THE AMERICAN MINERALOGIST, VOL. 53, JULY-AUGUST, 1968

EUCRYPTITE AND BIKITAITE FROM KING'S MOUNTAIN, NORTH CAROLINA

PETER B. LEAVENS, *Department of Geology, University of Delaware, Newark, Delaware* C. S. HURLBUT, JR., *Department of Geological Sciences, Harvard University, Cambridge, Massachusetts*
JOSEPH A. NELEN, *U. S. National Museum, Washington, D. C.*

ABSTRACT

Vein fillings in the King's Mountain pegmatite yield good eucryptite crystals with $a=13.490$, $c=9.016\pm0.007$ Å, $a:c=1:0.6684$ (X-ray), 1:0.6685 (morph.). Bikitaite had $a=8.614$, $b=4.957$, c 7.603 ± 0.022 Å, $\beta=114°$ 19.3′ (X-ray). Chemical analyses yielded the formulas $(Li_{5.80}Na_{0.06})Al_{5.98}$-$Si_{6.05}O_{24}$ for eucryptite and $Li_{2.10}Al_{2.00}Si_{3.97}O_{12}\cdot 1.95H_2O$ for bikitaite.

INTRODUCTION

Since its original description by Brush and Dana (1880) from Branchville, Connecticut, eucryptite has been reported from only three other localities. These are Center Strafford, New Hampshire; the Harding Mine, Dixon, New Mexico (Mrose, 1953); and Bikita, Rhodesia (Hurlbut, 1962). Bikitaite has been reported only from Bikita (Hurlbut, 1957). Both minerals have recently been found in lithium-rich pegmatites at King's Mountain, North Carolina, where they occur sparingly as single crystals in seams. Although the eucryptite crystals are much smaller than those from Bikita, they are free-growing and many are completely bounded by crystal faces. The bikitaite, however, is deeply etched and gives poor morphological measurements. Chemical analyses shows that both minerals are of nearly ideal composition.

OCCURRENCE

A large opencut mine in a pegmatite swarm at King's Mountain, North Carolina is operated by the Foote Mineral Company principally for the recovery of spodumene. The mining operation and the geology of the locality have been described by Kesler (1961). The pegmatites, as much as 2000 feet long and 200 feet thick, trending approximately north, and dipping steeply and irregularly both east and west, are intruded into thin-layered amphibolite and fine-grained mica schist. Diamond core drilling indicates that although the bodies are approximately tabular, many are complexly connected at depths of 100 to 500 feet.

The pegmatites show almost no zoning, and are remarkably uniform in mineralogy and texture. Occasional bodies of quartz, a few tens of feet long, with associated coarse spodumene and microcline may represent core segments. As a whole, the pegmatites are composed of about 41 percent microcline and albite feldspar, 32 percent quartz, 20 percent spodumene, 6 percent muscovite, and 1 percent other minerals (Kesler, 1961). The concentration of spodumene is remarkable.

Minor fractures in the pegmatites contain quartz, albite, rhodochrosite, and a number of phosphates, including apatite, vivianite and fairfieldite. In several of these fractures bikitaite has been found in small amounts, most notably in the large pegmatite exposed on the west side of the open pit, on the 7th level, at about 6N section (Kesler, 1961, Fig. 2). The mineral occurs primarily in intergrowths of bladed crystals, like jackstraws. Albite, quartz, apatite, and fairfieldite are associated with it. Eucryptite crystals and narrow vein fillings were found in a single fracture in the same pegmatite body, on the 8th level of the pit, near the 10N section (Kesler, 1961, Fig. 2). Associated minerals are albite, occasional small sprays of white fairfieldite, and rare, sharp quartz crystals. The association of quartz and eucryptite, without bikitaite, indicates that these two

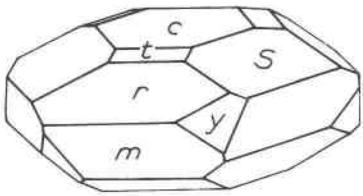

FIG. 1. Eucryptite, King's Mountain North Carolina.

minerals are co-stable. The veins of both eucryptite and bikitaite are small and have yielded only a limited number of specimens.

Crystallography

Eucryptite. Although some of the free-growing eucryptite crystals are as much as 5 mm in maximum dimension, most are smaller, measuring only 1–2 mm across. They are all colorless and transparent and except for the point of attachment to the vein wall are completely bounded by crystal faces. The typical habit is shown in Figure 1: but in some of the smaller crystals, all faces are equally developed, giving them a spherical appearance.

