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VOLCANIC ROCKS OF THE ISLAMIC ISLAND (IRAN)

(Рекомендовано членом редакційної колегії д-ром геол. наук, доц. С. Є. Шнюковим)

Neogene paleovolcan of the Islamic Island comprised by melaleucitite – feldspars leucitite – phonolite – trachyte series is situated on the coast of the Lake Urumia (Iran). Leucitites are composed of magnesium clinopyroxene, olivine, amphibole, Ba-Ti-phlogopite and feldspar. Clinopyroxenes of phonolite are enriched in Fe, phlogopites are depleted with Ba and Ti, feldspars are represented by Na-K-Ba-varieties or anorthoclase. Leucitic rocks are enriched with Ba, Rb, Sr and have moderate content of Ce, Y, Zr and low Nb. At the diagram SO2 – MgO/(MgO+FeO) most of analyzes of leucitic rocks are plotted between fields of kamafugitic and tephrite-leucitic series, partly (enriched with SiO2) – in the field of lamprophyric series. At the diagram Al2O3–CaO most of analyzes correspond to tephrite-leucitic series, partly – to lamproitic. At the diagram of Zr-Nb leucitic rocks are plotted in the field of potassium rocks of subduction areas. They are characterized by low content of Nb, Ta, Ti.

Unlike lamproite, leucitite of the Islamic Island has clayed (miaskite) composition. Their clinopyroxenes are more clayed then diopsides of lamproite. Clinopyroxenes and olivine of these rocks are more iron-rich than minerals of lamproite. These rocks are enriched in Ti and Ba, unlike typical lamproite. Presence of small amount of nepheline and sodalite, also distinguish them from typical lamproite. Leucite is similar to leucite from lamproite.

Therefore, leucitic rocks of the Islamic Island are represented by series of non-plagioclase rocks, which are evolved from melaleucitite through leucitic phonolite to trachyte, involving quartz-bearing ones. Leucititic rocks of the Islamic Island are similar to transitional lamproite, associated with subduction in Phanerozoic mountain belts.

Potassium alkaline rocks of Islamic Island with their mineralogical and geochemical peculiarities are similar to low-titanium lamproite. At the same time, leucitic rocks of the Islamic Island with their Ba-Ti-phlogopite and celsian feldspars might be treated as original formations. So leucitic rocks of the Islamic Island are similar to lamproites found in the folding belts characterized by occurrence of subduction.

Keywords: potassic rocks, Ba-Ti-mica, Na-K-Ba-feldspars, leucitite, phonolite, trachyte

Introduction. Neogene volcanic cone of Islamic Island paleovolcan, that is 22 x 13 km in size and about 600 m height, is composed of leucite, phonolite, and trachyte [4–5, 10].

Paleovolcan crater is comprised by steep bodies of trachyte, tephrite, and leucitic basalts. And its slopes are formed by gently flows of breccia and tuff with fragments of leucitites; tuff and agglomerate with fragments of phonolites; breccia with fragments of trachytes and leucites; breccia with fragments of phonolites; pyroclast with fragments of leucitic tephrites and phonolites; leucitic basalts and leucitic tephrite with breccia layers (fig. 1). Stratified layers are cut by steep dikes of trachytes, tephrites, leucitic basalts.

Setting of the problem. This paper focuses on the nature of volcanic rocks of the Islamic Island, their petrographic, mineralogical and geochemical features. Volcanic rocks are represented by melaleucitite-leucitite-leucitic phonolite-trachyte series (table 1). Potassic varieties are predominant and K-Na-series might be rarely found. This series show Na2O/K2O correlation value close to one and into the latest stage phonolites and trachytes it is slightly increased. The latest stage volcanic rocks are represented by trachytes of volcanic crater. Femic minerals of leucitite are represented by magnesium clinopyroxenes (diopsides) and Ba-Ti-phlogopite and rarely olivine. Phonolite is characterized by low magnesium of clinopyroxene and phlogopite, absence of olivine and more high content of Fe in femic minerals. Feldspars of leucitite are represented by sanidines or their Ba-bearing varieties (up to 4,0% BaO), and in phonolite it is represented by zonal celsian (up to 8,9% BaO) or anorthoclase. The main trace elements of leucitic rocks are represented by Ba, Rb, Sr, with typical moderate concentration of Ce, Y, Zr and low Nb. Such peculiarities are typical for potassium rocks in mountain belts, where subduction occurred.

Petrography of rocks. Melanocratic volcanic rocks are represented by melaleucitite and leucitite. Impregnations (up to 60–70%) are represented by clinopyroxene (diopside), leucite, sometimes alkaline feldspar (2–10 mm), with microimpregnations (to 0,5–1,0 mm) formed by olivine, frequently substituted by secondary minerals (up to 5–10%). Matrix of leucitite is composed of leucite, diopside, phlogopite, cemented by isotropic volcanic glass. Small needle-like crystal and microimpregnation of apatite (up to 0,4–0,5 mm), magnetite, and amphibole are present.

Impregnations of pale-green and almost colourless clinopyroxene are zoned, with inclusions of leucite, phlogopite, alkaline feldspar, rare nepheline and sodalite. Frequently together with recrystallized glass they are placed into zones of growth of pyroxene impregnations. Sometimes large glomeroporphyric aggregates of diopside are found. Usually pyroxene in matrix is optically homogenous. Leucite shows isotropic nature and frequently altered by zeolite-like mineral.

Phlogopite is presented in matrix, sometimes forming edges around olivine's grain. Usually phlogopite is zonal, pleochroic (in red-brown colour) [16]. Feldspars of leucitite are represented by potassium varieties, commonly by Ba-bearing (to 4,0% BaO), plagioclase is absent. Therefore, volcanic rocks of the Islamic Island might be treated as melaleucitite (olivine-pyroxene) – leucitite – phonolite – trachyte series.

