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THE PROBLEM OF Na–Li SUBSTITUTION IN PRIMARY Li–Al PHOSPHATES: NEW DATA ON LACROIXITE, A RELATIVELY WIDESPREAD MINERAL

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ABSTRACT

Wet-chemical analyses and X-ray-diffraction patterns of minerals of the amblygonite–montebrasite series occurring in the Gatumba pegmatite field, Rwanda, show that an impurity is detectable on the powder pattern if Na_2O exceeds 0.2 wt.%. In a sample from Buranga with 2.05 wt.% Na_2O, this impurity was identified as lacroixite. Electron-microprobe and wet-chemical analyses of two lacroixite samples from Rusororo and one from Buranga showed them to contain Li and OH in substitution for Na and F, respectively. The two lacroixite samples from Rusororo have the following idealized formulas: $(Na_{0.61}Li_{0.39})AlPO_4(F_{0.59}OH_{0.41})$ and $(Na_{0.86}Li_{0.14})AlPO_4(F_{0.81}OH_{0.19})$. The formula of lacroixite from Buranga is $(Na_{0.78}Li_{0.22})AlPO_4(F_{0.65}OH_{0.35})$. The unit-cell parameters of these three samples show that *b* decreases with increasing Li contents. The petrographic texture of the Buranga lacroixite suggests that this mineral is either a Na-metasomatic product or an exsolved phase in its montebrasite host, whereas the decreasing Li contents of the Rusororo lacroixite samples can be tentatively related to the lowering of temperature. An X-ray-diffraction examination of the so-called "Na-rich amblygonite" from Hebron showed it to be a mixture of amblygonite and lacroixite.

Keywords: lacroixite, amblygonite–montebrasite series, Na–Li substitution, composition, X-ray data, Gatumba pegmatite field, Rwanda.

SOMMAIRE

Des analyses chimiques par voie humide et des clichés de diffraction des rayons X, effectués sur des minéraux de la série amblygonite - montebrasite provenant du champ pegmatitique de Gatumba, Rwanda, montrent qu'une impureté apparaît sur les diffractogrammes de poudre dès que Na_2O atteint 0.2% en poids. Grâce à un échantillon de Buranga avec 2.05% Na_2O, cette impureté a été identifiée comme étant lacroixite. Les résultats des analyses à la microsonde électronique et par voie humide montrent que les deux échantillons de lacroixite de Rusororo et celui de Buranga contiennent Li et OH, qui se substituent au Na et au F, respectivement. Les formules idéalisées des deux échantillons de Rusororo sont $(Na_{0.61}Li_{0.39})AlPO_4(F_{0.59}OH_{0.41})$ et $(Na_{0.86}Li_{0.14})AlPO_4(F_{0.81}OH_{0.19})$. Pour l'échantillon de Buranga, la formule est $(Na_{0.78}Li_{0.22})AlPO_4(F_{0.65}OH_{0.35})$. Le paramètre cristallographique *b* de ces trois échantillons décroît quand la teneur en Li augmente. Tandis que les teneurs décroissantes en Li des exemples de Rusororo pourraient éventuellement être reliées à l'abaissement de la température, la texture pétrographique de la lacroixite de Buranga montre que le minéral est soit un produit de la métasomatose sodique, soit une phase d'exsolution dans les cristaux de montebrasite. Un examen par diffraction X d'un échantillon d'"amblygonite riche en Na" de Hebron révèle un mélange d'amblygonite et de lacroixite.

Mots-clés: lacroixite, série amblygonite–montebrasite, substitution Na–Li, composition, données de diffraction X, champ pegmatitique de Gatumba, Rwanda.

