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NA-RICH ALKALI-FELDSPAR PHENOCRYSTS FROM METALUMINOUS AND PERALKALINE SILICIC VOLCANIC ROCKS

Abstract — Na-rich alkali-feldspar phenocrysts, separated from 18 metaluminous and peralkaline silicic volcanic rocks, were analyzed for SiO_2, Al_2O_3, Fe_2O_3, CaO, Na_2O, K_2O, Ba, Rb and Sr. The optical properties of these samples were investigated by using the universal stage. The unit cell parameters of 17 of the analyzed samples were determined by least squares fitting of the values obtained from powder diffraction pattern, collected by Fe Kα radiation. Remarks were made on use of splitting of peaks collapsed in monoclinic system, as indicators of triclinicity; correlations are made with chemical composition of the feldspars. In the *b-c* plot of WRIGHT and STEWART [1968] some samples show a tendency to have small *c* and large *b* parameter relatively to the *b-c* high albite-high sanidine tie line: the high anorthite content seems generally to induce such an arrangement, even if any conclusive statement on this matter cannot be drawn.

Alkali feldspars phenocrysts separated from rocks of low peralkalinity, related to basaltic magmas are apparently systematically characterized by lower Or content than those occurring in rocks with similar peralkalinity and different origin. The distribution of Sr and Ba in the rock-feldspar pairs appears characteristically related to the origin of the rocks.

Riassunto — Sono stati presi in esame 18 campioni di feldspato alcalino provenienti da rocce vulcaniche alcaline ed iperalcaline.

Dei feldspati studiati vengono riportati i dati cristallografici, ottici e chimici. I dati cristallografici mostrano che alcuni feldspati si discostano leggermente dall'andamento previsto dal diagramma *b-c* di WRIGHT e STEWART [1968].

Rocce aventi lo stesso grado di alcalinità possono contenere feldspati a differente contenuto di Or. I dati chimici mostrano infatti che a pari grado di alcalinità rocce legate geneticamente a magmi basaltici contengono feldspati alcalini con un contenuto di Or più basso. La distribuzione di Sr e Ba tra roccia e feldspato alcalino sembra strettamente legata all'origine delle rocce esaminate.

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Introduction

The relationships of many physical properties with chemical composition and structural state of alkali-feldspars has been defined (Wright and Stewart [1968], Wright [1968], Stewart and Ribbe [1969], Smith [1974] with references). The studied samples however were mostly synthetic ones, obtained by ion exchange techniques (Orville [1960, 1962, 1964, 1967]), whereas data on natural samples are scarce. We thought it useful to make a comprehensive chemical, mineralogical and crystallographic study on some natural Na-rich alkali-feldspars, ranging in composition from Or_{12} to Or_{44}.

These feldspars occur as phenocrysts or microphenocrysts in metaluminous and peralkaline silicic volcanic rocks; these rocks were chosen because, owing to their peculiar composition, alkali -feldspar is the characteristic dominant solid phase. Samples were selected from some of the classic localities of such rock types, and include both continental (East African) and oceanic (Afar) rifts, the type localities of pantellerite and comendites (Pantelleria and S. Pietro islands) and some unusual occurence of oversaturated alkali trachytes (Monte Arci, Sardinia). As a whole the selected samples then represent a wide range of occurence of peralkaline silicic rocks from association with basalts or with calc-alkaline rocks, and include possible examples of crustal anatexis.

In table 1 petrographical descriptions of the rocks from which the alkali-feldspar phenocrysts were separated are reported.

Chemical data

Alkali feldspars phenocrysts were carefully separated from 18 volcanic rock samples by magnetic and heavy liquids methods.

Chemical analyses were carried out by X-ray fluorescence following the analytical procedure developed by Leoni and Saitta [1974] for SiO_2, Al_2O_3, Fe_2O_3, CaO, K_2O, Ba, Rb and Sr, and by atomic absorption for Na_2O (analyst R. Cioni). Results are listed in table 2, together with weight normative calculations: here the alumina deficit, when present, was saturated with Fe_2O_3. As expected, a rough direct correlation exists between Fe_2O_3 content of alkali feldspars and (Na+K)/Al molecular ratios (agpaicity indexes) of

TABLE I - *The host rocks of the investigated alkali feldspar phenocrysts.*

Sample	rock type	Petrography	Provenience	Reference
RV5	comendite	Porphyritic obsidian with alkali-feldspar, ferrohedenbergite, fayalite and magnetite phenocrysts.	Tullu Mojè (Eth. Rift Valley)	DI PAOLA (pers. comm.)
RV7	comendite	as RV5	»	»
RV8	alkali-rhyol.	Porphyritic obsidian with alkali-feldspar, greenish clinopyroxene, fayalite and magnetite phenocrysts. Apatite microphenocrysts.	»	»
RV12	alkali-rhyol.	as RV8	»	»
RV13	comendite	as RV5	»	»
RV 35	comendite	Porphyritic obsidian with alkali-feldspar, ferrohedenbergite and magnetite phenocrysts.	»	»
RV 97	pantellerite	Similar to RV35. Clinopyroxene is aegyrine-richer.	»	»
RV101	pantellerite	Porphyritic obsidian with alkali-feldspar, ferrohedenbergite and cossyrite phenocrysts.	Boseti (Eth. Rift Valley)	»
D202	pantellerite	Porphyritic obsidian with alkali-feldspar (4.6 %) green clinopyroxene (0.2%) and cossyrite (0.1%) microphenocrysts.	Boina (Afar Rift)	BARBERI et Al. [1975 a]
D217	alkali-rhyol.	Alkali-feldspar phenocrysts with oligoclase core; fayalite (Fe 96), green clinopyroxene and opaques microphenocrysts; same minerals in the partly devetrified groundmass.	»	»
D227	pantellerite	Porphiritic obsidian with alkali-feldspar (11.3 %) phenocrysts; rare green clinopyroxene (0.2 %), cossyrite (0.1%) and quartz microphenocrysts.	»	»
PANT5	metaluminous	Porphyritic lava with alkali-feldspar with distinct oligoclase core and subordinate sanidine (?!), soda pyroxene and fayalite phenocrysts.	Montagna Grande (Pantelleria)	VILLARI [1975]

