivines of the volcanite is higher than that in the lithoclasts. From the central to peripheral parts of the crystals the content of Si and Fe increases while that of Mg decreases (Table 1).

The pseudoleucite aggregates are built by analcime and K-feldspar. Analcime is with a constant composition with only insignificant variations and without major differences between the volcanites and lithoclasts including analcime in the peripheral parts of the magmatically corroded clinopyroxene (Table 2, sample 376/19). The most characteristic feature of the chemistry of K-feldspar from the alkaline basaltoids of the facieses is the high content of Or molecule ($Or_{76-97}Ab_{1-19}$). A relationship was found in the change of K_2O content in the K-feldspars of the subphenocryst pseudoleucite and in the small crystals of the groundmass. The content of Or molecule in K-feldspar ($Or_{76-83}Ab_{14-19}$) from the reaction cover of analcime is lower compared to the pseudoleucite crystals of the groundmass ($Or_{96-97}Ab_{1-2}$) (Table 3). The composition of the **plagioclase** microlites is ($An_{27-33}Or_{10-14}Cn_{1-1.4}$).

Table 1. Representative microprobe analyses of the clinopyroxenes and olivines from the alkaline basaltoids from the St. Spas Bakadjik region: c – core; r - rim

Mineral	clinopyroxenes						olivines			
Sample	376/1c	376/2r	376/14c	376/15r	361/1c	361/2r	376/12c	376/A r	361/7c	361/8r
SiO_2	52.25	50.98	52,58	52,67	52.17	50.41	40.11	41.04	38.66	40.42
TiO_2	0.44	0.51	0,34	0,24	0.55	0.50	0.11	0.12	0.00	0.00
Al_2O_3	3.01	4.19	2,07	1,99	3.13	4.34	0.69	0.57	0.00	0.37
$FeO^{(t)}$	6.73	7.29	6,95	7,67	6.46	6.85	15.49	16.17	19.59	20.85
MnO	0.04	0.20	0,18	0,20	0.09	0.12	0.72	0.63	0.37	0.42
MgO	14.45	13.64	13,11	12,45	16.04	14.61	42.72	41.59	40.52	36.83
CaO	23.29	22.46	24,20	24,24	21.48	22.40	0.22	0.15	0.35	0.60
Na_2O	0.02	0.05	0,00	0,00	0.16	0.44	0.00	0.00	0.00	0.00
K_2O	0.18	0.30	0,00	0,00	0.15	0.11	0.05	0.05	0.00	0.03
Total	100.41	99.62	99,43	99,46	100.23	99.78	100.11	100.32	99.49	99.52
Wo	47.84	47.50	50.41	50.81	43.92	46.50				
En	41.30	40.13	38.00	36.31	45.63	42.20				
Fs	10.86	12.37	11.59	12.88	10.45	11.30				
Mg#	79.3	76.9	77.1	74.3	81.6	79.2				
Fo							83.1	82.1	78.7	75.9
Fa							16.9	17.9	21.3	24.1

Analyses 376/1-13 и 361/1-5 (table 1-3) were carried out on JEOL Superprobe 733 by K. Rekalov
Analyses 376/14-19 и 361/6-12 (table 1-3) were carried out on JEOL JSM 35 CF Tracor Northern TN – 2000 by H. Stanchev

Table 2. Representative microprobe analyses of analcimes of the pseudoleucite aggregates from alkaline basaltoids from the St. Spas Bakadjik region: s – analcime subphenocrysts; g – analcime from groundmass