INTRODUCTION

Although amblygonite was first encountered at the Buranga pegmatite, Rwanda, in the nineteen-forties by R. de Dycker (Buttgenbach 1947), and although minerals of the $LiAlPO_4(F,OH)$ series were extensively mined before the nineteen-sixties in several pegmatites near Buranga, in the Gatumba field, these minerals are poorly known, and the relatively few data on their mineralogical properties are dispersed in the literature (Polinard 1950, Thoreau & Bastien 1954, von Knorring 1970, Dubois *et al.* 1972, Fransolet & Abraham 1983).

The initial purpose of this study was to chemically determine the fluorine contents of minerals in the amblygonite–montebrasite series, collected from several phosphate-rich lithium-bearing pegmatites of the Gatumba field. The interpretation of about twenty chemical analyses, complemented by a systematic X-ray investigation to check the reliability of methods proposed to determine values of the F/OH ratio (Černá *et al.* 1973, Kallio 1978), subsequently led to the identification of lacroixite from the Rusororo pegmatite and the Burunga mine.

Recently, Lahti & Pajunen (1985) reviewed the historical background of lacroixite $NaAlPO_4F$, published new data for this mineral, and determined its crystal structure. The present study of three lacroixite samples from the Gatumba pegmatites provides evidence of Li and OH substitution for Na and F, respectively, and warrants further discussions of the chemical composition and crystallographic properties of lacroixite, as well as the problem of Na-for-Li substitution in the amblygonite–montebrasite series.

Analytical Methods

All minerals reported here were identified by X-ray diffraction, using Debye-Scherrer cameras and a diffractometer equipped with a Fe target and a monochromator. The *d* values of the lacroixite samples, corrected with a $Pb(NO_3)_2$ internal standard (*a* 7. 8568 Å) and recorded with a scanning speed of ½° 2*θ*/min, were used to refine the unit-cell parameters with the program of Appleman & Evans (1973) and the structural data of Lahti & Pajunen (1985). The space group *C2/c*, determined by the latter authors, was checked by the Weissenberg technique on the material from the Rusororo pegmatite.

The wet-chemical analyses were performed using atomic absorption for Al, Fe, Mn, Mg, Ca, Na, K and Li, colorimetry for P, direct titration with a specific electrode for F, and the Penfield method for H_2O. Lacroixite was dissolved in concentrated HCl heated at 190°C in a steel bomb lined with teflon.

The electron-microprobe analyses were done with CAMEBAX equipment using the ZAF correction procedure of Henoc & Tong (1977) and the following standards: synthetic berlinite (P and Al), Fe_3O_4 (Fe), metallic Mn, MgO (Mg), albite (Na), wollastonite (Ca), and topaz (F).

Mineralogical Data

Lacroixite from the Rusororo pegmatite

Near the quarry of Rusororo, briefly described by Bertossa (1960) and cited as the "Amblygonite mine of Rongi" by Varlamoff (1961, 1973), now deserted and overgrown since the end of the mining activities, some boulders of montebrasite displaying complex replacement textures are still visible. Around the cores of montebrasite is an alteration rim, up to 30 cm wide, that consists mainly of an intimate mixture of abundant berlinite and of faintly bluish lacroixite. The individual grains of lacroixite (up to 10 mm) display a vitreous to pearly luster on the cleavages (as in montebrasite). Many of the alteration rims are interrupted by irregular masses of bluish white lacroixite in close association with deep blue scorzalite, easily recognized in the field. Both lacroixite and scorzalite occur as irregular veinlets, pods, or diffuse specks. Berlinite is seldom present in this second association.

Thin sections containing the two types of association show that the bluish color of lacroixite is caused by minute inclusions of scorzalite (10 to 50 μm) that look like exsolution products. The lacroixite grains are generally turbid and are locally stuffed with other undetermined minute inclusions. In the first association, however, berlinite occurs as a mosaic, and lacroixite has a poikiloblastic-like texture and appears rather transparent at the contact with the embedded globular grains (200 μm to 1 mm) of berlinite.