(*segue table 1*)

Sample	rock type	Petrography	Provenience	Reference
MMR110	alkali-trachyte	Porphyritic lava with abundant alkali-feldspar with oligoclase core phenocrysts; minor orto- and clinopyroxene phenocrysts, magnetite microphenocrysts. Rare xenolithes. Olocrystalline groundmass with fluidal pilotaxitic structure mainly constituted by alkali-feldspar microlites; opaques and greenish clinopyroxene grains.	Monte Arci (Sardinia)	Di Paola et Al. [1975]
MMR210	alkali-trachyte	Porphyritic lava with abundant alkali-feldspar with oligoclase core phenocrysts; minor clinopyroxene and biotite phenocrysts; magnetite and zircon microphenocrysts. Quartz xenocrysts. Alkali-feldspar, clinopyroxene and Fe-Ti oxides in the devitrified groundmass.	Monte Arci (Sardinia)	Cioni et Al. (in press)
SS41	comendite	Porphyritic perlite with quartz and alkali feldspar phenocrysts; rare opaques, cossyrite and zircon microphenocrysts. Colourless glassy groundmass frequently devitrified.	Punta Senoglio (S. Pietro Isl.)	Araña et Al. [1975]
SS48	alkali-rhyol.	Porphyritic perlite with quartz and alkali-feldspar phenocrysts; opaques microphenocrysts; rare hematite. Colourless glassy groundmass banded and frequently devitrified.	Le Commende (S. Pietro Isl.)	»
SS53	comendite	Porphyritic perlite with quartz and alkali feldspar phenocrysts. Rare soda pyroxene.	»	»
SS67	alkali-rhyol.	Porphyritic perlite with quartz and alkali-feldspar phenocrysts; opaques microphenocrysts; rare and completely altered mafic minerals. Colourless glassy groundmass with frequent crystallites.	Near Genarbi (S. Pietro Isl.)	»

TABLE 2 - *Chemical analyses and weight normative calculations of Na-rich alkali feldspars of the studied samples.*

	RV5	RV7	RV8	RV12	RV13	RV35	RV97	RV101	D202
SiO_2	65.99	66.92	65.35	65.28	67.11	66.86	66.76	66.74	67.00
Al_2O_3	20.04	19.14	20.90	20.92	19.15	19.27	18.82	18.36	18.46
Fe_2O_3	0.71	0.66	0.55	0.53	0.57	0.70	0.84	1.48	1.13
CaO	1.21	0.41	2.04	2.09	0.44	0.50	0.27	0.09	0.08
Na_2O	8.73	8.44	9.03	9.08	8.54	8.71	7.69	8.18	7.99
K_2O	3.32	4.43	2.13	2.10	4.19	3.96	5.62	5.15	5.34
Ba	2683	2077	2002	2017	2057	2685	257	620	93
Rb	23	96	5	8	9	17	21	43	43
Sr	238	36	576	578	43	123	<1	<1	<1
q	<0.1	0.1	0.4	0.1	0.6	0.1	-	-	-
or	19.06	26.2	12.6	12.4	24.8	23.4	33.6	30.5	31.6
ab	73.9	71.5	76.3	76.6	72.3	73.8	64.7	68.1	67.9
an	6.0	2.0	10.1	10.4	2.2	2.5	1.3	0.4	0.4
ne	-	-	-	-	-	-	0.3	0.8	<0.1
hm	0.5	0.2	0.5	0.4	0.2	0.3	0.1	0.2	0.2
(Na+K)/Al	0.90	0.98	0.82	0.82	0.97	0.97	1.00	1.04	1.03
or %	19.7	26.3	12.7	12.5	25.0	23.5	33.7	30.8	31.6
ab	74.3	71.7	77.1	77.1	72.8	74.0	65.0	68.8	68.0
an	6.0	2.0	10.2	10.4	2.2	2.5	1.3	0.4	0.4