Some rocks are represented by phonolite (samples I–3 and I–4a) with impregnation of red-brown phlogopites, rare clinopyroxene and altered leucite. The matrix is composed of fine grains of feldspar (anorthoclase), clinopyroxene and phlogopite with recrystallized glass, zeolites and microlites of feldspars (celsian), magnetite and products of olivine alteration.

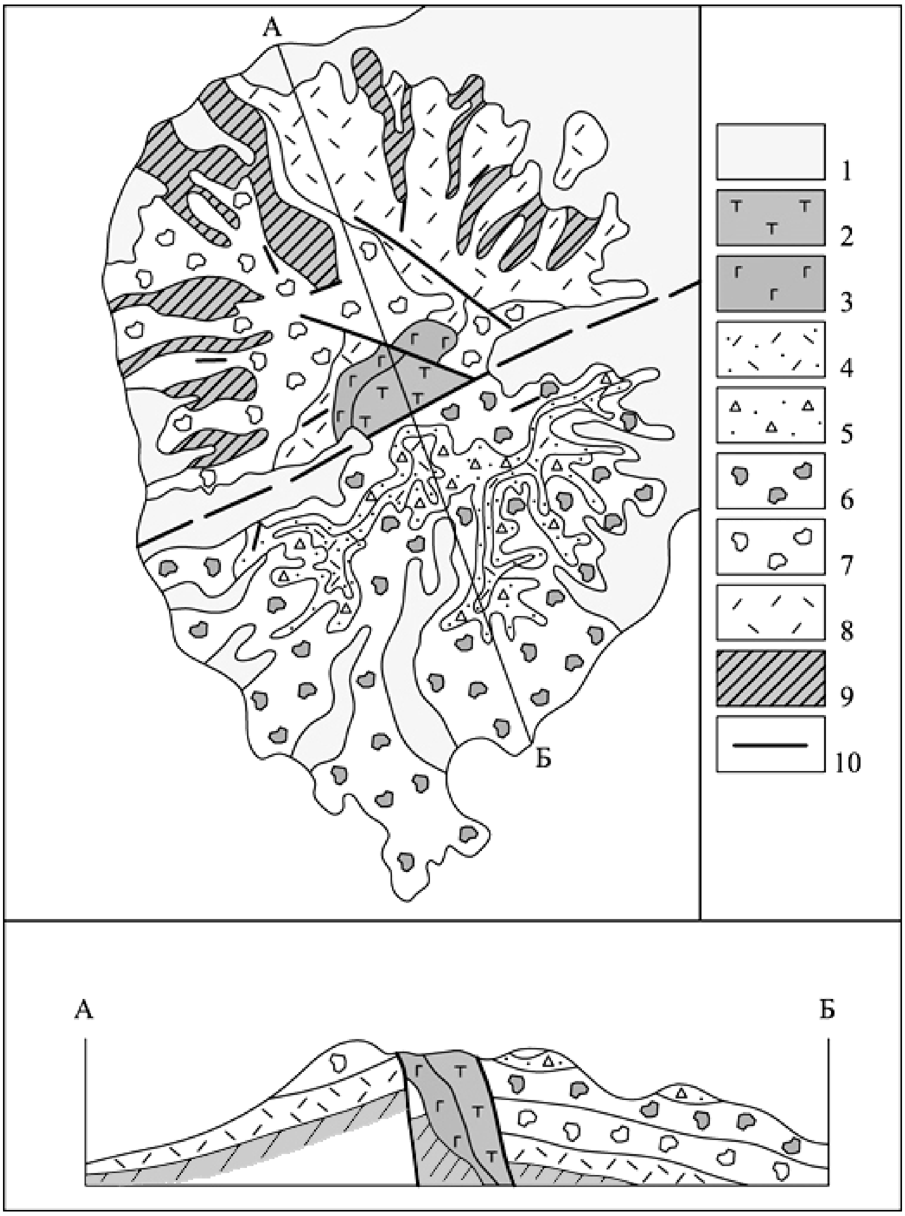

Fig. 1. Scheme of geological structure and cross-section of Islamic Island paleovolcan: 1 – Quaternary sediments; 2 – trachyte; 3 – tephrite and leucitic basalts; 4 – breccia and tuffs with leucitite fragments; 5 – tuffs and agglomerates with phonolite fragments; 6 – tuffs with fragments of trachyte and phonolite; 7 – breccia with fragments of phonolite, basement – agglomerates; 8 – pyroclast with leucitic tephrite and phonolite fragments; 9 – leucitic basalts and leucitic tephrite with breccia layers; 10 – dikes of trachyte, tephrite, leucitic basalts

Chemical features of the rock-forming minerals. On the basis of chemical analysis of data the same type minerals of leucitites and phonolites, especially phlogopites and feldspars are distinguished. Clinopyroxenes in phonolite are enriched in Fe. In the minerals of trachyte agpaitic coefficient (Na+K)/Al) reaches 1,04 [20]. Olivine is found in melaleucitite and leucitite. Frequently it is substituted by secondary minerals. Their composition corresponds to Fo87-82, with MnO content of 0,3–0,5%, CaO – 0,4–0,5%, NiO – to 0,15%.

Phlogopites in leucitite are represented by varieties with high content of BaO (to 12,6%), TiO2 (to 6,9%), F (to 5,1%). Content of TiO2, BaO, Al2O3 from core part of phlogopite grains to their margins is decreased, and SiO2 – increased (table 2).