The mean of several microprobe analyses of the lacroixite (Ru–I) containing embedded berlinite is given in Table 1. On the basis of 1 $(PO_4)^{3-}$ per formula unit (p.f.u.), the main cation numbers show a distinct nonstoichiometric ratio, in contrast with the results of Lahti & Pajunen (1985). Attempts at purification did not succeed in complete separation of berlinite from lacroixite in this assemblage, and several wet-chemical analyses indeed gave an excess of Al_2O_3 and P_2O_5. These analyses, however, showed Li and H_2O to be present in the mixtures. These results allowed me to complete the microprobe analytical data by calculating the Li_2O and H_2O contents to render stoichiometric the formula for lacroixite Ru–I, as indicated in Table 1. The simplified formula of this mineral is $(Na_{0.61}Li_{0.39})AlPO_4(F_{0.59}OH_{0.41})$.

Lacroixite Ru–II, which occurs in the scorzalite-rich veinlets of the second type of association and cross-cuts the association rich in berlinite, was purified by hand-picking under a binocular microscope. All minute inclusions of scorzalite could not be eliminated, but X-ray examination showed that impurities other than scorzalite are absent. The results of a wet-chemical analysis of lacroixite Ru–II are given in Table 2. Because Mg was not detected either in lacroixite Ru–I (Table 1) or the Buranga lacroixite (see below), the MgO content of 0.29 wt.% is assigned to scorzalite. The composition of the scorzalite inclusions was determined by microprobe analysis; the composition of lacroixite Ru–II was deduced (Table 2) to be $(Na_{0.86}Li_{0.14})AlPO_4(F_{0.81}OH_{0.19})$.

TABLE 1. MICROPROBE DATA ON LACROIXITE FROM RWANDA

	Rusororo Ru-I (n=19)		Buranga Bu.5.21 (n=7)	
	1	2	1	2
P_2O_5	44.23	1.000	43.08	1.000
Al_2O_3	32.27	1.016	32.18	1.040
FeO	1.56	0.035	0.61	0.014
MnO	0.37	0.008	0.39	0.009
CaO	0.12	0.003	-	-
Na_2O	11.27	0.584	14.25	0.758
Li_2O*	[3.45]	0.370	[1.99]	0.219
		1.000		1.000
H_2O*	[2.30]	0.410	[1.90]	0.347
F	6.99	0.590	7.52	0.652
		1.000		1.000
Total	102.56		101.92	
O = F	- 2.94		- 3.16	
Total	99.62		98.76	
Na/(Na+Li)		0.612		0.776

1. Analytical results (Analyst: Prof. K. Abraham)
n = number of point analyses
* = calculated wt. % for stoichiometry
2. Cation number on the basis of $1(PO_4)$ per formula unit.

TABLE 2. RESULTS OF A WET-CHEMICAL ANALYSIS OF LACROIXITE FROM RUSORORO

	1	2	3	4	
P_2O_5	43.24	3.93	42.98	1.000	1.000
Al_2O_3	31.62	2.82	31.49	1.020	1.020
FeO	2.99	1.47	1.66	0.038	}
MnO	0.37	-	0.40	0.009	}
MgO	0.20	0.29	-	-	}
CaO	0.35	-	0.38	0.011	} 1.002
Na_2O	13.88	-	15.18	0.809	}
K_2O	0.02	-	0.02	0.001	}
Li_2O	1.11	-	1.21	0.134	}
H_2O^+	1.51	0.50	1.10	0.202	}
H_2O^-	0.40	-	-		} 1.036
F	8.78	-	9.60	0.834	}
Total	104.56		104.02		
O = F	- 3.69		- 4.03		
Total	100.89		99.99		

1. Analysis of lacroixite Ru-II (Analyst: J.-M. Speetjens).
2. Impurity of scorzalite calculated on the basis of the electron microprobe analysis: 42.39% P_2O_5; 31.74% Al_2O_3; 16.02% FeO; 0.13 % MnO; 3.07% MgO (Analyst: Prof. K. Abraham).
3. Analysis "1" recalculated to 100%.
4. Cation numbers on the basis of $1(PO_4)^{3-}$ per formula unit.