	D217	D227	PANT5	MMR110	MMR210	SS41	SS48	SS53	SS67
SiO_2	66.25	67.09	65.06	65.25	65.29	66.53	66.48	66.63	66.39
Al_2O_3	19.94	18.52	20.89	19.74	19.73	18.72	18.98	18.84	18.96
Fe_2O_3	0.58	0.98	0.59	0.51	0.66	1.06	0.77	0.77	0.93
CaO	1.11	0.09	2.08	1.20	1.14	0.10	0.15	0.09	0.12
Na_2O	8.83	8.03	8.51	5.95	6.27	7.25	7.10	7.31	7.07
K_2O	3.28	5.29	2.87	7.35	6.91	6.32	6.52	6.36	6.53
Ba	3290	89	1984	492	473	60	58	49	58
Rb	18	40	11	79	87	105	107	118	118
Sr	357	<1	561	108	91	<1	<1	<1	<1
q	<0.1	<0.1	0.2	-	-	<0.1	-	-	0.2
or	19.4	31.3	17.0	43.5	40.9	37.4	38.6	37.6	38.6
ab	74.7	68.2	71.9	50.3	53.0	61.4	59.9	61.2	59.7
an	5.5	0.4	10.3	5.9	5.7	0.5	0.8	0.4	0.6
ne	-	-	-	<0.1	<0.1	-	0.1	0.4	-
hm	0.3	<0.1	0.6	0.2	0.4	0.7	0.7	0.4	0.9
(Na+K)/Al	0.91	1.02	0.82	0.90	0.90	1.00	0.99	1.00	0.99
or %	19.5	31.3	17.1	43.6	41.1	37.7	38.9	37.9	39.0
ab	75.0	68.3	72.5	50.5	53.2	61.8	60.3	61.7	60.4
an	5.5	0.4	10.4	5.9	5.7	0.5	0.8	0.4	0.6

The frequent deficits of Al_2O_3 was saturated with Fe_2O_3: ab is the sum of the $NaAlSi_3O_8$ (524 molecular weight) plus $NaFeSi_3O_8$ (582 molecular weight) normative minerals.

TABLE 3 - *Chemical data of the host rocks.*

Sample	RV5	RV7	RV8	RV12	RV13	RV35	RV97	RV101	D202
SiO_2(%)	68.8	69.8	69.4	69.5	69.9	70.3	71.1	68.5	72.1
Na_2O(%)	6.1	5.9	5.8	5.8	5.9	6.0	5.8	7.2	5.7
K_2O(%)	4.4	4.5	4.4	4.3	4.5	4.6	4.7	4.3	4.4
Ba(ppm)	751	478	719	690	497	498	22	351	<10
Rb "	118	130	132	127	131	122	115	152	147
Sr "	31	13	77	65	9	15	3	7	3
(Na+K)/Al (mol.)	1.01	1.09	0.98	0.97	1.10	1.10	1.35	1.84	1.52
Sample	D217	D227	PANT5	MMR110	MMR210	SS41	SS48	SS53	SS67
SiO_2(%)	65.0	70.9	63.6	n.d.	68.5	72.8	73.7	73.0	72.9
Na_2O(%)	5.9	5.9	6.7	n.d.	4.7	4.0	4.2	4.2	3.8
K_2O (%)	4.3	4.5	4.0	n.d.	5.8	4.5	4.3	4.4	4.5
Ba(ppm)	736	<10	n.d.	192	216	15	22	15	176
Rb(ppm)	106	148	49	171	171	320	323	334	326
Sr(ppm)	60	2	145	53	53	2	1	2	5
(Na+K)/Al (mol.)	0.96	1.49	0.91	n.d.	0.93	1.00	0.99	1.01	0.97

n.d = not detected
sources of major elements: see in the text.
Ba, Rb and Al contents of D202, D217 and D227 from Barberi et al. (1975)
Rb and Sr contents of PANT5 from Villari (1975)

host rocks. Major elements chemical analyses of the host rocks can be found in BARBERI et Al. [1975 a] (samples D202, D217, D227), in VILLARI [1975] (Pant 5), in ARAÑA et Al. [1975] (SS41, SS48, SS53, SS67) and in CIONI et Al. (in preparation) (MMR210). Chemical data of the samples RV were kindly provided by G.M. Di Paola. For the rock MMR110 major elements chemical data are not available.

Ba, Rb and Sr contents of host rocks, when not available in the literature, were determined by X-ray fluorescence: results are reported in table 3 together with SiO_2, Na_2O and K_2O contents and (Na+K)/Al ratios of the host rocks.

Optical properties

Fourteen of the analyzed samples were studied by using the universal stage; all these samples are optically homogeneous.

Samples with an Or content exceeding 37.5 wt. % (SS41, SS67, MMR110 and MMR210) showed monoclinic optics with optical axial plan normal to (010); sample with Or content less than 31.6 wt. % are optically triclinic. Combined albite-pericline twinning was observed only in feldspars with Or content lower than 26.2 wt. %.

Table 4 reports the orientation of the optical indicatrix and the values of the axial optical angle. With increasing Or content $\gamma \Lambda Y$ angle decreases, out of the experimental error, from 4-5° to zero (monoclinic samples) and the $\alpha \Lambda X$ angle decreases from 10° to 5-6°; the $\beta \Lambda Z$ angle, on the contrary, remains approximatively the same (18-21°) in triclinic specimens and in monoclinic ones.