Rarely in clinopyroxene of melaleucitite are present impregnations of low-titanium (2,84% TiO2) and low-barium (0,71% BaO) phlogopites with low content of F (0,30%): (K0,6-0,8 Ba0,2-0,4) (Mg1,5-2,3 Fe2+0,3-1,0 Ti0,2-0,5) [Fe3+0,1-0,3 Al1,1-1,4 Si2,3-2,7] (F0,8-1,3 OH0,7-1,2) [16]. Ba-Ti phlogopites of leucitites are distinguished from oxykinoshitalites and oxymicas from alkaline rocks of other regions by higher content of BaO, H2O, F, and lower TiO2 (fig. 2). Similarly Ba-Ti-micas (9–11% TiO2; 10–11% BaO) are described in essexite of Eltozersky massif [6].

Table 1

Chemical composition of alkaline rocks of the Islamic Island

№	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
№ sample	I-1	I-1a	I-2	I-3	I-4	I-4a	I-5	I-6	I-7	I-8	5	2	44	126	148	5	149
SiO_2	45,80	45,40	44,70	47,70	43,60	49,60	44,60	45,00	42,80	43,50	47,28	46,77	50,19	51,48	54,45	58,27	65,35
Ti02	1,71	1,82	1,26	1,47	1,23	1,78	1,33	1,32	1,42	1,72	0,97	0,98	1,44	0,85	0,77	0,73	0,23
Al_2O_3	8,37	10,4	11,2	14,1	11,20	13,8	11,6	11,1	12,9	12,1	10,9	11,66	16,51	16,51	15,3	16,31	15,92
Fe_2O_3	1,76	1,58	1,63	1,43	1,49	1,49	1,58	1,62	1,93	1,48	1,38	1,29	1,37	0,91	1,13	0,9	0,56
FeO	9,01	8,08	8,34	7,32	7,62	7,61	8,05	8,28	9,84	9,57	7,35	7,30	7,39	4,95	5,94	4,60	1,69
MnO	0,20	0,18	0,2	0,18	0,20	0,18	0,25	0,21	0,24	0,12	0,23	0,25	0,19	0,56	0,72	0,20	0,60
MgO	8,12	8,69	6,13	4,98	7,71	2,81	9,51	8,77	7,94	8,72	9,63	9,71	3,97	6,36	5,40	3,38	1,25
CaO	9,74	8,85	10,8	10,5	10,1	8,74	11,1	11,5	12,2	12,9	13,71	12,21	9,13	6,48	7,66	4,4	1,25
Na_2O	1,80	2,05	2.00	2,70	0,90	3,55	2,4	1,82	0,55	0,6	1,49	1,61	3,08	4,08	3,16	3,47	4,87
K_2O	5,20	5,30	5,70	3,00	5,80	5,65	5,9	5,4	5,5	5,8	5,13	6,19	6,09	7,07	4,78	7,62	7,86
P_2O_5	1,78	1,73	1,50	1,06	1,58	0,85	1,4	1,56	1,54	1,5	1,68	1,76	0,83	0,73	0,73	0,82	0,42
CO_2	0,77	0,88	0,66	0,55	1,01	0,88	0,88	0,88	1,4	0,87	–	–	–	–	–	–	–
S	0,04	0,02	0,03	0,02	0,02	0,03	0,04	0,04	0,02	0,10	–	–	–	–	–	–	–
H_2O^-	1,24	1,18	1,40	0,84	2,86	0,54	0,24	0,34	0,36	0,35	–	–	–	–	–	–	–
LOI	3,20	3,01	3,86	3,41	4,13	2,96	0,3	1,74	1,44	1,66	–	–	–	–	–	–	–
BaO	0,26	0,24	0,38	0,39	0,30	0,36	0,38	0,30	0,24	0,30	–	–	–	–	–	–	–
Total	99,00	99,50	99,80	99,70	99,70	101,00	99,60	99,90	100,00	101,00	99,75	99,73	100,19	99,98	100,04	100,70	100,00
Na+K/Al	1,03	0,87	0,84	0,55	0,69	0,87	0,89	0,80	0,53	0,60	0,73	0,80	0,71	0,87	0,68	0,86	1,04
Na+K	7,00	7,35	7,70	5,70	6,70	9,20	8,30	7,22	6,05	6,40	6,62	7,80	9,17	11,15	7,94	11,09	12,73
Fe/(Fe+Mg)	0,42	0,38	0,47	0,49	0,39	0,64	0,36	0,38	0,45	0,41	0,33	0,33	0,55	0,34	0,42	0,47	0,50
Geochemical features																	
Cu	113	128	94	147	134	151	136	127	159	153	–	–	–	–	–	–	–
Zn	74	61	88	53	102	80	54	75	8	124	–	–	–	–	–	–	–
Rb	329	348	152	52	136	126	169	245	174	198	–	–	–	–	–	–	–
Sr	931	809	1270	1170	752	1510	1200	1230	968	978	–	–	–	–	–	–	–
Y	28	30	36	34	34	36	27	34	26	32	–	–	–	–	–	–	–
Zr	277	320	347	332	371	328	394	311	322	320	–	–	–	–	–	–	–
Nb	38			34						30	–	–	–	–	–	–	–
La	54	64	62	74	76	49	62	70	61	68	–	–	–	–	–	–	–
Ce	111	110	139	133	133	115	124	131	118	107	–	–	–	–	–	–	–
Nd	55	52	67	62	55	58	61	72	57	47	–	–	–	–	–	–	–
Pb	31	34	29	40	43	42	37	31	24	149	–	–	–	–	–	–	–
Th	19	–	–	21	–	–	–	–	–	14	–	–	–	–	–	–	–
U	<2	–	–	6	–	–	–	–	–	<2	–	–	–	–	–	–	–

