

EAKERITE—a new

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Abstract

Eakerite, $\text{Ca}_2\text{SnAl}_2\text{Si}_6\text{O}_{16}(\text{OH})_6$, is found at the Foote Mineral Company spodumene mine, Kings Mountain, Cleveland County, North Carolina. It occurs in colorless, prismatic crystals up to 5mm long in seams with quartz, albite, bavenite, and apatite in spodumene-rich pegmatite. It is monoclinic, $P2_1/a$, $a = 15.83$, $b = 7.72$, $c = 7.44 \text{ \AA}$, $\beta = 101^\circ 19'$, $Z = 2$. The strongest x-ray lines are 7.31 (80) (001), 6.91 (50) (110), 5.93 (50) ($\bar{2}01$), 5.25 (90) ($\bar{1}11$), 4.81 (100) (111), 4.00 (50) ($\bar{3}11$), 3.88 (50) (400) and 3.02 (80) (221). The mineral is prismatic [001] and shows, in order of abundance, the forms {111}, {210}, {410}, {201}, { $\bar{2}01$ }, {001}, and {100}. The crystals somewhat resemble those of laumontite in habit. Eakerite is colorless; hardness about 5 1/2; gravity 2.93 ± 0.01 (meas.) 2.931 (calc. from x-ray data); optically biaxial, positive, $n_\alpha = 1.584$, $n_\beta = 1.586$, $n_\gamma = 1.600$ (Na light) with $2V \sim 35^\circ$. Analysis gave $\text{SiO}_2 = 46.75$, $\text{Al}_2\text{O}_3 = 14.07$, $\text{SnO}_2 = 18.59$, $\text{CaO} = 14.2$ and $\text{H}_2\text{O} = 6.7$ percent. Thermogravimetric analysis indicates that the water is held as hydroxyl.

Introduction

In August 1966, Mr. Jack Eaker, of Kings Mountain, North Carolina, sent the authors a specimen of a transparent, prismatic mineral from the Foote Mineral Company spodumene mine near Kings Mountain, Cleveland County, North Carolina. He thought the mineral might be a new species. X-ray examination confirmed his estimate, and wet chemical analysis established the formula $\text{Ca}_2\text{SnAl}_2\text{Si}_6\text{O}_{16}(\text{OH})_6$. The mineral has been given the name eakerite (pronounced EKERAIT) in Mr. Eaker's honor. The description and name were approved in advance of publication by the Commission on New Minerals and Mineral Names, IMA. Type specimens will be preserved at the National Museum of Natural History and the British Museum (Natural History).

The Foote mine has been described by Kessler (1961). It is an open pit developed in a complex swarm of pegmatites. The region is part of the Carolina tin-spodumene belt of tin- and lithium-enriched pegmatites.

The pegmatites of the Foote mine are tabular dikes which trend roughly NNE and dip steeply both east and west; the largest is more than 300 meters long and

75 meters thick at its widest point. Mineralogically the pegmatites are nearly homogeneous; they contain roughly 32% quartz, 41% feldspars (sodic plagioclase and microcline), 20% spodumene, 6% muscovite, and 1% other minerals. The quartz has an unusual, fine granular texture, and many of the other major minerals are broken and veined by quartz.

Several sets of fractures cut the pegmatites; the most prominent are vertical and strike E-W. The fractures contain a number of interesting secondary minerals including the new species switzerite (Leavens and White, 1967), eucryptite and bikitaite (Leavens, Hurlbut, and Nelen, 1968), and lithiophosphate (White, 1969). Besides eakerite, tin minerals found in the seams include stannian sphene, a new polymorph of wickmanite, and another new tin silicate now under investigation which is apparently a structural analogue of osumilite. Cassiterite is found as a primary mineral in black crystals in massive pegmatite.

Eakerite is found in open seams at about section 10N of Kessler's map (Kessler, 1961, fig. 2). All of the specimens have come from a very restricted area, perhaps a single vein. Specimens typically contain numerous crystals, standing or lying on the walls of the seam. Eakerite crystals are implanted on those of quartz and albite; they are commonly intergrown with needles and blades of bavenite, and are coated in some specimens with crystals of pink apatite. A few crystals of the polymorph of wickmanite have been found on eakerite crystals. The setting and mineralogy of the veins suggests a hydrothermal origin for eakerite.