This wet-chemical analysis provides an important argument to justify the addition of appropriate amounts of Li_2O and of water to complete the partial microprobe analyses of lacroixite. Moreover, if it is assumed that Li is derived from a $LiAlPO_4(F,OH)$ mineral, then the bulk-chemical analysis (Table 2) indicates about 13 wt.% of such a mineral in the mixture. Such an amount should be easily detected by X-ray-diffraction methods, but no amblygonite was observed in the present case.

TABLE 3. X-RAY POWDER-DIFFRACTION DATA FOR LACROIXITE FROM RUSORORO

I	$d_{obs.}$	hkl	$d_{calc.}$	I	$d_{obs.}$	hkl	$d_{calc.}$
45	4.723	110	4.720	5	1.769	202	1.770
40	4.624	$\bar{1}11$	4.620	10	1.708	$\bar{2}04$	1.708
15	3.402	021	3.402	5	1.702	042	1.701
25	3.246	111	3.246	<5	1.672	$\bar{3}31$	1.671
100	3.149	$\bar{1}12$	3.149	10	1.657	{$\bar{3}32$	1.658
10	3.100	002	3.101			{$\bar{1}14$	1.656
85	2.897	200	2.897	5	1.647	$\bar{2}42$	1.647
10	2.805	$\bar{2}02$	2.805	10	1.623	222	1.623
15	2.520	$\bar{2}21$	2.520	20	1.573	{330	1.573
35	2.464	022	2.466			{$\bar{2}24$	1.575
10	2.360	220	2.360	<5	1.550	004	1.550
10	2.198	$\bar{1}13$	2.199	<5	1.538	$\bar{3}33$	1.540
25	2.152	131	2.153	<5	1.492	{$\bar{4}22$	1.493
5	2.125	$\bar{1}32$	2.124			{$\bar{2}43$	1.490
10	2.054	$\bar{3}11$	2.053	<5	1.470	$\bar{1}52$	1.469
5	2.034	040	2.035	5	1.449	400	1.448
5	2.028	$\bar{3}12$	2.028	10	1.435	$\bar{1}34$	1.435
<5	1.986	221	1.986				
10	1.927	$\bar{2}23$	1.927				
10	1.879	310	1.879				

Sample Ru-I; diffractometer; monochromatized Fe radiation; lead nitrate as internal standard; intensities estimated visually.

TABLE 4. UNIT-CELL DIMENSIONS OF LACROIXITE

	1	2	3	4
a(Å)	6.414	6.415(1)	6.420(2)	6.422(1)
b(Å)	8.207	8.190(2)	8.181(6)	8.139(2)
c(Å)	6.885	6.870(2)	6.883(5)	6.875(1)
β	115°28'	115°29'(1')	115°31'(3')	115°34'(1')
V(Å^3)	327.2	325.8(1)	326.3(2)	324.2(1)
Na/(Na+Li)	1.000	0.858	0.776	0.612
F/(F+OH)	1.000	0.805	0.653	0.590

1. Greifenstein (Lahti & Pajunen 1985). 2. Rusororo (Ru-II); 27 *d* values were used in the calculation. 3. Buranga (Bu.5.21); 6 *d* values were used (see Fig. 1). 4. Rusororo (Ru-I); 34 *d* values were used (see Table 3).

Although the X-ray powder-diffraction data obtained from lacroixite Ru–I are in good agreement with the results of Lahti & Pajunen (1985), a new list of indexed diffraction peaks for lacroixite rich in Li and OH seems in order because several *d* values have significantly shifted as a result of a noticeable shortening of the *b* parameter (Tables 3, 4). For example, 040 and $\bar{2}42$ occur as additional peaks, and the indexing of a few other lines has been slightly modified (*e.g.*, indices for 2.054 and 1.657 Å).