1–3, 7–12 – leucitite; 5 – tuff lava (fragments of tuffs in leucitite); 4, 6, 15, 16 – phonolite; 17 – trachyte. Samples 1–10 – author's collection; 11–17 – reference data [20]

Table 2

Chemical composition (microprobe analyses) of Ba-Ti-phlogopites

N sample	I–5						I–8								I–3				I–4
Position	Gm		gm		in Cpx	In Cpx	gm		in Plc		in Plc	in Cpx		in Cpx	phen	phen	phen	phen	
Phase	C	r	c	r			c	r	c	r		c	r		c	c	c	c	
SiO2	32,22	33,73	30,77	33,72	31,48	34,37	29,88	30,79	29,49	29,15	36,38	31,80	31,42	37,41	38,32	38,48	38,88	38,32	45,47
TiO2	6,04	5,91	6,23	5,67	6,37	5,51	6,33	5,43	6,90	6,94	4,59	5,10	4,57	2,84	2,84	2.44	2,90	2,71	0,81
Nb2O5	–	–	–	0,01	–	0,06	0,01	0,02	–	0,02	0,02	–	0,04	–	–	–	–	–	–
Cr2O3	0,02	0,01	–	0,01	0,05	0,04	0,02	0,02	–	–	0,02	0,06	0,05	0,45	0,15	0,05	0,07	0,06	0,04
Al2O3	13,67	13,00	14,21	13,76	14,34	13,03	15,32	15,33	15,39	15,37	12,33	15,08	14,75	14,56	15,07	14,94	15,46	14,92	7,87
Fe2O3*	4,36	4,19	3,95	3,98	3,50	3,09	3,35	2,63	3,11	3,30	0,85	1,39	2,91	0,50	–	–	–	–	–
FeO	4,86	4,83	4,89	4,68	6,48	6,84	6,54	5,85	8,19	8,40	10,87	8,01	6,85	8,52	8,80	8,75	8,82	8,68	16,92
MnO	0,12	0,13	0,12	0,14	0,19	0,13	0,18	0,11	0,20	0,27	0,34	0,13	0,16	0,09	0,07	0,04	0,05	0,03	0,50
MgO	19,16	19,49	18,37	19,75	17,55	17,89	17,32	18,54	15,58	15,29	15,01	16,66	18,56	21,10	22,03	22,20	22,09	21,90	11,89
CaO	0,04	0,07	0,03	0,02	0,09	0,26	0,02	0,03	0,04	0,03	0,18	0,27	0,28	0,07	0,03	0,02	0,03	0,05	0,21
BaO	9,81	8,12	11,31	9,29	10,34	7,80	12,25	11,69	12,03	12,24	7,16	12,55	11,69	0,81	0,64	0,66	0,77	0,70	-
Na2O	0,70	0,71	0,63	0,72	0,70	0,91	0,57	0,59	0,61	0,62	0,85	0,62	0,63	0,37	0,51	0,45	0,50	0,48	0,00
K2O	5,50	6,16	5,01	5,79	4,94	6,18	4,75	4,91	4,59	4,59	6,35	4,26	4,91	9,38	9,50	9,59	9,48	9,45	7,52
F	4,73	4,49	4,50	4,57	3,73	5,06	3,81	4,27	3,75	3,98	5,19	3,97	4,06	0,30	0,81	0,53	0,72	0,47	–
Cl	0,01	–	–	0,01	0,02	–	0,01	0,01	–	–	–	0,03	0,04	0,03	–	–	0,02	0,01	–
H2O-	1,12	1,31	1,20	1,27	1,66	1,15	1,60	1,49	1,62	1,47	1,31	1,75	1,56	3,91	–	–	–	–	–
Total	102,16	102,15	101,23	102,39	101,43	102,32	101,95	101,70	101,49	101,67	101,44	101,66	102,48	100,33	98,76	98,15	99,79	97,78	91,23
O=(F, Cl)	1,99	1,89	1,90	1,93	1,57	2,13	1,61	1,80	1,58	1,68	2,19	1,68	1,72	0,13	–	–	–	–	–
Total	100,17	100,26	99,33	100,46	99,85	100,19	100,34	99,90	99,91	100,00	99,26	99,99	100,76	100,19	–	–	–	–	–

gm – groundmass; c, r – core and rim of grain; in Cpx – silicate melt and polycrystalline inclusions in clinopyroxene phenocryst; in Plc – silicate melt and polycrystalline inclusions in pseudoleucite phen – phenocryst; * – calculated from formula on the basis 11 oxygen, Fe2O3 is estimated only as tetrahedral Fe3+ in formula

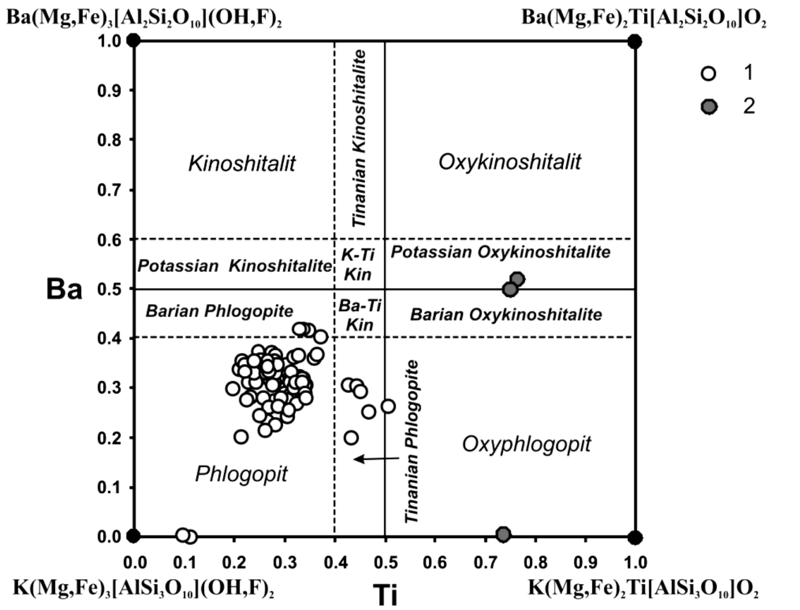

Fig. 2. Composition of Ba-Ti-micas:
1 – phlogopite of alkaline rocks, 2 – oxyphlogopite and oxykinoshitalite by [9, 15]

