OSARIZAWAITE FROM WESTERN AUSTRALIA[1]

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ABSTRACT

Osarizawaite, a basic lead copper aluminum sulfate of the alunite group was first described from Japan by Taguchi in August 1961. In June of that year the same mineral was discovered in the Marble Bar area of Western Australia, and independently derived data show close agreement in most respects with those of the Japanese work. The West Australian mineral has a color close to Ridgway's "Veronese Green" and occurs as friable aggregates of minute crystals commonly showing hexagonal outline and rarely the development of the rhombohedron. The mineral exhibits both uniaxial and biaxial character with mean $n = 1.72$. Specific gravity 4.037, 4.167 (calc). The chemical analysis leads to an idealized formula $Pb(CuAl)_3(SO_4)_2(OH)_6$, and the mineral is the aluminum analogue of beaverite, $Pb(Cu Fe)_3(SO_4)_2(OH)_6$.

X-ray powder diffraction data show that the mineral has a rhombohedral lattice with cell dimensions $a = 7.050$ Å, $c = 17.025$ Å, $c/a = 2.415$, $a_{rh} = 6.984$ Å, $\alpha = 60°38'$. By analogy to beaverite the space group is $R3m$.

INTRODUCTION

In June 1961 a mineral sample was received by the Government Chemical Laboratories, Perth, Western Australia, from Mr. James Henderson of Port Hedland, Western Australia, for routine determination of the mineral contents. The sample consisted of light green, friable aggregates of minute crystals associated with barite, quartz, hematite, goethite and clay. The green mineral proved to be a basic lead copper aluminum sulfate of the alunite group and the aluminum analogue of beaverite $(Pb(CuFe)_3(SO_4)_2(OH)_6)$. At that time no reference to the mineral was found in the available literature, and a paper describing the mineral under the name "edgarite" was accepted for publication by the American Mineralogist in March 1962. Subsequently, attention was drawn to a paper by Y. Taguchi describing the same mineral under the name osarizawaite which appeared in the Japanese Mineralogical Journal Vol. 3 No. 4 published in August 1961, and consequently the name "edgarite" has no validity.

Data from the two papers have been incorporated in this present article, which also includes data on the iron analogue, beaverite from a paper by Van Tassel (1958).

OCCURRENCE

The second known discovery of osarizawaite and the first Australian occurrence of the mineral is on Mt. Edgar Pastoral Station approximately

[1] Published with the permission of the Director, Government Chemical Laboratories, Perth, Western Australia.

35 miles east-southeast of Marble Bar, the main center of the Pilbara Goldfield, North West Division of the State of Western Australia.

The mineral occurs, associated with barite, quartz, iron oxides and clay, as two narrow "pipes" resulting from small local cross folds in the oxidized portion of a steeply dipping, narrow quartz-barite vein containing localized copper, lead and zinc minerals. The vein lies conformably within a belt of quartz and sericite schists of the steeply dipping Warrawoona Succession, on the southeast margin of a large, circular, granitic complex of younger Archaen age.

Some 40 feet from the osarizawaite the vein contains a complex mixture of brochantite, linarite, limonite, manganese oxides, jarosite, clay, anglesite, traces of cerussite and an unidentified, clay-like, hydrous zinc copper aluminum silicate, all associated with vuggy quartz and barite.

The type locality of osarizawaite is the Osarizawa Mine, Japan in the northeastern part of Akita Prefecture (Taguchi, 1961), and the mineral occurs in the oxidized zone of lead-zinc-copper veins associated with anglesite, kaolin, limonite, linarite, azurite, brochantite, malachite, chalcocite, covellite, sulfur, chalcedony and hydrous manganese oxides.

SEPARATION AND PURIFICATION

During the preliminary investigation it was not realized that the mineral occurred plentifully at the discovery site, and only half the original sample was used to prepare material for analysis.

A rough concentrate contaminated with barite, iron-stained osarizawaite and iron oxides was obtained with a Frantz Isodynamic Separator. The final product of 4.5 g was prepared by centrifuging the finely crushed concentrate in Clerici solution, using tubes described by Cheeseman (1957). Repeated washing with hot distilled water removed all but a trace of thallium from the sample.

No variation in the mean refractive index of the mineral was observed before and after treatment.