Eight crystals were measured on the two-circle goniometer all of which showed the forms illustrated in Figure 1; namely, *c*{0001}, *m* {10$\bar{1}$0}, *r* {10$\bar{1}$1}, *s* {01$\bar{1}$2}, *t* {10$\bar{1}$4}, *y* {12$\bar{3}$2}. In addition {11$\bar{2}$0} is present on some crystals. Although not as well developed nor as uniform, these same forms were also reported on eucryptite crystals from Bikita (Hurlbut, 1962). In addition the following new forms were observed on crystals from King's Mountain: $\{10\bar{1}2\}$, $\{12\bar{3}1\}$, $\{21\bar{3}1\}$, $\{\bar{1}321\}$, $\{\bar{3}121\}$ and $\{21\bar{3}4\}$. The axial ratio calculated from the morphology, $a:c=1:0.6685$, is in excellent agreement with $a:c=1:0.6681$, the morphological axial ratio of Bikita crystals.

Bikitaite. The bikitaite crystals have a bladed habit elongated on [010] and range in length from less than one mm to over thirty mm. They are colorless and transparent and bear a striking resemblance to those from the original locality described by Hurlbut (1958) in that the faces parallel to the length are of high quality but the ends are deeply etched. Of ten

TABLE 1. OPTICAL PROPERTIES AND SPECIFIC GRAVITY OF EUCRYPTITE AND BIKITAITE

Eucryptite		Bikitaite	
1.	2.	1.	2.
$\omega_D=1.572\pm0.001$	1.572 ± 0.001	$\alpha=1.509\pm0.001$	1.510 ± 0.001
$\epsilon_D=1.587$	1.586	$\beta=1.520$	1.521
Opt. (+)	(+)	$\gamma=1.522$	1.523
Specific gravity:		Opt. (−)	(−)
(meas.) 2.666 ± 0.005	2.657	2V=45°	45°
(calc.) 2.654	2.661	Disp. $r<v$	$r<v$
		Orient. $X\wedge c=29°$	$X\wedge c=28°$
		Specific gravity:	
		(meas.) 2.300 ± 0.005	2.34 ± 0.04
		(calc.) 2.293	2.29

1. King's Mountain, North Carolina.
2. Bikita, Rhodesia. Eucryptite, Hurlbut (1962); bikitaite, Hurlbut (1957).

crystals examined on the two-circle goniometer reflections were obtained from terminal faces on only one. Although poor, they were of sufficient quality to identify the faces as belonging to $\{010\}$, and the new forms $\{011\}$ and $\{121\}$. Most of the crystals are flattened, some on $\{001\}$ and others on $\{101\}$, a form not found on Bikita crystals. Other forms present on all crystals are $\{001\}$, $\{100\}$, $\{\bar{1}01\}$ and $\{\bar{2}01\}$.

OPTICAL PROPERTIES

The optical properties of eucryptite from King's Mountain are given in Table 1, with those of eucryptite from Bikita. They agree well not only with each other but also with the optical properties reported for eucryptite from other localities and for synthetic material. (See Hurlbut, 1962, for summary.) Likewise the optical properties of bikitaite from King's

Mountain and from Bikita (Table 1) are closely similar. The specific gravities of eucryptite and bikitaite as determined on the Berman Balance are also given in Table 1.

Unit-Cell Dimensions

X-ray diffraction data for eucryptite and bikitaite were obtained with Cu/Ni radiation using a 114.59 mm-diameter camera with the Wilson (assymetric) mounting to correct for film shrinkage. Unit-cell dimensions for the two minerals were refined from these data by the least-squares computer program of Evans *et al.* (1963). The refined cell dimensions for eucryptite are $a=13.490$ Å, $c=9.016$ Å with an average standard error of 0.007 Å. The axial ratio, $a:c=1:0.6684$. is in excellent agreement with the morphological axial ratio; agreement is less good with the values for synthetic eucryptite, $a=13.476$, $c=9.003$, given by Stewart (1960) with axial ratio, $a:c=1:0.6681$.

For bikitaite the refined cell dimensions are $a=8.614$ Å, $b=4.957$ Å, $c=7.603$ Å. $\beta=114°\ 19.3'$, with an average standard error of 0.022 Å. These values agree very well with the $a=8.611$, $b=4.960$, $c=7.610$, $\beta=114°\ 26'$ given for Bikita material by Phinney and Stewart (1961).