Physical Properties

Eakerite has been found only in crystals, up to 5 mm in length. Smaller crystals and the terminations of the larger ones are colorless; the lower parts of many of the larger crystals are highly flawed and milky white. The mineral has a conchoidal fracture and no recognizable cleavage or parting. The hardness is about 5 1/2. The specific gravity, measured on flawless crystals by immersion in Clerici solution, is 2.93 ± 0.01 ; gravity calculated from the formula and x-ray data is 2.931.

The indices of refraction, measured in Na light, are $\alpha = 1.584$, $\beta = 1.586$, $\gamma = 1.600$, $2V$ is about 35° , $r > v$ (marked), $X = b$, $Y \wedge c = +23 \frac{1}{2}^\circ$.

Eakerite is not soluble in acids or bases.

tin silicate

MAX H. HEY

Crystallography

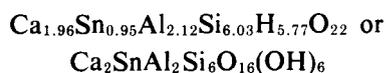
X-ray precession photographs of the 0, 1st and 2nd levels about the a and b axes of eakerite showed the mineral to be monoclinic, $P2_1/a$. X-ray diffraction data (Table 1), obtained with Cu/Ni radiation using a 114.59 mm Debye-Scherrer camera and corrected for film adjustment, were indexed and the cell dimensions refined using a least-squares computer program written by Evans et al (1963). Initial parameters were taken from the precession photographs. The refined cell dimensions are $a = 15.829 \pm 0.007 \text{ \AA}$, $b = 7.721 \pm 0.003 \text{ \AA}$, $c = 7.438 \pm 0.003 \text{ \AA}$, $\beta = 101^\circ 19' \pm 2'$ (errors are one standard deviation). The cell volume is 891 \AA^3 and $a_0:b_0:c_0 = 2.051:1:0.964$.

The observed forms are listed in Table 2 with calculated angles, and Fig. 1 illustrates the typical habit, front and back. The prism zone is striated parallel to $[001]$, and many crystals show trains of reflections corresponding to faces of the forms $\{h10\}$. All other faces tend to be undulose and give poor reflections.

In order of abundance the forms are $\{111\}$, $\{210\}$, $\{410\}$, $\{201\}$, $\{\bar{2}01\}$, $\{001\}$, and $\{100\}$. All of the crystals observed by the authors tend to exhibit the same habit. Interestingly, the prominence of several forms does not conform to the law of Bravais as extended by Donnay and Harker (1937); $\{210\}$ and $\{410\}$ should be less important and $\{100\}$ and $\{110\}$ more prominent. Structural analysis, presently underway, may help to explain this anomaly.

Chemistry and Formula

The analysis (M.H.H.) was carried out on 11.50 mg of eakerite. Details of the analysis are reported in the appendix. The results of the analysis are given in Table 3; on the basis of 22 oxygens the formula is



Typical crystal of eakerite with acicular bavenite, Foote Mineral Company spodumene mine, Kings Mountain, North Carolina (50X).