PHYSICAL PROPERTIES

In hand specimen the West Australian mineral shows a slight range of color between Ridgway's "light Veronese Green" and "Veronese Green" (31′ d-f). It occurs as earthy friable encrustations on barite and quartz together with minor clay, hematite and goethite.

The specific gravity was obtained with a fused silica pycnometer of 10 ml capacity using the method described by Ellsworth (1928). Air was removed from the fine-grained sample by subjecting the half-filled pycnometer to intermittent vacuum for periods of up to an hour. Of four results on the analyzed material the lowest was 4.010, the highest

TABLE 1. OPTICAL PROPERTIES OF OSARIZAWAITE

$\omega/\alpha = 1.714 \pm .003$	uniaxial and biaxial positive
$\epsilon/\gamma = 1.731 \pm .005$	2V up to 15°
Mean n 1.72	birefringence 0.017

Mean n of osarizawaite from Japan 1.735–1.757.
Birefringence strong.

4.022 and the mean $4.017 \pm .005$. With fine-grained minerals of this type it is probable that the highest result of 4.022 is the most reliable, and recalculation of this figure after the removal of impurities (silica and adsorbed water) gives the corrected specific gravity as 4.037.

The Japanese material[1] appears to be of two distinct types. The analyzed sample on which Taguchi's paper was based (Tables 3 and 9) has a color close to Ridgway's "Courge Green" (25'i)[2] and consists largely of discrete particles between 200 and 270 mesh. Many of the grains have hexagonal outlines and much of this material appears to be zoned.

The second type which Taguchi refers to as "green-tinged" with "lower mean index" is almost identical in color and particle size with the West Australian material and he has stated[3] that this is probably the equivalent of the pure aluminous end member. There are, however, differences in optical properties between the two green samples.

OPTICAL DATA

Under the microscope the analyzed eight green aggregates of osarizawaite are seen to consist of microscopic particles ranging in diameter from approximately 0.1μ to 10μ. The larger particles are generally in the form of hexagonal plates but a few show the development of the rhombohedron on the basal pinacoid.

Some particles form oriented aggregates having almost uniform extinction, and from these, moderately well defined positive interference figures can be obtained. As with other members of the alunite and related groups the mineral exhibits both uniaxial and biaxial character with 2V up to 15°.

The mean refractive index of the analyzed material for sodium light is 1.72, with $\alpha/\omega \approx 1.714$ (measured on aggregates showing lowest uniform birefringence).

[1] Supplied by Dr. Y. Taguchi of the Mitsubishi Metal Mining Co., Ltd., Japan.

[2] Determined by the writer—Taguchi describes it as the Japanese bush-warbler colour or greenish yellow.

[3] Personal communication.

The light green Japanese material has a mean refractive index of approximately 1.74 and the lowest n of the aggregates is approximately 1.725. This material was not analyzed and may represent a transition between the pure aluminum end member and the iron-bearing analyzed sample. Some of the minute grains within the aggregates show first order blues and greens representing a birefringence of the order of 0.04. In the analyzed West Australian material the maximum observed was yellow-white of the first order and the highest n of the aggregates is approximately 1.73, suggesting a birefringence considerably lower than that of the Japanese equivalent.

CHEMICAL DATA AND DISCUSSION

Methods of analysis

Lead was separated as the sulfate and precipitated as the chromate; copper was obtained electrolytically; iron photometrically with thioglycollic acid, and alumina by difference in the R_2O_3 group. Sulfur trioxide was precipitated as $BaSO_4$, and the total water obtained by a modification of the Kuzurian method with sodium tungstate as the flux and magnesium perchlorate as the absorbent.

Chemical Properties

The mineral is insoluble in water and dilute ammonium hydroxide but is readily soluble in hot dilute or concentrated hydrochloric and sulfuric acids, with the separation of the appropriate lead compounds. Nitric acid has little effect on the mineral.

Osarizawaite is stable at temperatures up to 400° C., after which it gives off abundant water accompanied by a change in color to drab green, and at dull red heat to a drab brown.

Discussion

The chemical analysis shown in Table 2 gives the mineral the formula $Pb(CuAl)_3(SO_4)_2(OH)_6 \cdot \frac{1}{2}H_2O$, which with the exception of the $\frac{1}{2}H_2O$ conforms to the general formula of the alunite group, $A^+B_3^{3+}(SO_4)_2(OH)_6$, in which the monovalent A^+ position is almost filled by Pb^{2+}, and Cu^{2+} substitutes for Al^{3+} in the B^{3+} position to give valence compensation (Dana, 7th Edition). The small amount of iron present in the analysis has been included with the copper and aluminum but could be due to impurity in the sample rather than substitution for aluminum in the structure.