Mineral	analcimes										
Sample	376/6s	376/5s	376/19	376/4g	376/8g	376/7g	376/13g	376/17s	361/10s	361/5s	361/11s
SiO_2	53.26	54.19	54.44	54.82	55.15	55.67	55.76	55.78	53.36	54.08	55.41
TiO_2	0.23	0.04	0.00	0.06	0.13	0.02	0.00	0.00	0.10	0.00	0.06
Al_2O_3	23.61	22.19	21.66	22.46	22.30	22.89	24.05	23.09	22.64	22.23	21.63
$FeO^{(t)}$	0.62	054	0.63	0.48	0.34	0.52	0.33	0.71	0.52	0.51	0.48
MnO	0.00	0.05	0.00	0.04	0.12	0.00	0.02	0.00	0.03	0.00	0.02
MgO	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
CaO	0.59	0.48	0.46	0.43	0.14	0.20	0.57	0.24	0.44	0.41	0.42
Na_2O	11.64	11.53	12.93	11.81	12.31	12.16	9.50	12.19	11.27	12.09	10.75
K_2O	0.07	0.00	0.00	0.06	0.09	0.06	0.07	0.00	0.42	0.30	0.44
H_2O*	9.98	10.98	9.88	9.84	9.42	8.48	9.70	7.99	11.22	10.38	10.79
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00

*H_2O is calculated by difference to 100%

Table 3. Representative microprobe analyses of K-feldspars (from pseudoleucite aggregates), plagioclases, titanomagnetites: r – peripheral cover around analcime; g – groundmass; m – microlites

Mineral	K-feldspars						plagioclases		titanomagnetites	
Sample	376/11r	376/3g	376/10g	376/18r	361r	361/6r	376/16m	376/9m	361/9	361/12
SiO_2	61,74	63.18	63.24	64.88	63.64	65.48	58.12	59.41	0.28	0,17
TiO_2	0.14	0.01	0.04	0.00	0.09	0.13	0.00	0.00	4.27	3,89
Al_2O_3	21.32	19.05	19.35	16.68	20.33	15.48	23.94	24.46	1,02	0,86
$FeO^{(t)}$	0.89	0.29	0.17	0.23	1.06	0.90	0.42	0.39	92.07	93,10
MnO	0.09	0.00	0.00	0.13	0.00	0.00	0.02	0.04	1.63	1,57
MgO	0.53	0.00	0.00	0.00	0.69	0.00	0.00	0.00	0.24	0,26
CaO	0,77	0.26	0.33	0.58	0.63	0.40	7.62	5.43	0.37	0,20
Na_2O	1.92	0.16	0.24	1.71	1.93	2.50	6.83	6.37	0.00	0,00
K_2O	12.42	16.36	16.42	15.54	11.25	15.17	2.03	2.39	0.00	0,00
BaO	0.06	0.00	0.00	0.00	0.00	0.00	0.70	0.74	0.00	0,00
Total	99.88	99.31	99.79	99.75	99.62	100.06	99.68	99.23	99,88	100,05
Or	77.6	97.3	96.2	83.4	76.5	78.6	10.6	14.2		
Ab	18.2	1.4	2.2	14.0	19.9	19.7	54.6	57.4		
An	4.1	1.3	1.6	2.6	3.6	1.7	33.7	27.0		
Cn	0.00	0.00	0.00	0.00	0.00	0.00	1.1	1.4		

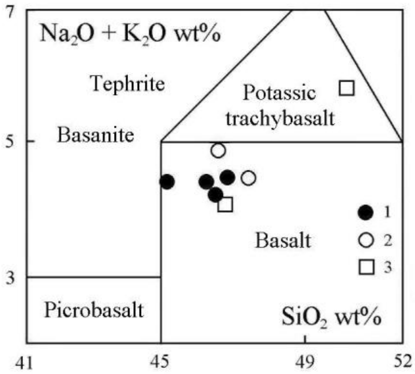

Figure 2. Total alkali vs. silica classification diagram (after Le Maitre et al., 1989) with the point of alkaline basaltoids from the St. Spas Bakadjik: 1 – Volcanic facies; 2 – Explosive facies; 3 - (shoshonite after Stoinov, 1955)