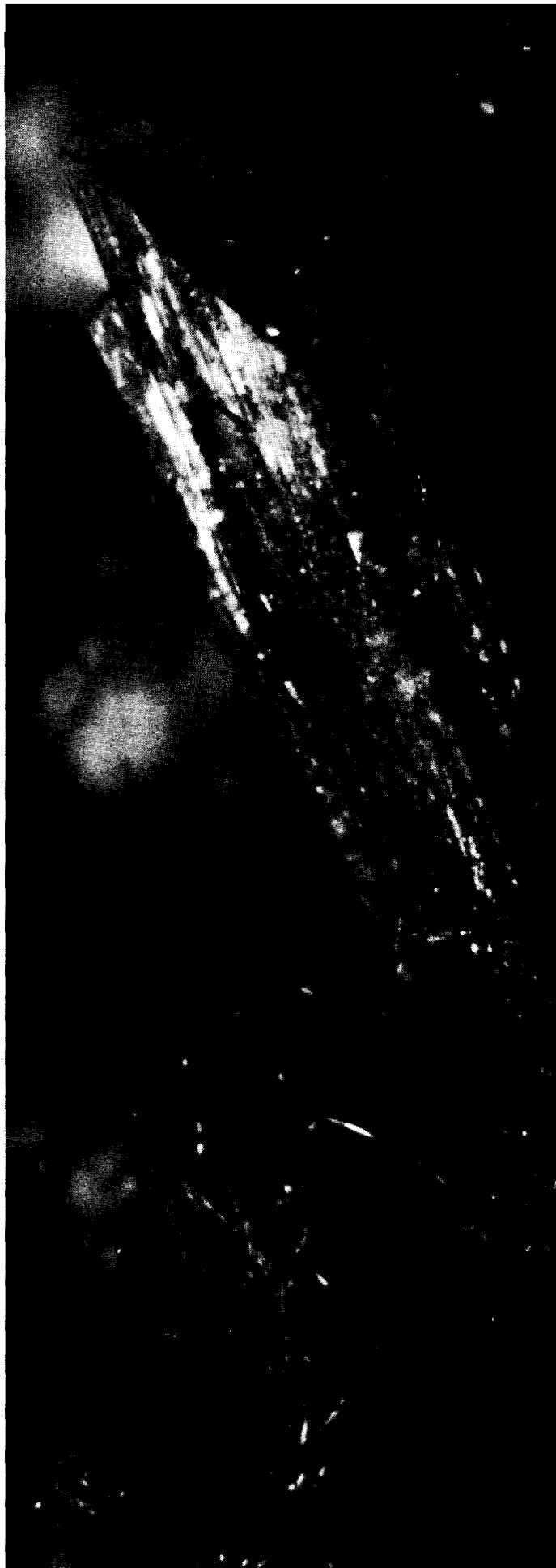


Table 1

X-ray powder diffraction data for eskerite (Cu/Ni radiation, camera diameter 114.59 mm, intensities visually estimated)

hkl	d(obs)	d(calc)	I
200	7.76	7.76	20
001	7.31	7.29	80
110	6.905	6.913	50
$\bar{2}01$	5.944	5.927	50
$\bar{1}11$	5.257	5.252	90
111	4.812	4.812	100
211	4.116	4.113	10
$\bar{3}11$	3.999	3.999	50
400	3.882	3.880	50
$\bar{4}01$	3.738	3.744	5
410	3.466	3.467	5
$\bar{1}21$	3.396	3.399	40
$\bar{1}12$	3.353	3.349	60
012	3.291	3.298	5
$\bar{2}21$	3.229	3.235	50
112	3.116	3.115	30
221	3.021	3.023	80
$\bar{4}12$	2.767	2.767	20
$\bar{2}22$	2.623	2.626	30
600	2.584	2.587	5
511	2.527	2.526	15
$\bar{5}12$	2.491	2.492	5
$\bar{4}22$	2.351	2.351	30
601	2.300	2.300	10
$\bar{4}03$	2.271	2.270	5
$\bar{3}31$	2.249	2.255	5
$\bar{1}32$	2.112	2.116	20
$\bar{2}23$	2.079	2.076	30
132	2.052	2.053	5
$\bar{3}32$	2.028	2.030	5
$\bar{8}01$	1.973	1.974	5
223	1.908	1.912	5
332	1.876	1.875	5
$\bar{1}33$	1.785	1.785	5
$\bar{3}33$	1.748	1.751	5
133	1.729	1.729	10
423	1.704	1.704	5
$\bar{8}03$	1.688	1.680	5
$\bar{2}24$	1.675	1.674	10
$\bar{9}12$	1.653	1.653	5
$\bar{7}32$	1.619	1.620	5
333	1.603	1.604	10
250	1.515	1.515	5
623	1.493	1.494	10
$\bar{3}51$	1.467	1.466	5
$\bar{4}51$	1.428	1.428	10
$\bar{6}44$	1.254	1.255	5