TABLE 4 - *Optical orientation and 2V values.*

	wt % Or (chem.)	$\gamma \Lambda y$	$\alpha \Lambda x$	$\beta \Lambda z$	$2V\alpha$ ($\sigma \pm 1°$) (aver. of five det.)
RV12	12.5	5°	9°	18°	51°
RV8	12.7	5°	10°	18°	50°
D217	19.5	4°	8°	19°	48°
RV5	19.7	4°30'	9°	19°	49°
RV35	23.5	4°	10°	17°	46°
RV13	25.0	4°	9°	20°	47°
RV7	26.3	3°	7°	20°	46°
RV101	30.8	2°	6°	21°	48°
D227	31.3	2°	7°	21°	47°
D202	31.6	2°	6°	20°	46°
SS41	37.7	0°	6°	20°	46°
SS67	39.0	0°	6°	20°	46°
MMR210	41.1	0°	6°	17°	45°
MMR110	43.6	0°	5°	18°	44°

The values of the optic axial angle are only approximately related to the Or contents: the variations of this parameter are too small (from 50-51° to 44-45°) relative to the increase of the Or contents (from 13 to 43%) and, as is well known, cannot be utilized for an accurate estimation of the alkali feldspar composition; moreover it is to be noted that some samples have anorthite contents greater than 5% and it is known that the presence of CaO considerably affects the axial optical angles.

X-RAY CRYSTALLOGRAPHY

Methods: the separated alkali-feldspars were studied by X-ray diffraction powder techniques; Fe Kα radiation (λ = 1.9373 Å) was used in collection of spectra owing to the better resolution of peaks obtainable using this radiation. A Philips large angle vertical goniometer was used with the following conditions: scan speed 1/4° per min., time constant 4 sec., chart speed 20 mm per min., scan width 0.5°, 0.2 mm., 0.5° up to 2θ = 18°, 1.0°, 0.2 mm., 1.0° from 18 to 70 in 2θ, 4.0°, 0.2 mm., 4.0° from 70 up to nearly 100° in 2θ. The spectra were calibrated against an external standard of quartz.

The samples were checked for the presence of one or more phases; the diffraction patterns of the K-rich samples (Or > 37%), with the exception of SS67 sample, showed the superposition of two phases, whereas the Na-rich samples contained one phase. In the samples with two phases one is largely predominant, typically monoclinic and very similar to the single phase of SS67; the other has a « moderate triclinic » geometry and its amount (estimated by peak height) is nearly 5%. After homogenization of the samples at 1000° C for 4 hours powder diffraction spectra showed the presence of only one phase.

Whereas for the single phase feldspars there was no doubt in the choice of diffraction peaks ,we retained useful to refine the exsolved samples using the peaks of the dominant phase.

The crystallographic system was indicated by splitting of peaks as 131 (monoclinic) in doublets (131 and $1\bar{3}1$ in triclinic system); the choice was supported also by the optical inspection of the samples: therefore we refined as triclinic the feldspars with Or content up to 31.6 wt. % (D202) and as monoclinic the feldspars with Or content exceeding 37.7 wt. % (SS41). As starting parameters, values given in literature (WRIGHT and STEWART [1968], SMITH [1974]) for synthetic feldspars of suitable composition were taken and, when available, data of our already refined samples. All 2θ values were given unit weights. In the last stages of the refinement, peaks unequivocally indexed were used, with differences between observed and calculated 2θ less than 0.04°. For the other peaks the typical observed — calculated maximum difference ranged, in the various samples, from 0.10° to 0.20° 2θ. At low angles all the peaks were indexed.

The final parameters, with estimated standard deviations, are given in table 5.

TABLE 5 - *Lattice parameters, with estimated standard deviations (in parentheses).*

	a	b	c	α	β	γ	V	wt %Or(chemical)
RV12	8.227(2)	12.927(1)	7.135(1)	92°43'(1)	116°14'(1)	90°14'(1)	678.9(2)	12.5
RV8	8.194(2)	12.911(1)	7.124(1)	92°48'(1)	116°13'(1)	90°7' (1)	675.1(1)	12.7
PANT5	8.217(2)	12.913(2)	7.123(1)	92°34'(1)	116°19'(1)	90°14'(1)	676.6(1)	17.1
D217	8.244(1)	12.938(1)	7.139(1)	92°15'(1)	116°20'(1)	90°11'(1)	681.8(1)	19.5
RV5	8.242(2)	12.930(2)	7.143(1)	92°20'(1)	116°20'(1)	90°9' (1)	681.4(1)	19.7
RV35	8.233(1)	12.936(1)	7.137(1)	91°58'(1)	116°15'(1)	90°14'(1)	681.2(1)	23.5
RV13	8.252(1)	12.941(1)	7.139(1)	91°39'(1)	116°22'(1)	90°15'(1)	682.7(1)	25.0
RV7	8.267(1)	12.937(2)	7.143(1)	91°39'(1)	116°19'(1)	90°11'(1)	684.4(1)	26.3
RV101	8.296(2)	12.937(2)	7.145(2)	91°24'(1)	116°14'(1)	89°51'(1)	687.6(1)	30.8
D227	8.282(2)	12.953(1)	7.157(1)	91°5' (1)	116°18'(1)	90°13'(1)	688.2(1)	31.3
D202	8.302(1)	12.957(1)	7.159(1)	91°6' (1)	116°17'(1)	90°7' (1)	690.3(1)	31.6
SS41	8.311(1)	12.963(1)	7.161(1)	90°	116°21'(1)	90°	691.4(1)	37.7
SS53	8.297(3)	12.956(2)	7.152(1)	90°	116°23'(1)	90°	688.8(2)	37.9
SS48	8.315(3)	12.966(2)	7.159(1)	90°	116°22'(1)	90°	691.5(3)	38.9
SS67	8.326(1)	12.973(1)	7.163(1)	90°	116°17'(1)	90°	693.8(1)	39.0
MMR210	8.300(1)	12.973(3)	7.153(1)	90°	116°12'(1)	90°	691.0(2)	41.1
MMR110	8.328(3)	12.987(2)	7.161(1)	90°	116°13'(1)	90°	694.8(2)	43.6