At the same time, mica in phonolite (sample I–3) has low TiO2 (2,5–2,9%), BaO (0,4–0,8%) and F (0,5–0,8%), that is similar to micas from impregnations into leucitite's clinopyroxene. Low-Ti (0,57–0,81% TiO2), high-Fe and Mg (up to 17% FeOtot and 10,4–11,95% MgO) and low-Al (7,87–8,46% Al2O3) are established for mica found into tufflava (sample I–4).

Magnesium number of clinopyroxene (Mg/(Mg+Fe)·100%) drops from leucitite (90,4%) to phonolite (69,4%). Impregnation of clinopyroxene has zonal structure: content of Fe from center to margin increases. The main chemical peculiarities are summarized in table 3.

Table 3

Chemical composition (microprobe analyses) of clinopyroxene

N sample	I–8	I–8	I–8	I–8	I–5	I–5	I–5	I–4a
SiO2	53,86	47,99	47,64	47,26	53,54	51,64	52,24	49,12
TiO2	0,22	1,23	1,60	1,92	0,16	0,95	0,28	0,74
Al2O3	1,36	4,86	5,97	5,12	1,07	2,37	1,85	2,10
Cr2O3	0,41	–	0,08	0,01	0,10	0,01	0,07	0,02
FeO	2.85	6,91	6,73	7,85	3,98	6,49	5,28	10,85
MnO	0,09	0,14	0,13	0,21	0,02	0,25	0,15	0,07
MgO	15,39	13,99	13,35	13,30	17,12	15,05	16,09	14,08
CaO	23,99	22,79	22,47	22,77	23,82	22,87	23,72	22,50
Na2O	–	0,78	0,58	0,70	0,20	0,72	0,42	–
Sum	98,17	98,69	98,55	99,14	100,01	100,35	100,10	99,48
Fe/Fe+Mg	0,096	0,242	0,219	0,23	0,12	0,19	0,16	0,304

An. 1 is carried out from the lightest concentrate of pyroxene, and another – from the rock slice

Chemical compositions of feldspars analyzed by microprobe are summarized in table 4. Frequently they are found as impregnations in leucite, pseudoleucite, and clinopyroxene. Their composition corresponds to potassium alkaline feldspars (sanidines), Ba-bearing (to 4,0% BaO) and Na-Ba-K variety of celsian (BaO to 8,85%). From center of the grains to their margin content of BaO decreases (sometime from 7,81 to 2,05%), and content of Na2O (from 2,8 to 4,5%), and partly CaO (from 0,6 to 1,2%) increases (fig. 3).

Table 4

Chemical composition (microprobe analyses) of feldspars

N sample	I–8	I–8	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–3
SiO2	64,42	58,83	57,46	57,28	59,58	59,24	59,27	64,53	58,50	59,18	55,02	60,31
TiO2	0,03	0,04	0,23	0,29	0,34	0,23	0,07	0,23	0,17	0,15	0,23	0,26
Cr2O3	–	0,12	–	–	–	–	–	–	–	–	–	–
Al2O3	18,96	18,94	20,60	20,68	20,41	20,47	20,44	19,38	20,49	20,40	23,35	22,79
FeO	0,29	0,86	0,58	0,54	0,69	0,71	0,74	0,45	0,62	0,66	0,65	0,71
MnO	0,01	0,01	0,01	0,01	0,04	–	–	0,03	0,03	0,02	–	–
MgO	0,04	0,71	0,01	–	–	0,01	–	–	0,02	0,01	0,07	

End table 4

N sample	I–8	I–8	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–4a	I–3
CaO	0,10	0,05	0,61	0,76	0,95	0,68	0,86	1,17	0,60	0,76	1,00	4,91
BaO	0,26	4,01	8,85	8,64	6,29	7,45	7,81	2,05	8,05	7,66	8,73	–
Na2O	0,73	1,67	2,97	2,82	4,48	3,17	2,97	4,30	2,87	3,62	2,14	6,21
K2O	14,97	12,30	8,70	8,59	7,24	7,63	7,15	7,61	8,27	7,18	8,64	3,32
Sum	99,82	97,54	100,04	99,62	100,03	99,60	99,31	99,74	99,62	99,64	99,83	98,51
Cs	0,6	7,6	16,4	16,3	11,5	15,1	16,2	3,9	16,0	15,0	17,4	-
An	0,6	0,3	3,1	4,1	4,8	3,7	4,8	6,3	3,3	4,2	5,5	34,1
Ab	6,7	15,8	27,2	26,5	40,6	31,4	30,6	41,5	27,8	35,1	21,1	38,8
Or	92,2	76,3	53,3	53,1	41,1	49,8	48,4	48,4	52,9	45,6	56,0	27,1

At the same time more Na-rich feldspar anorthositic composition with high content of CaO (4,9%) is found in phonolite (I–3) that is similar to anorthoclase (CaO – 3,76%) from volcanic rocks of the Mountain Erebus (Antarctic Region) or romben-porphyry (Or10-15 Ab45-75 An10-45) from laurvikite Oslo region (Norway) [11]. Therefore, feldspars of phonolite have abnormally high content of Na2O and CaO and low content of K2O and BaO.