The 1:1 ratio of Pb:Cu affords an internal check on the analysis as does the 3:2, (Cu+Al+Fe):SO_4 ratio; thus the presence of the excess water is the one feature not accounted for by the type formula of the

TABLE 2. CHEMICAL ANALYSIS OF OSARIZAWAITE, $Pb(CuAl)_3(SO_4)_2(OH)_6$
Analyst M. B. Costello

	Weight %	Mol. ratios	Theor. Comp. Pb (Cu Al)$_3$ (SO$_4$)$_2$ (OH)$_6$	Mol. ratios
PbO	33.15	0.913	36.07	1
CuO	11.83	0.915 ⎫	12.85	1
Al$_2$O$_3$	17.51	1.056 ⎬2.001	16.48	1
Fe$_2$O$_3$	0.77	0.030 ⎭		
SO$_3$	26.02	1.999	25.87	2
H$_2$O$^+$	10.42	3.557	8.73	3
H$_2$O$^-$	0.09			
Insol[1]	0.19			
Total	99.98		100.00	
G (meas.)	4.037			
G (calc.)	4.167			

[1] Including 0.17% SiO$_2$.

Spectroscopic analysis on hand picked material containing impurities (barite, iron oxides and quartz) confirmed major elements and showed the presence of traces of silver and titanium. Elements looked for but not found—As, Ca, Cd, Co, Cr, Ni, P, Sb, Sn, V, Zn.

group. That this water is part of the structure and not adsorbed water is shown by the results of the heating experiments (Table 5) in which only 0.09 of the 10.51% total water is driven off below 400° C. With a slight rise of temperature to 410° C. the structural water begins to dissociate from the molecule, and the mineral completely dehydrates by 515° C.

Some of the excess water may occupy vacant sites in the lattice in the unfilled A$^+$ position as suggested by Hendricks (1937), but this can account only for a small proportion of the excess in this case. A further possibility is that the biaxial phase present in the sample, which was first suspected from x-ray powder diffraction patterns and later confirmed by optical methods, owes its lattice strain to the inclusion of this excess water. If this is so the discrepancy between the observed and calculated densities of the mineral (4.037 and 4.167 respectively) may perhaps be explained.

A similar case has been reported by Winchell for the allied mineral natrojarosite, $NaFe_3(SO_4)_2(OH)_6$, in which a hydrous form having a formula, $NaFe_3(SO_4)_2(OH)_6 \cdot H_2O$, has refractive indices and specific gravity appreciably lower than those reported for the normal anhydrous natrojarosite.

The type osarizawaite from Japan also shows an excess of water

TABLE 3. CHEMICAL ANALYSIS OF OSARIZAWAITE (JAPAN)
FROM TAGUCHI (1961) TABLE 1

	Wt. %	Mol. prop.	Mol. rat.	Recalc.	Ideal
PbO	32.72%	0.1466	1.02	35.41%	35.45%
CuO	11.27	0.1417	0.99 } 1.01	12.20	12.40
ZnO	0.22	0.0027	0.02	0.24	0.24
Fe_2O_3	4.43	0.0277	0.19 } 1.04	4.79	4.72
Al_2O_3	12.35	0.1211	0.85	13.36	13.18
SO_3	22.92	0.2862	2.00	24.80	25.43
SiO_2	2.18				
As	0.00				
CaO	0.00				
MgO	0.00				
CO_2	0.45				
$H_2O(+)$	8.50	0.4717	3.30	9.20	8.58
$H_2O(-)$	4.05				
Total	99.09%			100.00%	100.00%

Recalc.: Recalculated to 100% after deducting impurities.

Ideal: Ideal $Pb(Cu, Zn)(Al, Fe)_2(SO_4)_2(OH)_6$ in which $CuO/ZnO = 1417/27$ and $Fe_2O_3/Al_2O_3 = 277/1211$.

(equivalent to $0.3\ H_2O$) but with a molecular ratio of unity for the Pb position and with minor substitution of Zn^{2+} and Fe^{3+} for Cu^{2+} and Al^{3+} respectively. The mean n of this material is however, considerably higher than that of the West Australian mineral (Table 1).