Symmetry: The deviations from the monoclinic cell (see table 5) are slight (not more than 15') in γ angles and larger (up to about 3°) in α angles; the last angle shows a regular trend with changing K content, going from 92°43' for RV12 (the most Na-rich sample) to nearly 91° in K-rich triclinic feldspars. This fact is in agreement with the known data on triclinic-monoclinic transition of feldspars (SMITH [1974]). Whereas the knowledge of α angles requires a full collection and refinement of diffraction data, there are other parameters, directly observable, which can be utilized as indicators of triclinicity: the 2θ separation for peaks which coincide in monoclinic feldspars. 2θ separations values are reported against Or percentages in Fig. 1, whereas table 6 give their 2θ values.

Structural state: the term « structural state » refers to the ordered or disordered distribution of Al cations in tetrahedral sites. Information on this matter can be drawn from the lattice parameters (*b-c* plot of WRIGHT and STEWART [1968] or other interplanar spacings (Tr [110] and Tr [1$\bar{1}$0] of KROLL [1973]. In fig. 2 a *b-c* plot of the analyzed alkali-feldspars, drawn on the diagram of WRIGHT and STEWART [1968] is reported. This plot (as well as the computed values of Tr [110] and Tr [1$\bar{1}$0]) indicates for all our samples a high temperature structural state, that is a disordered distribution of Al cations in tetrahedral sites; this is not surprising in view of

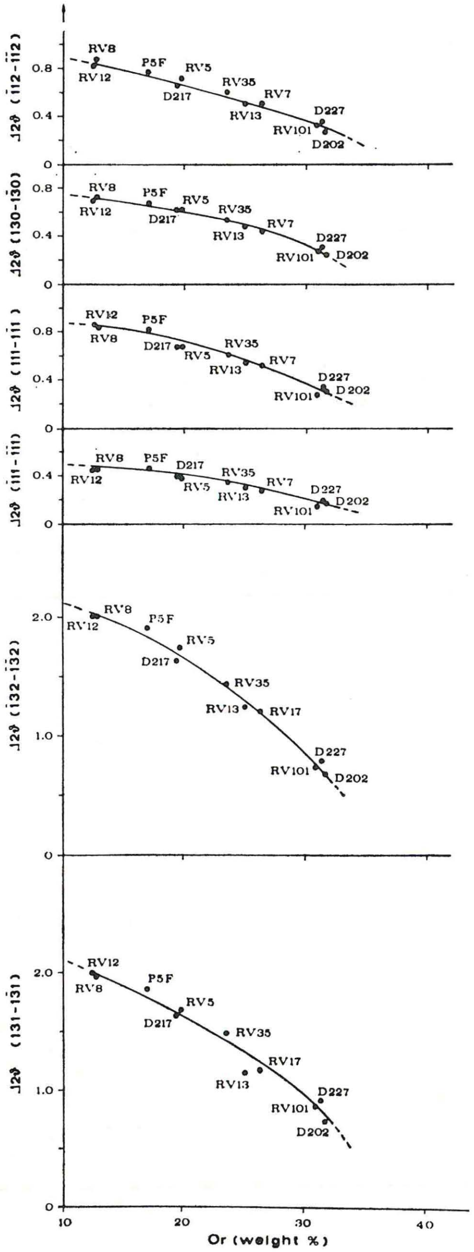

Fig. 1 - Δ 2 θ splitting in triclinic feldspars of peaks which coincide in the monoclinic system vs Or (wt%) content.

TABLE 6 - *Fe $K\alpha$ 2ϑ values of characteristic triclinicity indicators for RV12 and D202 samples (these samples represent, among the triclinic ones, the Na-richest and the Na-poorest).*

Indices	2ϑ range	
	RV12	D202
$(\bar{1}\bar{1}1)$	19.10°	19.15
$(\bar{1}11)$	19.55°	19.32°
$(\bar{1}30)$	29.87°	29.89°
(130)	30.57°	30.15°
$(\bar{1}\bar{1}2)$	32.35°	32.45°
$(\bar{1}12)$	33.17°	32.70°
$(1\bar{3}1)$	37.50°	37.87°
(131)	39.50°	38.60°
$(\bar{1}\bar{3}2)$	40.32°	40.75°
$(\bar{1}32)$	42.32°	41.45°

the volcanic nature of the rocks from which the feldspars were separated.