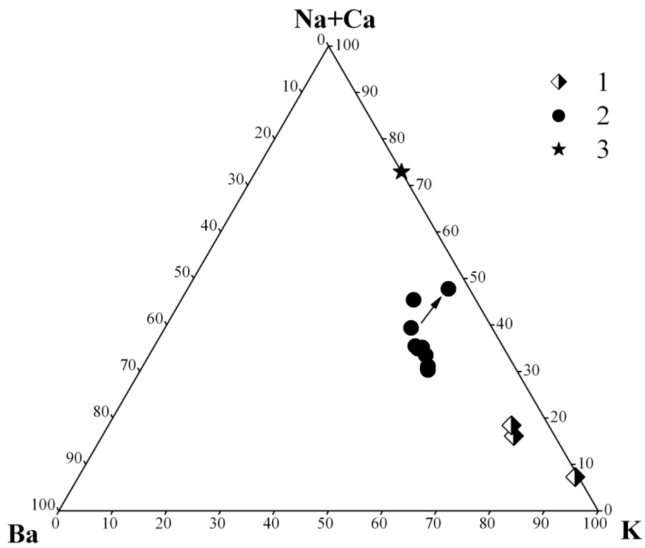

Fig. 3. Component diagram of feldspars:
1 – feldspars of leucitite, 2 – feldspars of phonolite, 3 – anorthoclase of phonolite.
The trend of compositional change in feldspars (from center to rim) is indicated with arrow

Impregnations in clinopyroxenes of melaleucitite nepheline and sodalite are also presented. Nepheline has "standard" composition (16,3% Na2O and 5,5–5,6% K2O), with high content of FeOtot (1,3–1,4%), low CaO (0,07%) and BaO (0,05–0,07%). Sodalite has typical composition (24,0% Na2O and about 8% Cl). Leucite also has typical composition with abnormally high content of Fe (FeOtot – 0,4-0,9%) and low Na2O and CaO (table 5).

***Table* 5**

Chemical composition (microprobe analyses) of leucite

№ sample	I–8	I–8	I–8	I–5	I–5	I–5
SiO2	54,84	54,23	54,59	54,82	54,58	55,00
TiO2	0,06	0,02	0,20	0,01	0,04	0,10
Al2O3	23,07	23,24	22,59	22,54	22,45	22,06
FeO	0,63	0,43	0,89	0,88	0,65	0,85
MnO	–	–	0,02	0,02	–	0,02
MgO	–	0,02	0,01	–	–	–
BaO	0,11	0,36	0,24	0,02	0,02	0,02
CaO	0,00	0,12	0,12	–	–	0,09
Na2O	0,06	0,05	0,76	0,24	0,35	0,14
K2O	21,23	21,23	20,31	21,29	21,26	21,27
Sum	100,01	99,69	99,72	99,81	99,36	99,55

Magnetite forms microimpregnations in matrix or impregnations in other minerals. It has high contents of TiO2 (7,22–11,87%), Al2O3 (2,43–5,57%), MgO (1,30–4,30%), MnO (0,64–1,89%), Cr2O3 (0,01–0,21%).

Petrochemical features of alkaline rocks. Alkaline rocks of the Islamic Island are saturated with Al and have high content of normative anorthite (up to 15–18%). Alkaline rocks of the Islamic Island belong to potassium and natrium-potassium differentiated series. Two fields of alkaline rocks are distinguished in the diagram of Na2O–K2O: more acid trachyte, syenite and feldspar leucitite with Na2O/K2O value = 1:2–1:1, and more melanocratic leucites with Na2O/ K2O value = 1:4 – 1:6 – 1:8 (fig. 4). There is also clear positive correlation between content of SiO2 and Na2O (fig. 5) in more acid varieties, at the same time correlation between SiO2 and K2O is not distinct (fig. 6).

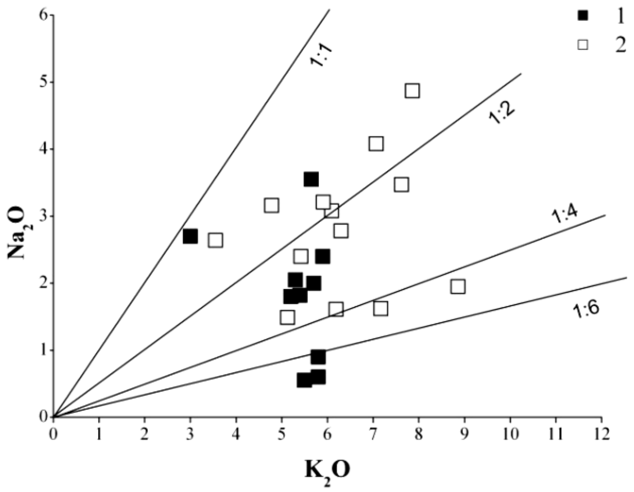

Fig. 4. Diagram of Na2O – K2O: 1 – author's analyses, 2 – published analyses [20]. Lines correspond to Na2O:K2O ratios (1:1; 1:2; 1:4; 1:6)

Correlation between SiO2, MgO, SiO2 and (K2O+Na2O) is fixed, such as differentiated series of magmatic rocks. Leucitite-trachytic and leucitite-phonolite trends are distinguished in the diagram MgO-SiO2 (fig. 7). Correlation between (K2O+Na2O) and SiO2 is positive (fig. 8).