Lacroixite from the Buranga pegmatite

A pale greyish blue sample of montebrasite from the Buranga pegmatite, replaced by pure white montebrasite, gave 2.05 wt.% Na_2O (Table 5), rather similar to the Na content quoted for Hebron amblygonite (Černá *et al.* 1973). However, the X-ray pattern of the Buranga sample showed 6 readily discernible diffraction-peaks attributable to lacroixite (Fig. 1). These *d* values were used to calculate the unit-cell dimensions of this lacroixite (Table 4), whose occurrence can be added to the long list of phosphate minerals known for this famous pegmatite.

In thin sections the greyish blue montebrasite looks turbid or cloudy from place to place, particularly along some directions corresponding roughly to the main cleavages. Observation at high magnification clearly shows minute grains (up to 10 × 75 μm) with a lower birefringence than that of the host material, and with uniform optical orientation (Fig. 2). As is evident in Figure 3, the backscattered-electron image as well as the mapping of Na in such a "turbid zone" provide evidence for the existence of minute inclusions of a Na-rich mineral within a Na-free host.

The analytical results obtained with the electron microprobe corroborate the presence of lacroixite within montebrasite (Tables 1, 5). The interpretation of the microprobe analysis of lacroixite (Table 1) again suggests the presence of additional Li and OH to maintain stoichiometry. On the basis of $1(PO_4)^{3-}$ p.f.u., the idealized composition for this Buranga lacroixite is $(Na_{0.78}Li_{0.22})AlPO_4(F_{0.65}OH_{0.35})$.

A similar heterogeneous distribution of Na within

TABLE 5. CHEMICAL COMPOSITION OF HETEROGENEOUS $LiAlPO_4(F,OH)$ MINERALS

	Montebrasite Buranga (Bu.5.21)				Amblygonite Hebron (USNM 62576)	
	1	2	3	4	5	6
P_2O_5	47.97	47.77	48.63	1.000	47.05	1.000
Al_2O_3	33.90	36.18	34.08	0.976	33.49	0.991
Fe_2O_3	0.17	0.03	0.08	0.001	0.10	0.002
MnO	0.04	n.d.	-	-	0.12	0.003
MgO	0.02	n.d.	0.02	0.001	-	-
				0.978		0.996
CaO	0.03	n.d.	0.03	0.001	0.20	0.005
Na_2O	2.05	n.d.	-	-	3.03	0.147
Li_2O	9.01		10.49	1.025	8.36	0.844
				1.026		0.996
H_2O^+	3.73		4.34	0.703	2.60	0.453
H_2O^-	0.07		-		-	
F	4.52	3.90	4.00	0.307	8.97	0.712
				1.010		1.147
Total	101.51		101.67		103.92	
O = F	- 1.90		- 1.68		- 3.77	
Total	99.61		99.99		100.15	

1. Bulk composition; wet-chemical analysis by J.-M. Speetjens. 2. Microprobe analysis of montebrasite hosting lacroixite. Analyst: Prof. K. Abraham (see Fig. 3). 3. Composition 1 recalculated to 100% assuming that Na is derived only from lacroixite as given in Table 1. 4. Cation numbers on the basis of $1(PO_4)^{3-}$ per formula unit. 5. Results of wet-chemical analysis by J.-M. Speetjens. 6. Cation numbers on the basis of $1(PO_4)^{3-}$ per formula unit.