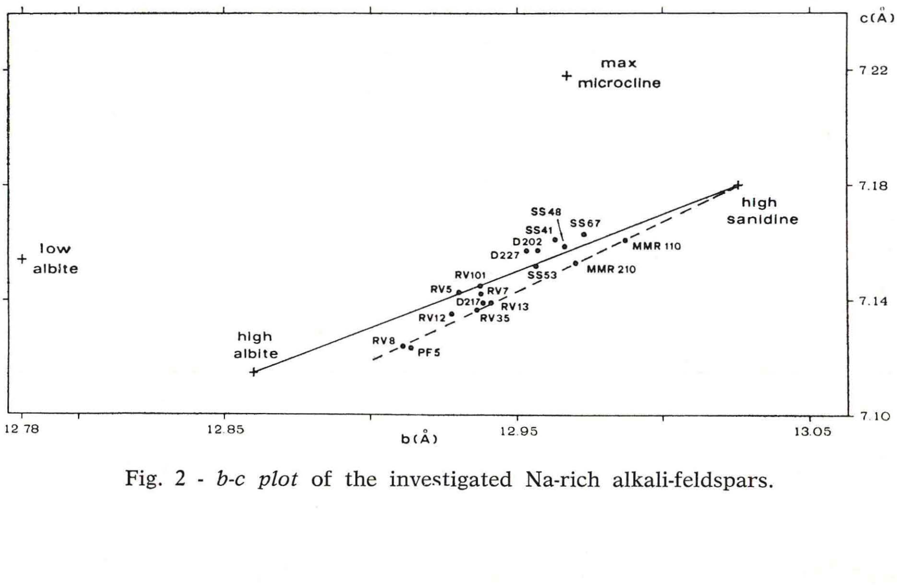

Fig. 2 - *b-c plot* of the investigated Na-rich alkali-feldspars.

Similarly to what observed by WRIGHT and STEWART [1968] about the anorthoclases of CARMICHAEL and MACKENZIE [1964] some of our samples show tendency to have small *c* and large *b* relatively to the *b-c* line in the high-albite high-sanidine series (fig. 2); the high anorthite content, in our samples, may be the cause of this displacement. On the other hand the relatively high anorthite content (5.8 wt. %) of samples such as RV5 lying on the high-albite high-sanidine tie line, prevents any general statement on the effects of anorthite content on the *b* and *c* parameters of the high temperature alkali-feldspars.

Or content and characteristic peaks: WRIGHT [1968], relating Or content with 2θ value of the $\bar{2}01$ peak, gave some equations (of the form $y = mx + b$, where y is the weight % of Or and x is 2θ ($\bar{2}01$) value for alkali feldspars of different structural state, calculated using Cu Kα diffraction data. We determined the 2θ value for Fe Kα and applied Wright's equation for high-albite high-sanidine series to calculate Or content. The results, compared with chemical data, are reported in table 7. The table shows that Wright's equation overestimates low Or content (RV12 and RV8) and understimates high Or content (SS and MMR series). The deviations seems

TABLE 7 - *Or content (wt. %) evaluated from ($\bar{2}01$) peak.*

	Or(wt.%) (chem.)	2θ(Fe Kα)	2θ(Cu Kα)	Or(wt.%) (from $\bar{2}01$) peak) a)
RV12	12.5	27.55	21.84	16.8
RV8	12.7	27.57	21.86	15.0
PANT5	17.1	27.55	21.84	16.8
D217	19.5	27.50	21.81	19.6
RV5	19.7	27.50	21.81	19.6
RV35	23.5	27.50	21.81	19.6
RV13	25.0	27.46	21.77	23.3
RV7	26.3	27.41	21.73	27.0
RV101	30.8	27.33	21.67	32.5
D227	31.3	27.34	21.68	31.6
D202	31.6	27.30	21.65	34.4
SS41	37.7	27.27	21.63	36.2
SS53	37.9	27.28	21.64	35.3
SS48	38.9	27.26	21.62	37.1
SS67	39.0	27.25	21.61	38.0
MMR210	41.1	27.22	21.60	39.0
MMR110	43.4	27.22	21.60	39.0

a) b = Or content by Wrigth's equation

determined not by An content, but by slight deviations from linearity of 2 θ ($\bar{2}01$) against Or content.

Alkali-feldspars phenocrysts and host rocks

Na-rich alkali-feldspars is the dominant phenocrystic phase in oversaturated alkaline and peralkaline volcanic rocks and its fractionation is usually considered as a major factor in the compositional evolution of these rocks. Fig. 3 is a plot of Or content of feldspar phenocrysts against the agpaicity index of the host rocks. Data refer to oversaturated both peralkaline and meta-aluminous rocks bearing Na-rich alkali-feldspar phenocrysts.