PETROCHEMICAL FEATURES

On the total alkali-silica classification diagram the studied volcanites fall in the field of the basalts and some being on the border with basanites. Only the described by Stoinov (1955) shoshonites from the Bimbal bair locality are in the field of the potassium trachybasalts (Fig. 2). According to the degree of SiO_2 saturation the basalts from field B on the TAS diagram can be subdivided into alkaline and subalkaline (Le Maitre et al., 1989). The content of normative nepheline give reason to relate the studied rocks to the alkaline basalts (Table 4). On the normative tetrahedron of Yoder and Tilley (1965) these volcanites dispose to the left of the critical plane of undersaturation of SiO_2 in the field of the alkaline basalts. In correspondence to the leading principle of IUGS for classification of the magmatic rocks, which is based on the modal composition (for any case when it can be determined) the described volcanites around Pobeda village, Yambol region have to be nominated as pseudoleucite basanites (containing modal clinopyroxene, olivine (>10%), plagioclase, and pseudoleucite), while the alkaline basaltoids of the explosive facies in the northern slopes of St. Spas Bakadjic – as pseudoleucite tephrites (with modal clinopyroxene, olivine (5-8%), plagioclase, and pseudoleucite).

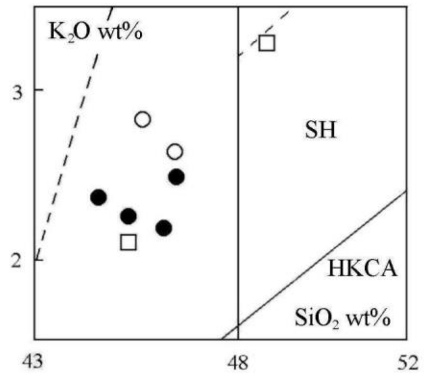

Figure 3. SiO_2 vs. K_2O (Peccerillo and Taylor, 1976) diagram with the point of alkaline basaltoids from the St. Spas Bakadjik Series: HKCA – high K calc-alkaline, SH – shoshonitic. Symbols as in Fig. 1.

The alkaline basaltoids are low-silica and high magnesium containing. They are undersaturated in SiO_2 with normative olivine and nepheline and with shoshonitic series (Fig. 3). With dominating shoshonitic series are also the other volcanic products of St. Spas paleovolcano (Banushev, 2001). K_2O dominates above Na_2O. The ratio K_2O/Na_2O is between 1.01 and 1.47 and is higher for the lithoclasts while the peralkaline index (P.I.) is from 0.56 to 0.63 (Table 4). The index of hardening (SI – 38-42) and the index of differentiation (D.I. – 18-23) are close to that of the primary weakly differentiated magmas.

The main petrogenic oxides of the volcanites and the chemical composition of the clinopyroxenes are used for discrimination of the tectonic environments. Using the diagram MgO-Al_2O_3-FeO^* (Pearce et al., 1977) one can see that the alkaline basaltoids of St. Spas Bakadjik display the character of within-plate ocean-island basalts (Fig. 4). This conclusion is confirmed also by the chemical composition of the clinopyroxenes (Fig. 5).

DISCUSSION

There is no doubt that one of the most interesting features of the alkaline basaltoids in the region of St. Spas Bakadjik is the established therein pseudoleucite aggregates (composed of analcime and K-feldspar), which form pseudomorphoses after leucite. The genesis of pseudoleucite is related to various processes. Many of researchers consider it being firstly crystallized as leucite, which, as a result of reaction with the enriched in Na residual magma transforms into nepheline-feldspar pseudomorphoses, the so-called pseudoleucite reaction (Bowen and Ellestad, 1937). Later, Fudali (1963) has proved that the sodium leucites can undergo a subsolidus breakdown resulting in the formation of twins of nepheline with K-feldspar. There are cases described for which it is considered that the primary pseudoleucite phase is analcime rich in K (Larsen, Buie, 1983).