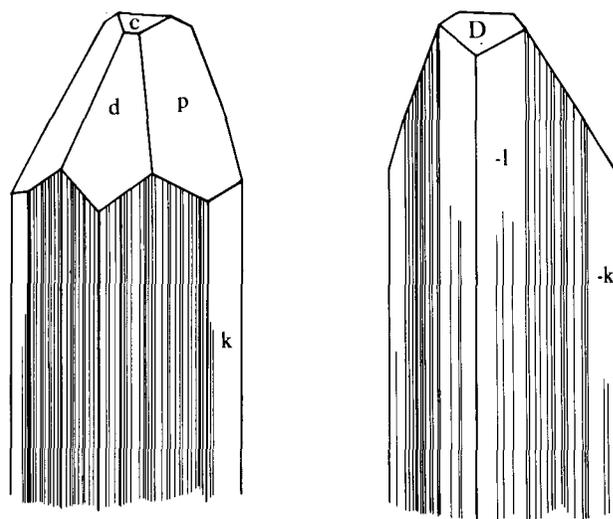


Fig. 1. Eskerite crystal in two orientations.

Semiquantitative microspectrochemical analysis by the U.S. Geological Survey showed, in addition to the major components, the following trace elements: Li 0.3, Be 0.3, Fe 0.1, Mn 0.03, Na 0.03, K 0.03, Ti 0.03 and Mg 0.03 weight percent. The significance of these numbers is discussed by Waring and Worthing (1961) and Waring (1962).

Thermal Study

A thermogravimetric analysis was made on 10.25 mg of eskerite, using a heating rate of 10°C per minute. Eskerite does not lose weight below about 350°C; it then loses weight slowly to about 725°C, having lost nearly 3% weight at that temperature. Between 725°C and 775°C, weight loss increases smoothly but steeply to about 6 1/2%, then slows. The run was discontinued at 1175°C, with a total weight loss of about 10 1/2%. Independent tests show that eskerite fuses at about 1075°C.

The abrupt weight loss between 725° and 775° is surely water; the high temperature and narrow range of dehydration support the proposed formula for eskerite with water held as hydroxyl. The earlier 3% weight loss is about equivalent to one H₂O in the formula; however, the presence of a water molecule would necessitate the unusual formula Ca₂SnAl₂Si₆O₁₇(OH)₄·H₂O. A structural analysis by one of us (Leavens, in progress) should elucidate the true nature of the water in eskerite.

Appendix

Details of the chemical analysis. The mineral was ignited at 800°C in a muffle; ignition at 900° gave no further loss in weight (<0.002 mg), and the mineral had not fused. The ignited mineral was fused with 120 mg Na₂CO₃, and the melt dissolved in a small

Table 2.
Crystallographic Data for Eakerite

$a : b : c = 2.050 : 1 : 0.9633$ β $101^{\circ}19'$ $p_0 : q_0 : r_0 = 0.474 : 1.018 : 1$ $r_2 : p_2 : q_2 = 0.982 : 0.483 : 1$
 μ $78^{\circ}41'$ p'_0 0.483 , q'_0 1.038 , x'_0 0.200

Forms:		ϕ	ρ	ϕ_2	$\rho_2 = B$	C	A
c	001	90°00'	11°19'	78°41'	90°00'	-----	78°41'
d	201	90 00	49 38	40 22	90 00	38 19	40 22
D	$\bar{2}01$	-90 00	37 01	127 01	90 00	48 40	127 01
k	210	44 51	90 00	0 00	44 51	82 02	45 09
l	410	63 19	90 00	0 00	63 19	79 54	26 41
p	111	34 08	48 53	57 16	51 25	43 18	65 00

excess of H_2SO_4 and evaporated to fumes, then 100 mg $Na_2S_2O_7$ added and the whole fused just below a red heat.

The melt was dissolved in dilute (1:9) H_2SO_4 and filtered with a King microfilter; the crude silica was washed with 1:9 H_2SO_4 , ignited, and weighed. After expulsion of the silica with $HF + H_2SO_4$ and weighing, the minute residue was fused with a speck of $Na_2S_2O_7$, dissolved and added to the main solution, which was made up to 20 ml with dilute (1:9) H_2SO_4 ; 1 ml 6% cupferron was added, and the stannic cupferrate extracted with 10 ml carbon tetrachloride; after separation, two more drops of 6% cupferron were added, and further extractions with 5, 2, and 2 ml carbon tetrachloride were made. The combined carbon tetrachloride extracts were collected in a weighed porcelain crucible and allowed to evaporate in a warm place, then ignited and weighed as SnO_2 .