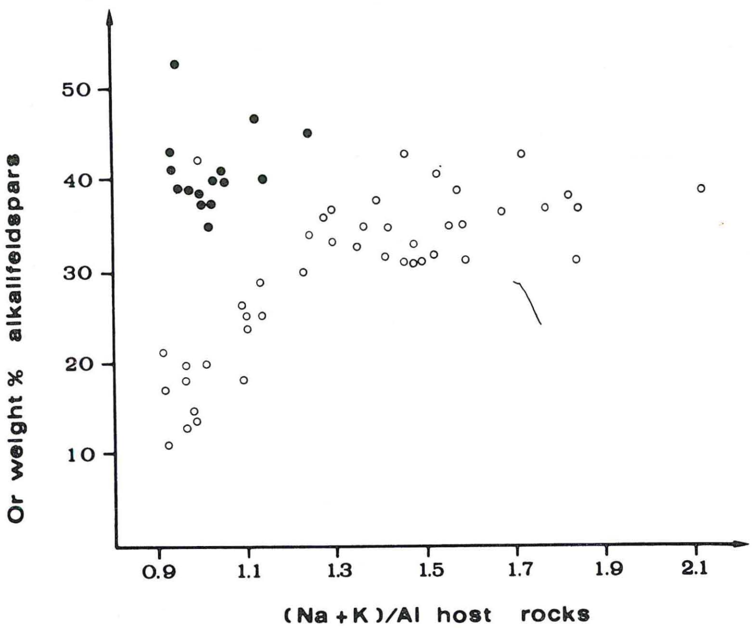

Fig. 3 - Or weight % of alkali-feldspars phenocrysts vs agpaicity indexes [(Na+K)/Al mol] of the host rocks. Empty circles: rocks considered to be generated by basalt magma fractionation; full circles: rocks for which a different origin has been proposed. Source of data: this paper, Barberi et Al. [1975 a and 1975 b]; Villari [1975], Carmichael and Mc Kenzie [1963], Gibson [1972], Piccirillo et Al. [1975], Carmichael [1962], Chayes and Zies [1962], Ewart et Al. [1969], Nicholls and Carmichael [1969], Carmichael [1960], Araña et Al. [1973], Mac Donald et Al. [1970].

A separation within alkali-feldspars from low peralkalinity rocks appears when the magma association and petrogenesis of the host rocks is considered. Actually the feldspar phenocrysts of rocks considered to be generated by basalt magmas fractionation, as those from Ethiopian Rift Valley (Di Paola, pers. comm.), Ethiopian Plateau (Piccirillo et Al. [1975]), Afar Rift (Barberi et Al. [1975 a, 1975 b], Gibson [1972]), Pantelleria (Villari [1975], Carmichael [1962], Carmichael and MacKenzie [1963], Chayes and Zies [1962]), Mayor Islands (Ewart et Al. [1969], Nicholls and Carmichael [1969]), Iceland (Carmichael [1960]), Gran Canaria (Araña et Al. [1973]) and Kenya (Nicholls and Carmichael [1969], MacDonald et Al. [1970]), have Or contents lower than those of feldspars from rocks for which a different origin has been proposed. The only exception is represented by an Iceland alkali rhyolite (sample 1F, (Carmichael [1960]). The host rocks are also characterized by a lower peralkalinity. Although the relative scarce number of samples prevents any generalization, available data seem suggest the impossibility of deriving strongly peralkaline liquids by processes other than fractional crystallization.

The two groups of rock-feldspar pairs are further distinguished on the basis of the distribution of some trace elements. Figures 4, 5 and 6 compare (Na + K)/Al ratios of the host rocks with Ba, Sr and Rb contents both of alkali feldspar phenocrysts and host rocks, and with the rock/feldspar concentration ratios. As the rocks studied usually have less than 5% phenocrysts these ratios are roughly equivalent to liquid/alkali feldspar partition coefficients, indicating the tendency of Ba and Sr to concentrate in the feldspar phase.

Presently available data suggest that rocks formed by fractional crystallization of parent basaltic magmas are characterized, with increasing peralkalinity by:

— parallel increase of Ba content both in rocks and feldspars up to (Na + K)/Al values of about 1.10-1.15, then by a sudden decrease of Ba which is extremely depleted at high peralkalinities;
— parallel and continuos decrease of Sr and increase of Rb contents;
— values constantly inferior to 1 both of the $Ba_{w.r.}/Ba_{a.f.}$ and $Sr_{w.r.}/Sr_{a.f.}$ ratios;

— a progressive decrease of $Rb_{w.r.}/Rb_{a.f.}$ ratios which are constantly greater than 1.

The parallel increase of the Ba contents in the rocks and in the alkali feldspar phenocrysts together with whole-rock/alkali-feldspar Ba concentration ratios constantly lower than 1 suggests that alkali-feldspar did not partecipate alone to the fractionation until to (Na+K)/Al values of 1.10-1.15: other Ba poor mineralogical phases were evidently involved in the differentiation process. When the peralkalinity exceeds the value of 1.10-1.15 the alkali-feldspar becomes the dominant phase. The abrupt decrease of Ba contents in the rocks and in the feldspars at 1.10-1.15 peralkalinity points to an important alkali-feldspar fractionation which practically removed all Ba present in the liquid. Such an interpretation is confirmed by the peak shown by the $Sr_{w.r.}/Sr_{a.f.}$ ratio at (Na+K)/Al values of about 1.10-1.15. The rocks not originated by fractional crystallization of a basalt parent magma are distinguished by relatively lower Ba and Sr and higher Rb contents in both whole rocks and feldspar phenocrysts.