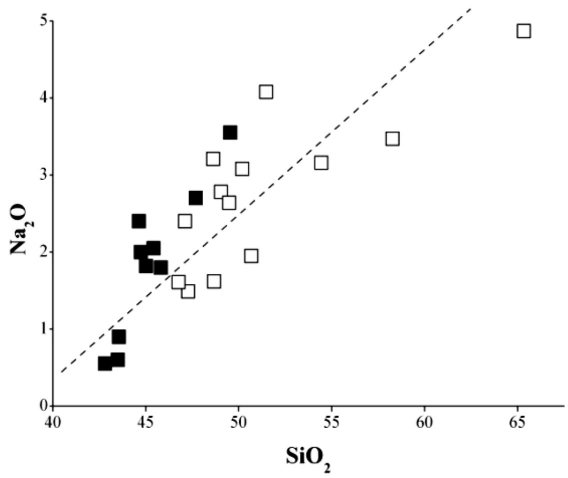

Fig. 5. Diagram of SiO2 – Na2O: The legend is the same as on fig. 4

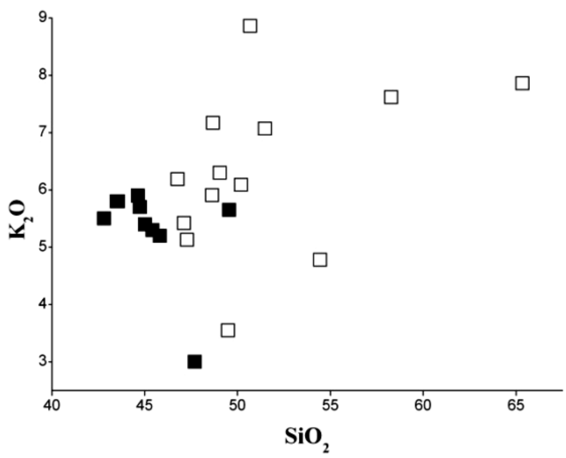

Fig. 6. Diagram of SiO2 – K2O: The legend is the same as on fig. 4

Geochemical features of the rocks. Rocks of the Islamic Island are characterized by high concentration of Ba, Rb, P, low Ti, Nb, Zr, Ce, La, Nd, Y. Ba was found in phlogopites and feldspars, and Rb was found in potassium minerals. Apatite is the main concentrator of TR and Y.

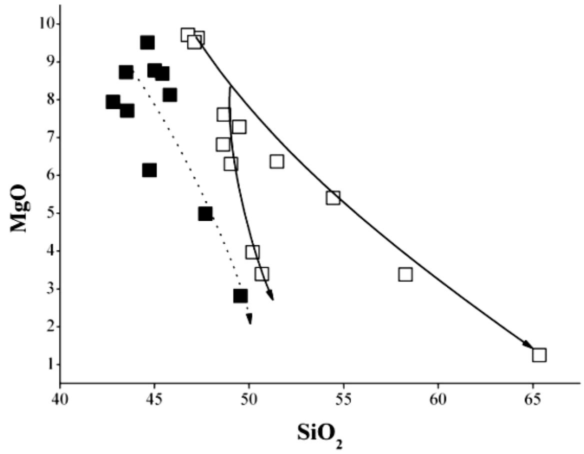

Fig. 7. Diagram of SiO2 – MgO: The legend is the same as on fig. 4.
Solid disintegration line of the chemical composition of the Islamic Island alkaline rocks after [20], and dashed one is the same curve based on author's data

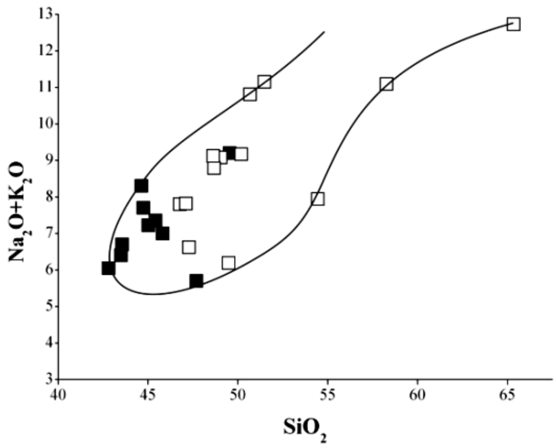

Fig. 8. Diagram of SiO2 – (Na2O + K2O): Supposed evolution field of magmatism of the Islamic Island alkaline rocks after [20]. The legend is the same as on fig. 4

Conclusion. There are known several series of potassium alkaline rocks with ultrabasic, basic, and medium varieties: kamafugitic, lamproitic, alkaline basaltic – phonolite – trachytic, feldspars leucitites (tephrite) and others [7]. On the diagram SO2–MgO/(MgO+FeO) most of analyzes of leucitic rocks of the Islamic Island are plotted between fields of kamafugitic and tephrite-leucitic series, partly (enriched with SiO2) – in the field of lamprophyric series. On the diagram Al2O3–CaO most of analyzes correspond to tephrite-leucitic series, partly – to lamproitic.

Leucititic rocks of the Islamic Island are similar to rocks of Tezhar complex of Armenia [8], rocks of Italy [3, 12], Spain [18], Australia [2], Scotland [19] and other regions [1, 10]. They also are similar to transitional lamproite, associated with subduction in Phanerozoic mountain belts [13, 17]. On the diagram of Zr-Nb leucitic rocks of the Islamic Island are plotted in the field of potassium rocks of subduction areas. They are characterized by low content of Nb, Ta, Ti, and by negative anomalies of these elements at the spider-diagrams [14].

Unlike lamproite, leucitite of the Islamic Island has clayed (miaskite) composition. Their clinopyroxenes are more clayed then diopsides of lamproite. Clinopyroxenes and olivine of these rocks are more iron-rich than minerals of lamproite. Alkaline amphiboles (K-richterite and Na-K-arfvedsonite), which are common for leucitic lamproite, are absent. These rocks are enriched by Ti and Ba, unlike typical lamproite. Presence of small amount of nepheline and sodalite, also distinguish them from typical lamproite. Leucite from alkaline rocks are similar to leucite from lamproite.