Table 4. Chemical composition of alkaline basaltoids from St. Spas Bakadjik region

	Volcanic facies				Explosive facies	
	376/3	376/1	376/2	376	361/1	361
SiO_2	44.56	45.58	46.13	46.55	45.88	46.30
TiO_2	0.71	0.56	0.58	0.62	0.63	0.65
Al_2O_3	10.55	10.23	10.26	9.97	10.14	10.57
Fe_2O_3	8.83	8.92	7.90	9.36	8.18	7.44
FeO	4.17	3.78	4.62	4.10	3.87	4.75
MnO	0.18	0.14	0.13	0.19	0.19	0.18
MgO	12.54	12.41	11.95	11.15	11.87	11.03
CaO	12.42	11.89	12.60	12.31	12.16	12.09
Na_2O	2.09	2.17	2.16	1.89	2.02	1.82
K_2O	2.23	2.27	2.18	2.52	2.84	2.69
P_2O_5	0.42	0.44	0.41	0.43	0.53	0.47
LOI	1.06	1.58	1.21	1.15	1.56	2.21
Total	99,76	99.97	100.13	100.24	99.87	100.20
K/Na	1.11	1.04	1.01	1.33	1.40	1.47
P.I.	0.57	0.59	0.58	0.59	0.63	0.56
K_Φ	50.9	50.5	51.1	54.0	50.3	52.4
CIPW						
Or	13.36	13.65	13.04	15.04	17.09	16.24
Ab	4.48	8.59	7.97	10.35	5.68	8.52
An	12.95	11.63	11.96	11.35	10.35	12.96
Ne	7.27	5.45	5.68	3.13	6.33	3.89
Di	36.53	35.54	38.12	37.11	37.20	35.74
Hy	0.00	0.00	0.00	0.00	0.00	0.00
Ol	10.40	10.56	9.64	7.66	9.07	9.40
Mt	12.15	11.19	11.58	12.14	11.46	11.01
Hm	0.56	1.35	0.00	1.07	0.42	0.00
Il	1.37	1.08	1.11	1.19	1.22	1.26
Ap	0.93	0.98	0.90	0.95	1.18	0.98

$K/Na = K_2O/Na_2O$; P.I. = $(Na_2O + K_2O)/Al_2O_3$ (mol);
$K_\Phi = 100. (Fe_2O_3 + FeO)/(Fe_2O_3 + FeO + MgO)$

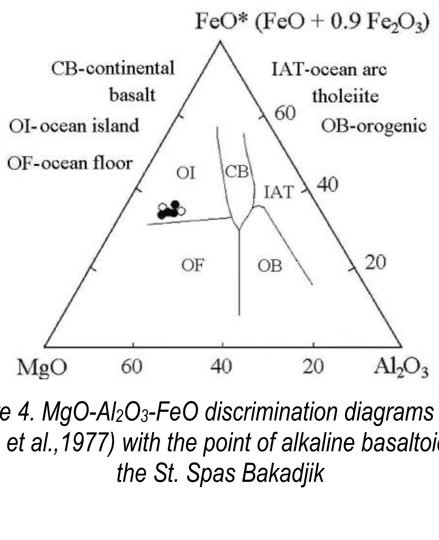

Figure 4. MgO-Al_2O_3-FeO discrimination diagrams (after Pearce et al.,1977) with the point of alkaline basaltoids from the St. Spas Bakadjik

Known are also pseudomorphose of analcime into leucite. According Barrer and Hinds (1953); and Deer et al. (1992) analcime and leucite transform into each other through irreversible ion-exchange: $NaAlSi_2O_6.H_2O + K_{aq}^+ \leftrightarrow KAlSi_2O_6 + Na_{aq}^+ + H_2O$. The experiments show that the solid solution of leucite undergoes exchange reaction with the sodium glass or with the enriched in Na water vapor. It can be transformed into sodium variety by ion exchange in the subsolidus zone and subsequent cooling causes differentiation of the solid solution (Taylor and MacKenzie, 1975) The processes of transformation of leucite into pseudoleucite are accompanied by destruction of the mineral structure by with preservation of the crystal morphology. The described reactions have to be looked upon as a result of adopting of the mineral to the changing conditions. In this aspect pseudoleucite corresponds to association, which is stable in the new P, T conditions.