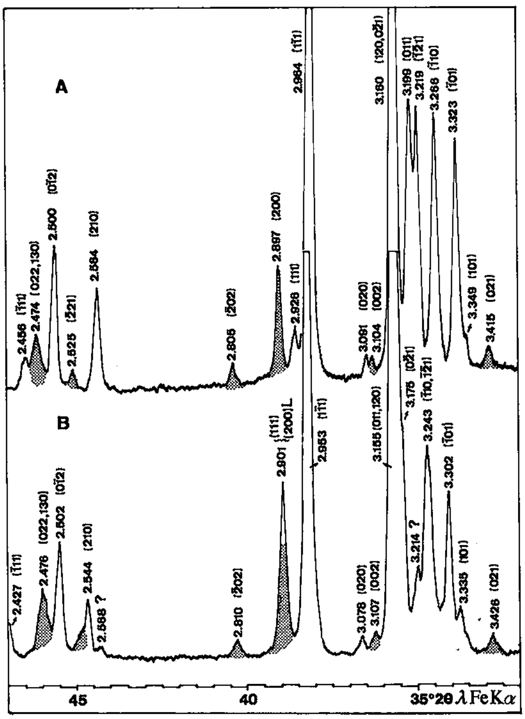

FIG. 1. Selected portions of powder diffractograms showing typical lacroixite (L) peaks separated by shading from those of montebrasite from Buranga (A), and those of amblygonite from Hebron (B). Two additional peaks attributed to an undetermined impurity are present on diffractogram (B).

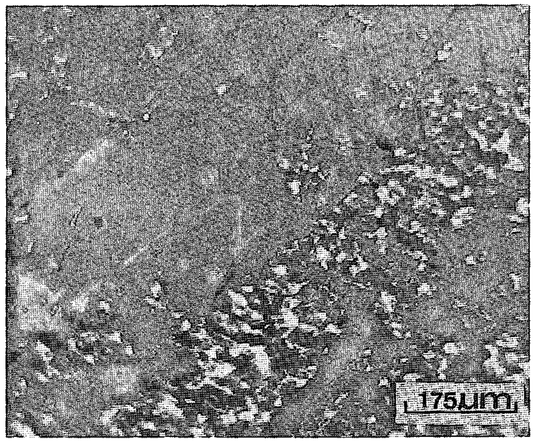

FIG. 2. Photomicrograph (crossed nicols) of the Buranga montebrasite, showing a "cloudy zone" rich in minute lacroixite grains (white), as well as the typical polysynthetic twins of montebrasite (upper left).

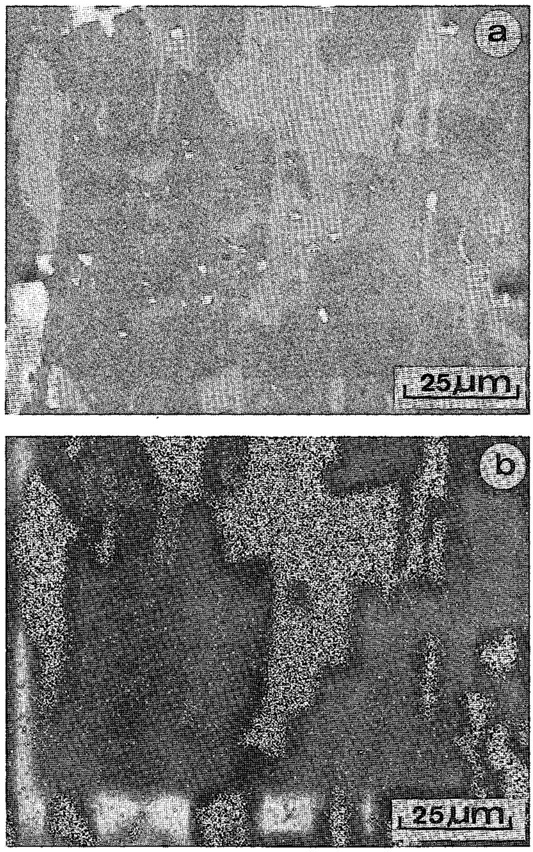

FIG. 3. Back-scattered electron (a) and sodium distribution (b) pictures of a portion of Buranga montebrasite invaded by a "cloudy zone" (see Fig. 2). The brighter areas on the sodium map show the shape of the lacroixite grains within montebrasite.

montebrasite associated with triplite and griphite was described in the Buranga pegmatite (Fransolet & Abraham 1983). However, the presence of lacroixite could not be verified.

