SECOND OCCURRENCE OF BRAZILIANITE

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Abstract

Brazilianite occurs in the Palermo pegmatite, North Groton, Grafton County, New Hampshire. It differs in crystal habit from that of the crystals from Brazil. Chemical analysis confirms the formula $NaAl_3(PO_4)_2(OH)_4$. X-ray data and the physical properties agree in general with those given in the original description. The optical properties of the mineral from Brazil have been redetermined more accurately.

Introduction

A second locality for brazilianite, at the Palermo mine, North Groton, New Hampshire, has been found. The mineral was originally described in 1945 by Pough and Henderson from a pegmatite in the Conselheira Pena district, Minas Geraes, Brazil, and supplementary notes were later published by others (see appended bibliography).

Brazilianite was recognized and collected by the writers during a visit to the Palermo mine in July, 1947, and a considerable amount of additional material was obtained in later visits. The mineral occurs rather abundantly, although only locally, associated with whitlockite, apatite, and quartz in a granite pegmatite presently being worked for mica, feldspar, and beryl. The writers wish to express their appreciation to Mr. H. A. Ashley, operator of the mine, for his cordial aid in collecting material at the locality.

Occurrence and Paragenesis

The Palermo pegmatite mine (Palermo Number One), first opened about 1863, has been one of the foremost producers of mica in New England and is currently being worked for feldspar and beryl. The present workings are in the form of an irregular open pit in the exposed central part of the pegmatite and they overlie, without connection, extensive underground workings.

The Palermo Number One pegmatite has a roughly oval-shaped outcrop 160 by 220 feet, on the top and south side of a low knob. It is a lens-shaped dike which strikes about N. 30° E., dips about 50° southeast, and plunges about 45° northeast.

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The pegmatite is well-zoned internally, as are many of the other pegmatites in the immediate vicinity. The zoning was studied in detail by members of the U. S. Geological Survey[1] during the pegmatite investigations in New England from 1942 to 1945. For the present description, the zones may be divided into three groups:

(1) The outer zones of fine- to medium-grained texture contain quartz, muscovite, biotite, plagioclase (oligoclase to albite) and black tourmaline.

(2) The intermediate zone, coarse-grained, contains quartz, muscovite, biotite, albite, perthite, beryl, tourmaline, lazulite, other phosphates, and small amounts of sulfide minerals. The lower part of this zone has been worked for sheet-mica, and the upper part for feldspar and beryl. The beryl occurs in crystals up to eight feet long.

(3) The quartz core, at the center of the pegmatite, contains several other minerals, especially at the edge. Single crystals of triphylite range up to fourteen feet or more in length, affording cleavage blocks several feet square. Large perthite crystals are found here; bronze scrap mica and blue-green beryl are present in smaller amounts. The brazilianite that was found in place occurred in cavities essentially at the contact of the intermediate zones and the quartz core.

Locally, the pegmatite was traversed by late-stage, relatively low temperature hydrothermal solutions which preferentially attacked the triphylite with the formation of ludlamite, messelite (?), siderite, triploidite, apatite, and minor sulfides. The apatite in part, whitlockite, siderite, quartz, and minor quantities of amblygonite and eosphorite-childrenite occur as drusy crystals in small solution cavities in the altered triphylite. Albite was not formed in any significant amount by the solutions and albitization is generally absent in the part of the pegmatite exposed in the surface workings. Near the surface, the triphylite crystals, normally greenish- or bluish gray in color, are more or less oxidized to a soft brownish-black mass composed essentially of iron and manganese oxides, heterosite, secondary iron phosphates including dufrenite, and several unidentified minerals.

The brazilianite appears to belong to the above-mentioned hydrothermal period of formation; it has been found in the vicinity of, but not actually in, the altered triphylite crystals. It occurs as drusy crystals associated with small quartz crystals, tiny white hexagonal prisms of apatite and whitlockite, and in small anastamosing cavities in coarsely granular aggregates of feldspar and quartz. The sequence of formation was quartz-brazilianite-apatite-whitlockite-quartz. In part, the brazilianite occurs

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[1] Pegmatite investigations in New England, 1942–1945, by E. N. Cameron, D. M. Larrabee, A. H. McNair, J. J. Page, V. E. Shainin, and G. W. Stewart, U. S. Geological Survey. (Report in preparation.)

as ill-formed crystals completely embedded in the granular wall rock of the cavities. This type of occurrence suggests that the brazilianite may be a relatively early deposit from the hydrothermal solutions or may represent a deposit from such solutions when not modified by reaction with the triphylite. At the outcrop, the granular brazilianite-matrix is rendered friable by weathering. Hundreds of brazilianite crystals were obtained from this material by separating them in the laboratory from the associated minerals by the use of heavy liquids.