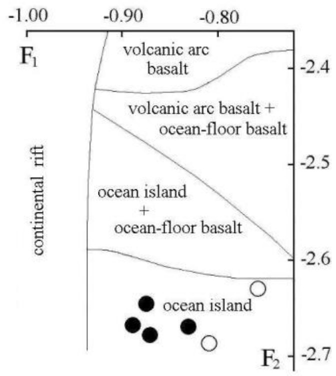

Figure 5. F_1-F_2 discrimination diagram of the composition of the clinopyroxene phenocrysts (after Nisbett and Pearce, 1977)

The first published data in the Bulgarian literature about pseudiomorphoses of analcime after leucite in the melanocratic shoshonites in the region of Pobeda village, Yambol district has been given by Stoinov (1955). Later, Yanev (1994) has reported about metaleucite replaced by analcime in absarokites in Eastern Rhodopes. According to Stanisheva (1969) the mineralogical and structural changes of leucite from Tamarino Bakadjik had taken place in two stages. During the first one pseudoleucite formed being a fine mixture of K-feldspar and nepheline, which replaces entirely the leucite crystal preserving its morphology. The second stage is connected with a change of pseudoleucite and the formation of epileucite.

The pseudoleucite aggregates in the alkaline basaltoids from the region of St. Spas Bakadjik are represented as subphenocrysts as well as small crystals in the groundmass. The microprobe analyses show that the smaller crystals are built entirely by analcime or K-feldspar while the bigger subphenocrysts – by analcime with a peripheral stripe of K-feldspar. The morphology of the crystals and the zonal arrangement of clinopyroxene inclusions give reason to suppose that the pseudoleucite aggregates have firstly crystallized as leucite and then as a result of ion exchange in the subsolidus zone have transformed into analcime and K-feldspar. The released potassium enters the composition of the newly formed K-feldspar, which localizes in the peripheral parts of the analcime crystals and in the interstitial space. During this process a part of the small analcime crystals is partially or entirely replaced by K-feldspar while the subphenocrysts are preserved with a stripe of K-feldspar stripe around them of varying thickness. The K-feldspars (especially those in the groundmass) are characterized by a high content of Or molecule ($Or_{96-97}Ab_{1-2}$) corresponding to K-sanidine. Such high values of K_2O are typical for some sanidines of the alkaline volcanites (Deer et al., 1963). Data exists showing that during a rapid crystallization the K-feldspars in volcanites display a tendency of enrichment in K_2O (Edgar, 1976). Similar petrochemical features of the rocks (increased alkalinity) and rapid crystallization are found also for the studied volcanites. However, it can not be excluded that part of K-feldspar in the interstitial space with a very high content of Or molecule could be a result of a later hydrothermal activity.

CONCLUSION

The alkaline basaltoids (pseudoleucite tephrites and psedoleucite basanites) are a product of a mantle, weakly differentiated, olivine-basalt magma with increased K-alkalinity. Crystallization of leucite had taken place in conditions of low pressure and from SiO_2 undersaturated melt. It can be proposed that as a result of ion exchange leucite had transformed into K-feldspar pseudoleucite aggregates. The alkaline basaltoids of St. Spas Bakadjik are comparable with the products of the widely developed in the region Tamarino Bakadjik olivine-basaltic volcanism with which they display a definite petrochemical similarity.

ACKNOWLEDGEMENTS

Thanks are due to M. Kanazirski for the critical reading of the manuscript and the constructive comments as well as to Y. Yanev and B. Kamenov for the fruitful discussions.

REFERENCES

Banushev, B. 2001. Petrological characteristic of agglomerates from the Tamarino and St. Spas paleovolcanoes. - *Ann. Univ. Min. Geol., I – Geol., 43-44*, 21-26.

Barrer, R. M., Hinds, L. 1953. Ion-exchange in crystals of analcite and leucite, - *Jorn. Chem. Soc.,* 1879 p.

Bowen, N. L., Ellestad, R. B. 1937. Leucite and pseudoleucite. - *Amer. Mineral., 22,* 409-415.