The aqueous layer was evaporated in a silica dish and the H_2SO_4 fumed off thoroughly, the residue

being dissolved in a little water and 2 drops concentrated HCl . To the clear solution were added 30 mg sodium citrate, and the solution transferred to a 15 ml microbeaker with filterstick, 12 ml 2% 8-hydroxyquinoline in acetic acid added, then ammonia in slight excess; after a 30 minute digestion on the water-bath, the aluminum 8-hydroxyquinolate was filtered off, washed with hot water, dried at $130^{\circ}C$, and weighed.

The filtrate and washings were evaporated in a silica dish and the citrate destroyed with nitric and perchloric acids; after expulsion of nearly all the perchloric acid the residue was transferred with water to a 10 ml microbeaker with filterstick, diluted to 4 ml, 100 mg ammonium oxalate in 2 ml water added, and then a slight excess of ammonia. After digestion for 30 minutes on the water-bath and standing overnight the precipitate of $CaC_2O_4 \cdot H_2O$ was filtered off, washed with cold water, dried at $105^{\circ}C$, and weighed, then dissolved in perchloric acid and titrated with $N/20 KMNO_4$ as a check. CaO is certainly the least

Table 3.
Chemical Analysis of Eakerite

	%	Atomic ratios	Atoms per 22 oxygen
SiO_2	46.75	Si 0.778	6.03
Al_2O_3	14.07	Al 0.274	2.12
SnO_2	18.59	Sn 0.123	0.95
CaO	14.2	Ca 0.253	1.96
H_2O	6.70	H 0.774	5.77
TOTAL	100.3	O 2.84	22

reliable determination, and could be in error by as much as 0.5%.

Acknowledgements

Mr. Louis Shrum, of Lincolnton, North Carolina, supplied several samples of the new mineral. The x-ray data refinement was done by Miss Judy Konnert of the U.S. Geological Survey. The thermogravimetric analysis was run by the Thermal Analysis Applications Laboratory of the Du Pont Instruments Company. The spectrographic analysis was performed by Claude L. Waring of the U.S. Geological Survey.

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obituary

J. Frank Schairer, 66, died suddenly on September 26, 1970 while swimming in the Chesapeake Bay, Maryland. With his passing mineralogy lost a truly wonderful man and a prodigious contributor to science. Dr. Schairer was a member of the National Academy of Sciences and for 43 years a physical chemist at the Carnegie Institution's Geophysical Laboratory.

Two of the numerous awards Dr. Schairer received in recognition of his scientific achievements include the Arthur L. Day Medal of the Geological Society of America and the Roebing Medal of the Mineralogical Society of America. He was president of the Mineralogical Society of America in 1943 and of the Geochemical Society in 1960. Last year a special volume of the *American Journal of Science* was published to mark his 65th birthday.

During his student days at Yale University Dr. Schairer was an avid mineral collector and author of Bulletin No. 51 of the Connecticut State Geological and Natural History Survey *The Minerals of Connecticut*. He spoke frequently to mineral clubs on this subject, and those who had the privilege of hearing him will recall it as a memorable experience.

Nor did Dr. Schairer's interests and boundless energy end with science. He was a founding member of the Potomac Appalachian Trail Club and the National Capital Orchid Society, and enthusiastic fisherman and square dancer.

Dr. Schairer was one of those rare individuals who enriched the life of everyone he met. He will be sorely missed by his hosts of friends all over the world, for as H. S. Yoder, Jr.¹ said: "The man is indeed a legend in his own time", and "Mr. Frank, as he was known to the mountain people of Virginia, is one of the richest men in the world when friends are counted."

¹H. S. Yoder, Jr. Presentation of the Roebing Medal to J. Frank Schairer. *American Mineralogist*, 49, 453-456, 1964.

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