Discussion

The new data on lacroixite from two pegmatites in the Gatumba field invite several comments and expand our knowledge of this mineral.

From infrared spectral results, Lahti & Pajunen (1985) considered that only a very limited substitution of OH for F in lacroixite may be possible. The wet-chemical and electron-microprobe analytical data in the present study indicate that Li and OH may occur in major quantities in lacroixite. In addition, marked variations of Na/(Na + Li) and F/(F + OH) have been noted (Table 1), even from one association to another in the Rusororo pegmatite. Although the available data are still too scarce, it seems that these variations affect the unit-cell parameters of lacroixite. To test this possibility further, the unit-cell dimensions given in Table 4 have been plotted against Na/(Na + Li) (Fig. 4). Whereas the *a* and *c* parameters seem relatively unaffected by the substitution of Li for Na, *b* decreases significantly as Li increases, possibly because of the smaller ionic radius of Li compared to Na. This conclusion, based on only four data-points, admittedly is tenuous, especially as F-for-OH substitution affects the unit-cell values in a similar way (Fig. 4).

The wet-chemical and the microprobe analyses both indicate a persistent presence of Fe, Mn and Ca, in contrast with the chemical data for lacroixite from Greifenstein (Lahti & Pajunen 1985). As the octahedral sites populated by Al are either filled comletely, or Al is in excess (possibly because of analytical error), it is reasonable to accept that Ca, Mn and also Fe occupy the larger alkali positions. Such a hypothesis implies a coupled substitution to maintain the charge balance of the chemical formula, *i.e.*, $Na^+ + (F,OH)^- \rightarrow R^{2+} + O^{2-}$. The anion involved in this coupled substitution occupies the non-tetrahedral oxygen position of the titanite structure. Therefore, the water contents calculated for stoichiometry (Table 1) are a little too high. In the case of lacroixite Ru-I, the presence of 0.046 divalent cations in the alkali positions implies 0.046 oxygen with 0.590 F and 0.364 OH p.f.u. From this OH content, one deduces 2.04 wt.% H_2O. Following the same argument, the lacroixite from Buranga contains 1.78 wt.% H_2O. The analytical error associated with a determination of H_2O by the Penfield method is relatively high, however, so that this argument cannot be corroborated by the results of the wet-chemical analysis (Table 2).

The fact that lacroixite is characterized by a titanite-type structure (Lahti & Pajunen 1985), which is rather flexible in accepting various coupled substitutions, could explain why lacroixite contains the highest weight-percentages of FeO of any Al-rich phosphate minerals occurring in the two pegmatites (except, of course, the minerals of the scorzalite – lazulite and the childrenite - eosphorite series). Whereas 1.56% FeO was detected in lacroixite Ru-I (Table 1), the FeO contents determined previously for these Al phosphates have never exceeded 1 wt.%, *e.g.*, 0.18% as an upper limit in montebrasite, 0.27% in trolleite, 0.08% in brazilianite (wet-chemical procedure), 0.26% in augelite, and 0.85% in bertossaite (electron microprobe) (unpublished results).

From a genetic point of view, the two different values of the Na/(Na + Li) ratio reported for lacroixite from Rusororo are puzzling. Lacroixite Ru-I associated with berlinite replaced montebrasite, and was replaced in turn by another association charac-