CRYSTALLOGRAPHY

The brazilianite crystals from the Palermo mine, N. H., differ in habit from the crystals from Brazil principally in the near suppression of the prism zone and in the relatively large development of *n*{011} and *g*{$\bar{1}$11}. This gives the crystals an elongate, four-sided appearance as shown in Fig. 1, in which the *b*-axis is drawn in front. In the conventional projection, Figure 2, the crystals appear rather foreshortened. The other forms

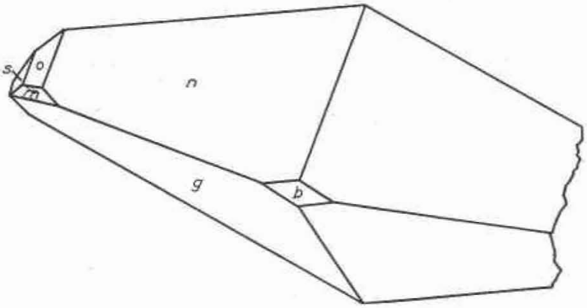

FIG. 1. Brazilianite from the Palermo mine. Drawn with the *b*-axis in front.

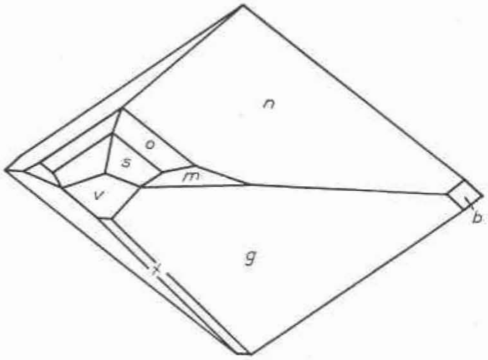

FIG. 2. Conventional projection of the crystal shown in Fig. 1.

observed were *a*{100}, *o*{111}, *s*{211}, *q*{$\bar{1}$21}, *v*{$\bar{3}$01}, *x*{$\bar{1}$01} and *b*{010}, none of which are new to the species. On 50 or so crystals examined under a binocular, all of the faces except *q*{$\bar{1}$21} and *a*{100} were present, although in varying and usually unequal development. The forms *q* and *a* were noted on only a few crystals and are not shown in the drawings. The crystals are attached to the matrix by one end of the [100] axis, a feature also shown frequently by the Brazilian crystals.

Several crystals were measured on the two-circle goniometer. The quality of the reflections obtained was not very good, due to curvature and growth hillocks on the faces, especially *n*{011} and *g*{$\bar{1}$11}. The best reflections are given by the modifying faces *o*, *s*, *n*, and *v*. The negative orthodome *x*{$\bar{1}$01} ordinarily is present only as line-faces and does not afford readily distinguishable signals. In Table 1 the angles obtained from the averaged measurements of the best crystals are given in comparison with the angles cited by Pough and Henderson.[2] Their choice of orientation and unit, it may be noted, is in agreement with the *x*-ray cell obtained independently by the Weissenberg method by Hurlbut and Weichel (5) and by the Laue and rotation method by Franco and Loewenstein (6). Hurlbut and Weichel give $a_0=11.19$, $b_0=10.08$, $c_0=7.06$, with $a_0:b_0:c_0=1.110:1:0.700$, and the space group $P2_1/n$.

TABLE 1. ANGLE TABLE FOR BRAZILIANITE FROM PALERMO MINE, NEW HAMPSHIRE

Monoclinic, prismatic $-2/m$
$a:b:c=1.1056:1:0.6992$; $\beta=97°22'$

Forms	Measured angles (Palermo)		Angles (Brazil) of Pough and Henderson	
	ϕ	ρ	ϕ	ρ
a 100	90°00′	90°00′	90°00′	90°00′
b 010	0 00	90 00	0 00	90 00
m 110	42 15	90 00	42 22	90 00
n 011	10 40	35 24	10 29	35 25
x $\bar{1}$01	−90 00	27 2	−90 00	26 57
v $\bar{3}$01	−90 00	60 47	−90 00	60 44
o 111	47 36	46 7	47 39	46 4
g $\bar{1}$11	−38 49	41 61	−36 2	40 51
s 211	63 11	57 31	63 33	57 30
q $\bar{1}$21	−19 58	56 00	−19 59	56 06

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[2] The original angle table of these authors contains numerous minor errors of computation and the values here given are recalculated from their elements.

The x-ray powder diffraction spacing data for the brazilianite from New Hampshire are given in Table 2. The patterns of the Palermo and Brazilian material correspond exactly.