Chemistry

A new chemical analysis of bikitaite from King's Mountain (USNM 120225) was made on crystals that microscopic examination showed to be free of impurities. Since free crystals of eucryptite were very limited, the chemical analysis was carried out on the more abundant material intergrown with albite and quartz. A portion of a vein (USNM 120179) was crushed ($-25+60$ mesh), and eucryptite grains hand picked under a

Table 2. Chemical Analysis of Eucryptite from King's Mountain, North Carolina

	1	2	3	
Li_2O	11.45	11.45	(Li)	5.80
Na_2O	.26	.26	(Na)	.06
Al_2O_3	40.28	40.30	(Al)	5.98
SiO_2	47.97	47.99	(Si)	6.05
	99.96	100.00		

1. Joseph A. Neien, Analyst.
2. Analysis recalculated to 100%.
3. Formula content on basis of 24 oxygens: $(Li_{5.80}Na_{.06})\ Al_{5.98}Si_{6.05}O_{24}$

TABLE 3. CHEMICAL ANALYSIS OF BIKITAITE FROM KING'S MOUNTAIN, NORTH CAROLINA

	1	2	3	
Li_2O	7.71	7.71	(Li)	2.10
Al_2O_3	25.09	25.08	(Al)	2.00
SiO_2	58.63	58.60	(Si)	3.97
H_2O	8.62	8.61		1.95
	100.05	100.00		

1. Joseph A. Nelen, Analyst.
2. Analysis recalculated to 100%.
3. Formula content on basis of 12 oxygens: $Li_{2.10}Al_{2.00}Si_{3.97}O_{12}$ 1.95H_2O

stereoscopic microscope. The pink fluorescence of eucryptite under short wave ultraviolet light enables one to distinguish it easily from other minerals.

Lithium and sodium were analyzed flamephotometrically on 30 mg of eucryptite and 100 mg of bikitaite. Silicon and aluminum were determined on 100 milligram (eucryptite) and 200 milligram (bikitaite) samples using standard silicate-analysis techniques. Water in bikitaite was determined by the Penfield technique on a sample of 200 mg.

The analytical results given in Tables 2 and 3 indicate a high purity of the minerals. Semiquantitative spectrographic analysis[1] showed no elements, other than those found by wet analysis, present in significant amounts. Both analyses give molecular proportions very close to the theoretical values for "pure" materials, closer than those derived from previously reported analyses of either mineral (Hurlbut, 1957, 1962). For eucryptite, assuming 24 oxygens, the analysis yields the formula: $(Li_{5.80}Na_{0.06})Al_{5.98}Si_{6.05}O_{24}$; the bikitaite analysis, assuming 12 oxygens, yields the formula: $Li_{2.10}Al_{2.00}Si_{3.97}O_{12} \cdot 1.95\ H_2O$.

ACKNOWLEDGEMENTS

Daniel Appleman, U.S.G.S., Washington, ran the unit-cell refinements. Sam Davis of Bakersville, N.C., K.C. Brannock of Kingsport, Tenn., and Jack Eaker of King's Mountain, N.C., supplied some of the specimens. Part of this work was done while the senior author was a National Academy of Sciences-National Research Council post-doctoral research associate at the Department of Mineral Sciences, Smithsonian Institution.

[1] Semiquantitative spectrographic analyses made by W. B. Crandell of the U.S. Geological Survey showed for eucryptite: Fe 0.05, Mg 0.00, Ca 0.007, Mn 0.005, Be 0.0005, Cu 0.00015, Ga 0.02; and for bikitaite: Ca 0.0007, Na 0.05, Mn 0.001, Ga 0.007.

References

Brush, G. J., and E. S. Dana (1880) On the mineral locality at Branchville, Connecticut. *Amer. J. Sci.* (3), **20**, 257–285.

Evans, H. T., Jr., J. E. Appleman, and S. S. Handwerker (1963) The least-squares refinement of crystal unit cells with powder diffraction data by an automatic computer indexing method. *Amer. Crystallogr. Ass. Meet., Cambridge, Mass. Abstr.* **42**.

Hurlbut, C. S. (1957) Bikitaite, $LiAlSi_2O_6.H_2O$, a new mineral from Southern Rhodesia. *Amer. Mineral.*, **32**, 792–797.

——— (1958), Additional data on bikitaite. *Amer. Mineral.*, **43**, 768–770.

——— (1962), Eucryptite from Bikita, Southern Rhodesia. *Amer. Mineral.*, **47**, 557–561.

Kesler, T. L. (1961) Exploration of the King's Mountain pegmatites. *Mineral. Eng.*, **13**, 1062–1068.

Mrose, M. E. (1953), α-eucryptite problem (Abstr.). *Amer. Mineral.*, **38**, 353.

Phinney, W. C., and D. B. Stewart (1961) *U. S. Geol. Surv. Prof. Pap.* **424**, D353–357.

Stewart, D. B. (1960) The system $LiAlSiO_4$-$NaAlSi_3O_8$-H_2O at 2000 bars. 21st *Internat. Geol. Cong.*, Part XVII, 15–30.