SUMMARY AND CONCLUDING REMARKS

The lattice parameters of the natural Na-rich alkali-feldspar agree fairly well with the values determined for the corresponding synthetic samples. The various methods proposed in the literature to determine chemical composition and structural state give useful results also when applied to natural specimens. It is confirmed

Fig. 4 - Agpaicity indexes of the host rocks vs: a) Ba contents of alkali-feldspars phenocrysts; b) Ba contents of whole host rocks; c) $Ba_{whole\ rock}/Ba_{alkalifeldspar}$ ratios. Empty symbols: rocks considered to be generated by basalt magmas fractionations (squares: Tullu Mojé; triangles: Boina; circles: others). Full circles: rocks for which a different origin has been proposed. Dashed lines are proposed variation trends for Boina (B) and Tullu Mojé (TM). Sources of data: this paper, BARBERI et Al. [1975 a], PICCIRILLO et Al. [1975], CARMICHAEL [1960].

Fig. 5 - Agpaicity indexes of the host rocks vs: a) Sr contents of alkali-feldspars phenocrysts; b) Sr contents of whole host rocks; c) $Sr_{whole\ rock}/Sr_{alkalifelspar}$ ratios. Same symbols as in fig. 4. Sources of data: this paper, BARBERI et Al. [1975 a], PICCIRILLO et Al. [1975].

Fig. 6 - Agpaicity indexes of the host rocks vs: a) Rb contents of alkali-feldspars phenocrysts; b) Rb contents of whole host rocks; c) $Rb_{whole\ rock}/Rb_{alkalifelspar}$ ratios. Same symbols in fig. 4. Same sources as in fig. 5.

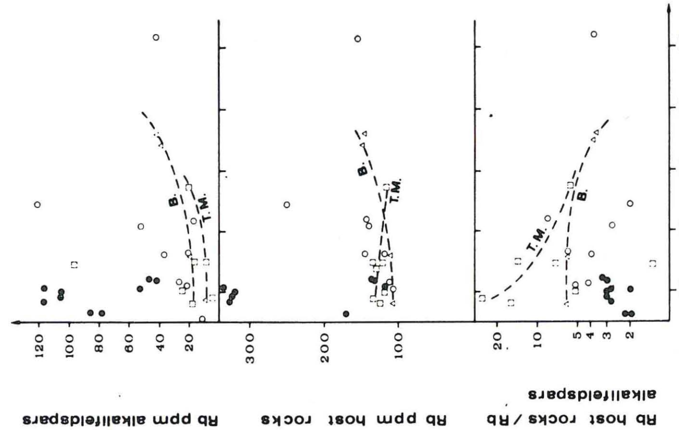

Fig. 6

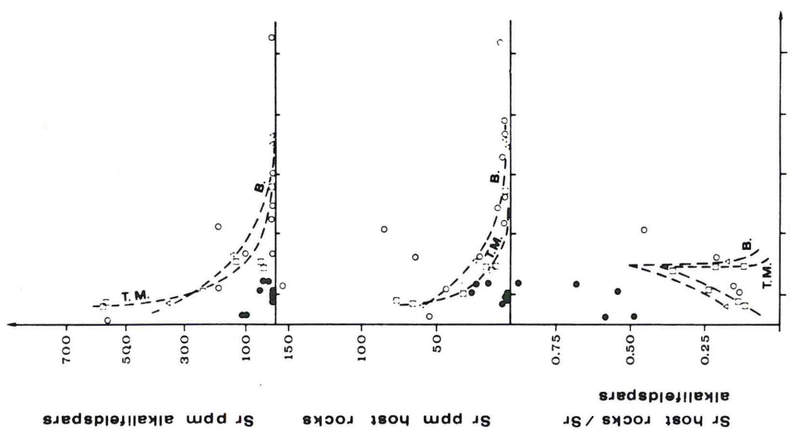

Fig. 5

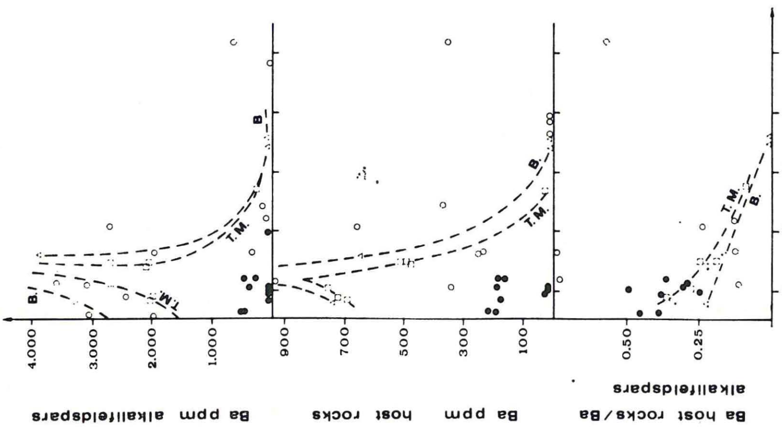

Fig. 4

that variable anorthite content complicates the study of natural samples causing slight deviations from ideal situation, as the anomalous arrangement in the *b-c* diagram or the high standard error in the application of determinative methods.

The rocks considered for this study, although all metaluminous or peralkaline and oversaturated, have different origins (fractionation of basalt, crustal anatexis, association with calc-alkaline magmas, alkali transfer in a volatile phase). Available data indicate that the low peralkalinity rocks related to basaltic magmas are apparently systematically characterized by feldspar phenocrysts with-lower Or content than those occurring in rocks with the same peralkalinity and of different origin. The two groups of rocks appear also characterized by different distribution of trace elements such as Sr and Ba in the rock-feldspar pairs.

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