Deer, W. A., Howie, R. A., Zussman, J. 1963*. Rock-Forming Minerals.- Longmans, London,* 4. 482 p.

Deer, W. A., Howie, R. A., Zussman, J. 1992. An Introduction to the Rock-Forming Minerals. – *Longman Group Limited, Longman House,* 696 p.

Edgar, A. D. 1974. An Experimental Study.- In: Sorensen (editor), The Alkaline Rocks.- *John Wiley & Sons, London - New York - Sydney – Toronto,* 400 p.

Fudali, R. F. 1963. Experimental studies bearing on the origin of pseudoleucite and associated problems of alkalic rock system. – *Geol. Soc. Amer. Bull., 74,* 1101-1126.

Larsen, E. S., Buie, B. F. 1938. Potash analcime and pseudoleucite from the Highwood Mountains of Montana. – *Amer. Mineral.,* 23, 837 p.

Le Maitre, R. W (ed). 1989. A Classification of Igneous Rocks and Glossary of Terms. Recommendations of the IUGS Subcommission on the Systematics of Igneous Rocks. - *Oxford, Blackwell Sci Public.,* 193 p.

Morimoto, N. 1988. Nomenclature of pyroxenes. *Fortschr. Miner., 66, 2,* 237-252.

Nisbet, E. G., Pearce, J. A. 1977. Clinopyroxene composition in mafic lavas from different tectonic setting. - *Contrib. Mineral. Petrol., 63,* 149-160.

Pearce, T. H., Gorman, B. E., Birkett, T. C. 1977. The relationship between major element chemistry and tectonic environment of basic and intermediate volcanic rocks. – *Earth Planet. Sci. Lett. 36,* 121-132.

Peccerillo, A. & Taylor, S. R. 1976. Geochemistry of Eocene calc-alkaline volcanic rocks from the Kastamonu area, Northern Turkey.- *Contrib. Mineral. Petrol., 58,* 63-81.

Petrova, A., Simeonov, A. 1989. New data on the lithostratigraphy of the Upper Cretaceous in the Eastern Srednogorie.- *Rev. Bulg. Geol. Soc., 50*, 3, 6-14.

Popov, P., Antimova, C. 1982. On the geological structure of the western parts of Bourgas ore region. – *Ann. Geol. Min. Hight Inst., II – Geol., 28*, 9-31.

Popov, P., Kovachev, V., Strashimirov, Str., Zelev, V., Arnaudova, R., Banushev, B., Stavrev, P., Radichev, R. 1993. Geology and metallogeny of the Bourgas ore region. – *Tr. MGU, 1*, 93 p.

Savov, S., Filipov, L. 1995. *Description note on the geologic map of Bulgaria scaled 1:100000; map page Yambol.* -Sofia, Geol. Institute, BAS and Geologia and Geofisica Ltd.. 49 p.

Stanisheva, G. 1968. New data for the volcanism in the Eastern Srednogorie. – *Jubilee Geol. Vol*., 395-406.

Stanisheva, G. 1969. Leucite basanites in the Tamarinski Bakadjik, district of Yambol. – *Izvest. Geol. Inst., Ser. Geochem., Miner. and Petrogr., 18*, 233-257.

Stoinov, S. 1955. Volcanic and dyke rocks in the region of Bakadjiks, Yambol region. - *Izvest. Geol. Inst., 3*, 57-93.

Taylor, D., MacKenzie, W. S. 1975. A contribution to the pseudoleucite problem. – *Contrib. Mineral. Petrol., 49,* 321-333.

Yanev, Y. 1994. Mineral composition of Cs-bearing absarokites in Zenda village, Eastern Rhodopes. – *Geologica Balc., 24, 1*, p. 62.

Yoder, J. R., C. E. Tilley. 1962. Origin of Basalt magmas: An Experimental Study of Natural and Synthetic Rock systems. – *J. Petrol., 3*, 342-532.

Recommended for publication by Department of Mineralogy and Petrography, Faculty of Geology and Prospecting