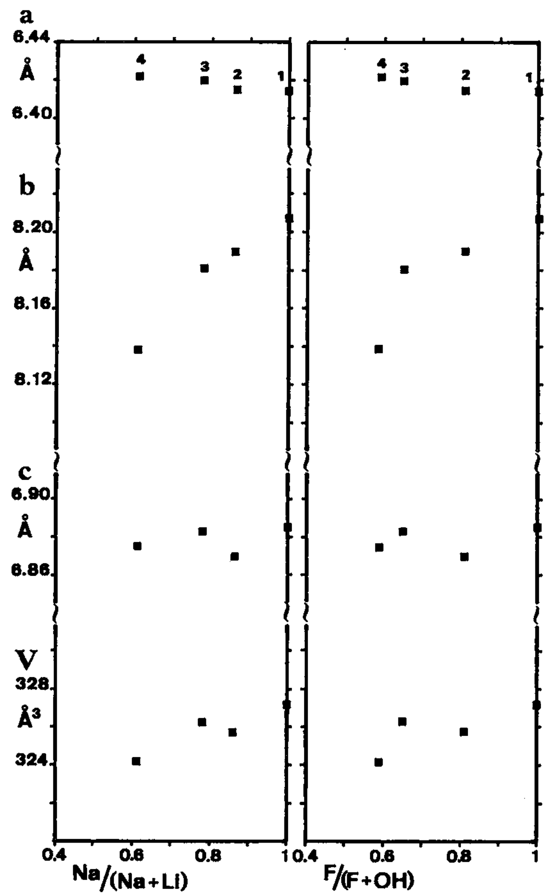

FIG. 4. Unit-cell dimensions of lacroixite plotted against the Na/(Na + Li) and F/(F + OH) ratios (1, 2, 3, 4 refer to Table 4).

terized by lacroixite Ru–II, with abundant scorzalite and a small amount of berlinite. This observation suggests that the decreasing Li contents perhaps relate to a lowering of the temperature. However, more data are required to ascertain whether Li contents may serve as a geothermometer for lacroixite formation; interestingly, Li-free lacroixite from Greifenstein occurs in druses of a lithium-bearing granite, associated with other phosphate minerals that are typical of a low-temperature hydrothermal environment (Lahti & Pajunen 1985).

The Buranga montebrasite – lacroixite association raises another problem, critical for both the crystal chemistry and genesis of the $LiAlPO_4(F,OH)$ minerals. The petrographic texture exhibited by the lacroixite grains within montebrasite suggests an analogy with chessboard albite, or exsolution (Figs. 2, 3).

In the first case, lacroixite would be taken to represent a product of Na metasomatism that affected the amblygonite – montebrasite masses, as reported by Moore (1973). This evolutionary stage of Al-rich phosphate associations could be related to the same event of Na metasomatism that is known to transform the Li(Fe,Mn) PO_4 mother-phases into alluaudite in Fe–Mn phosphate associations (Moore 1971, Fransolet *et al.* 1985, 1986).

The second alternative is that lacroixite and montebrasite are the exsolution products of a pre-existing homogeneous $(Li,Na)AlPO_4(OH,F)$ phase, thereby requiring a miscibility gap in the binary Li-Na montebrasite solid-solution series. If natromontebrasite ("fremontite") described by Schaller (1911, 1914) and Na-bearing amblygonite from Hebron (Černá *et al.* 1973) are actually homogeneous, a closure of the miscibility gap must be inferred to exist at higher temperatures. All the amblygonite – montebrasite samples initially studied here, however, were found to contain lacroixite impurities if the bulk samples contain more than 0.20 wt.% Na_2O. Consequently, a sample of the Na-bearing amblygonite from Hebron was re-examined. The wet-chemical results from a fragment of this sample (U.S.N.M. 62576) accompany those obtained from the Buranga material (Table 5). The X-ray powder pattern (Fig. 1) clearly demonstrates that the mineral from Hebron contains lacroixite in amounts roughly similar to those observed in the Buranga material.

Several occurrences of lacroixite in close association with amblygonite from various localities in Czechoslovakia are known (F. Čech, written comn. 1987), and lacroixite thus may be much more widespread than was considered previously. The possibility of a miscibility gap in the Na–Li montebrasite solid solution requires much additional study. A reinvestigation of the type natromontebrasite of Schaller (1911) is in progress to answer the important question of its validity as a mineral species.

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