TABLE 2. X-RAY POWDER SPACING DATA FOR BRAZILIANITE FROM PALERMO MINE, NEW HAMPSHIRE

Copper radiation, nickel filter

I	d	I	d	I	d
3	5.84	1	2.34	2	1.58
10	5.04	1	2.30	1	1.56
1	4.62	1	2.23	3	1.52
1	4.21	2	2.17	2	1.50
4	3.77	1	2.11	5	1.44
1	3.48	4	2.05	1	1.42
3	3.30	3	2.01	1	1.39
2	3.16	4	1.98	3	1.31
8	2.98	3	1.93	3	1.30
7	2.87	2	1.85	1	1.27
1	2.80	1	1.82	2	1.26
8	2.73	3	1.75	2	1.24
8	2.68	2	1.72	1	1.22
3	2.61	1	1.66	1	1.18
3	2.47	2	1.64	3	1.15
2	2.41	1	1.62		

PHYSICAL AND OPTICAL PROPERTIES

The properties of the mineral from the two localities are practically identical. The (010) cleavage is good in quality but not easily developed, and broken fragments commonly show many conchoidal fracture surfaces. The hardness is 5½. The specific gravity of the Palermo crystals, determined on the microbalance, is 2.985±.005. A redetermination of the gravity of the Brazilian material gave 2.980±.005, which is somewhat higher than the two earlier reported determinations, 2.94 (1) and 2.976 (5). The color is pale yellow to chartreuse yellow, somewhat paler and less green than the Brazilian material in pieces of equal size. The crystals are transparent and have a vitreous luster. They range in size to as much as one inch measured along [100]. Most individuals are smaller, one-fourth inch or so on the average along [100].

The indices of refraction and optical orientation of the Palermo crystals as measured by the writers are given in Table 3. The data for the Brazilian material, given for comparison, are redeterminations with sodium light by M. L. Lindberg, and are closely confirmed by values obtained in white light by J. J. Glass and W. T. Pecora of the U. S. Geological Survey.[3] The indices of refraction of brazilianite from Brazil originally given by Pough and Henderson were low by about 0.003. Optical data for the Brazilian crystals in agreement with those reported here[4] were determined by Hurlbut and Weichel (5), but through inadvertence, the original slightly lower values of Pough and Henderson were printed instead of their new data; the optical orientation given by Hurlbut and Weichel, $X=b$ and $Y \wedge c=15°$, is incorrect.

TABLE 3. OPTICAL DATA FOR BRAZILIANITE

Orientation	n_{Na} (Palermo)	n_{Na} (Brazil)
$X \wedge c=-20°$	$1.602 \pm .001$	$1.602 \pm .001$
$Y=b$	$1.609 \pm .001$	$1.609 \pm .001$
Z	$1.623 \pm .001$	$1.621 \pm .001$
2V (calc.)	71°	75°
Sign	+	+
Dispersion	$r<v$, faint	$r<v$, faint

CHEMISTRY

A chemical analysis of the Palermo material made by M. L. Lindberg in the laboratory of the U. S. Geological Survey conforms closely to the

TABLE 4. CHEMICAL ANALYSES OF BRAZILIANITE

	1	2	3
Na_2O	8.56	8.29	8.42
K_2O	—	0.20	0.37
Al_2O_3	42.25	42.85	43.82
Fe_2O_3	—	0.03	—
TiO_2	—	0.05	—
P_2O_5	39.23	38.79	37.97
H_2O	9.96	$\left\{\begin{matrix}+9.91\\-0.04\end{matrix}\right\}$	9.65
Total	100.00	100.16	100.23

1. Theoretical requirements for $NaAl_3(PO_4)_2(OH)_4$.
2. Palermo mine, North Groton, New Hampshire. M. L. Lindberg, analyst. Includes MnO trace; F none; Li_2O none. Ratios $Na_2O+K_2O:R_2O_3:P_2O_5:H_2O=.982:3.046:1.976:3.995$. Analysis on Harvard spec. no. 98124.
3. Conselheira Pena district, Minas Geraes, Brazil. E. P. Henderson, analyst. Includes Cl trace; F none. Analysis on U. S. National Museum spec. no. 105048.

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[3] Measured on the original analyzed sample, U. S. National Museum No. 105048.

[4] C. S. Hurlbut, Jr., private communication, August 1947.

formula, $NaAl_3(PO_4)_2(OH)_4$, established by the original analysis of Henderson (Table 4). The mineral is not attacked by oxalic, hydrochloric, nitric, or cold sulfuric acid, but is slowly decomposed by hydrofluoric and by hot sulfuric acid. The sodium carbonate fusion of the Palermo mineral is pinkish violet.

Spectrographic examination of brazilianite from both localities by H. C. Harrison[5] shows traces of the following elements:

Palermo: Ca>Si, Cu, Be>Fe, Mg, Mn, Ti, V, Ba, Sr, Pb>Cr, B.
Brazil: Ca>Si, Cu, Pb>Fe, Mg, Mn, Ti, V, Sn, Zr, Ba>Cr, B, Ag, Be>Li.

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[5] Department of Mineralogy and Petrography, Harvard University, Private communication, August 1947.