Therefore, leucitic rocks of the Islamic Island are represented by series of non-plagioclase rocks, which are evolved from melaleucitite through leucitic phonolite to trachyte, involving quartz-bearing ones.

There is thermal barrier between phonolite and granites eutectic in the system of SiO2 – nepheline – calcilith, thus genetic relationship between alkaline nepheline and quartz-feldspar rocks is considered to be impossible. At the same time in potassium field of this system (SiO2 – calcilith) such barrier is absent, and quartz-trachytic or potassium granitic melts can be separated from alkaline potassium (leucite-bearing) magmas. Probably, this process is realized in series of melaleucitite – leucitic phonolite – quartz-bearing trachyte rocks of the Islamic Island.

Potassium alkaline rocks of Islamic Island with their mineralogical and geochemical peculiarities are similar to low-titanium lamproite. At the same time, leucitic rocks of the Islamic Island with their Ba-Ti- phlogopite and celsian feldspars might be treated as original formations. In the future, it is desirable to carry out a detail comparative characterization of leucite rocks of the Islamic Island and similar series of other parts of the world.

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ВУЛКАНІЧНІ ПОРОДИ ISLAMIC ISLAND (ІРАН)

Неогеновий палеовулкан Islamic Island, складений мелалейцит – лейцит – фоноліт – трахітовою серією порід, розташований на березі озера Urumia (Іран). Лейцити складаються з магнезіального клінопіроксену, олівіну, амфіболу, флогопіту та калішпату. Клінопіроксен фонолітів збагачений Fe, флогопіти представлені Ba-Ti різновидами, польові шпати – Na-K-Ba-різновидами (гіалофаном) або анортоклазом. Лейцитові породи збагачені Ba, Rb, Sr, характеризуються помірним вмістом Ce, Y, Zr і низьким Nb. На діаграмі SO2 – MgO/(MgO+FeO) більшість аналізів лейцитових порід розташована між полями камафугітової і тефрит-лейцитової серій, частково (збагачені SiO2) – у полі лампроїтової серії. На діаграмі Al2O3 – CaO більшість аналізів відповідає тефрит-лейцитовій серії, частково – лампроїтовій. На діаграмі Zr – Nb лейцитові породи розташовані в полі калієвих порід, характерних для субдукційних областей. Вони характеризуються низьким вмістом Nb, Ta, Ti.

На відміну від "перехідних" лампроїтів, лейцитові породи Islamic Island мають глиноземистий (міаскітовий) склад. Їхні клінопіроксени більш глинисті, ніж діопсиди лампроїтів, містять більшу кількість заліза (як і олівіни). Ці породи збагачені Ti і Ba, містять невелику кількість нефеліну й содаліту, на відміну від типових лампроїтів. Лейцит схожий на лейцит з лампроїтів.

Таким чином, лейцитові породи Islamic Island представлені серією безплагіоклазових порід, які еволюціонували від мелалейцитів через лейцитові фоноліти до трахітів, у тому числі, кварцвмісних. За мінералогічними та геохімічними особливостями вони схожі з низькотитанистими лампроїтами. Лейцитові породи Islamic Island подібні до лампроїтів, знайдених у складчастих поясах, які характерні для субдукційних процесів.

Ключові слова: калієві породи, Ba-Ti слюда, Na-K-Ba польовий шпат, лейцит, фоноліт, трахіт.

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ВУЛКАНИЧЕСКИЕ ПОРОДЫ ISLAMIC ISLAND (ИРАН)

Неогеновый палеовулкан Islamic Island, сложенный мелалейцит – лейцит – фонолит – трахитовой серией пород, расположен на берегу озера Urumia (Иран). Лейциты состоят из магнезиального клинопироксена, оливина, амфибола, флогопита и калишпатов. Клинопироксены фонолитов обогащены Fe, флогопиты представлены Ba-Ti разновидностями, полевые шпаты – Na-K-Ba-разновидностями (гиалофаном) или анортоклазом. Лейцитовые породы обогащены Ba, Rb, Sr, характеризуются умеренным содержанием Ce, Y, Zr и низким Nb. На диаграмме SO2 – MgO/(MgO+FeO) большинство анализов лейцитовых пород расположено между полями камафугитовой и тефрит-лейцитовой серий, частично (обогащенные SiO2) – в поле лампроитовой серии. На диаграмме Al2O3 – CaO большинство анализов соответствует тефрито-лейцитовой серии, частично – лампроитовой. На диаграмме Zr – Nb лейцитовые породы расположены в поле калиевых пород, характерных для субдукционных областей. Они характеризуются низким содержанием Nb, Ta, Ti.

В отличие от "переходных" лампроитов, лейцитовые породы Islamic Island имеют глиноземистый (миаскитовый) состав. Их клинопироксены более глинисты, чем диопсиды лампроитов, содержат большее количество железа (как и оливины). Эти породы обогащены Ti и Ba, содержат небольшие количества нефелина и содалита, в отличие от типичных лампроитов. Лейцит похож на лейцит из лампроитов.

Таким образом, лейцитовые породы Islamic Island представлены серией безплагиоклазовых пород, которые эволюционировали от мелалейцитов через лейцитовые фонолиты до трахитов, в том числе, кварцсодержащих. По минералогическим и геохимическим особенностям они сходны с низкотитанистыми лампроитами. Лейцитовые породы Islamic Island подобны лампроитам, найденным в складчатых поясах, характерным для субдукционных процессов.

Ключевые слова: калиевые породы, Ba-Ti слюда, Na-K-Ba полевой шпат, лейцит, фонолит, трахит.