Analyses of beaverite have been reported in a number of Russian papers which were not available to the writer,[1] and in three cases minor substitution of zinc for copper can be inferred from the chemical data.

Three analyses of beaverite from Van Tassel (1958) are shown in Table 4. Two of these are of material from the type locality, Beaver County, Utah, and the third from Kipushi, Katanga. The Kipushi mineral was very impure (37% insolubles) but Van Tassel concludes:

"L'analyse du minéral, malheureusement fort impur, de Kipushi, a fourni des rapports moléculaires qui se rapprochent très bien, sauf pour SO_3, des rapports d'une beaverite, où l'aluminium est complètement remplacé par le fer. Les données analytique, relatives à la beaverite, encore extrement rares dans la litterature minéralogique, ne permettent pas d'être fixe sur les possibilités de la substitution Fe-Al. C'est une raison pour laquelle l'analyse du minéral de Kipushi merité d'être signalée. Les remplacements d'aluminium par Fe^{+++} sont si fréquents dans le groups de l'alunite, qu'il ne semble pas nécessaire de considerer l'aluminium comme essential pour la beaverite et qu'il parait justifier d'identifier le minéral de Kipushi comme une beaverite exempte d'aluminium. Il peut être signalé sous

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[1] Dr. M. Fleischer of the U.S.G.S. supplied the references and a summary of data from these papers.

TABLE 4. CHEMICAL ANALYSES OF BEAVERITE, $Pb(CuFe)_3(SO_4)_2(OH)_6$

(From R. Van Tassel (1958) Table 1)

	1. Kipushi, Katanga			2. Utah			3. Utah		
	%	% Sol.	Ratios	%	% Sol.	Ratios	%	% Sol.	Ratios
PbO	20.9	33.5	0.150	29.44	32.50	0.146	29.87	31.69	0.142
CuO	7.5	12.0	0.151	9.70	10.74	0.135	11.69	12.40	0.156
Al$_2$O$_3$	nd			3.64	4.03	0.040	3.51	3.72	0.036
Fe$_2$O$_3$	14.8	23.8	0.149	17.28	19.13	0.120	17.99	19.08	0.119
Na$_2$O$_2$	0.07	0.11							
K$_2$O	0.11	0.17							
SO$_3$	12.4	19.9	0.249	21.32	23.60	0.295	22.92	24.32	0.304
H$_2$O$^-$	0.15	0.25		⎰9.02	10.00	0.555	0.17	0.18	
H$_2$O$^+$	nd			⎱			8.12	8.61	0.478
Insol	37.7			10.05			5.92		
Total	93.63			100.45	100.00		100.19	100.00	

1 and 3. Analysts R. Van Tassel and L. Van Stiphoudt

2. B. S. Butler and W. T. Schaller (1911)

3. Sample supplied by A. Pabst, from the type locality. *X*-ray powder data of this material is shown in Table 8.

ce rapport, qu'à l'occasion de l'interprétation d'une analyse d'une plumbojarosite hétérogène de Yellow Pine District, Nevada, A. Knopf (1915) appliqué la formule CuO·PbO ·3Fe$_2$O$_3$·4H$_2$O, donc sans aluminium, pour le calcul de la teneur en beaverite."

The analyses from the Russian sources supplied by Dr. Fleischer showed no evidence, apart from minor substitution, of an aluminum/iron series between osarizawaite and beaverite, and since intermediate members of the alunite/jarosite series are extremely rare in nature, it is not unreasonable to assume a similar condition for osarizawaite and beaverite. It is suggested that the formula for beaverite should be written as $Pb(CuFe)_3(SO_4)_2(OH)_6$ in conformity with the accepted formula for jarosite, $KFe_3(SO_4)_2(OH)_6$.

It is of interest that Hendricks (1937, p. 783) in discussing the structural relationship of the alunite and related groups has said

"A particular mineral has the possibility of showing any of the various types of replacement. . . . There is no explanation in the structure for the observation that the various minerals are usually found free of extensive isomorphous replacement."

Taguchi rejects the "Dana" concept of inclusion of Cu with Fe and Al in beaverite, preferring the Winchell formula of $PbCu(AlFe)_2(SO_4)_2(OH)_6$ and reasons that—

"The replacement between Cu^{++} and Fe^{+++} or Al may be very difficult according to the

TABLE 5. THERMAL BEHAVIOR OF OSARIZAWAITE

Temp. ° C.	Time	Cumulative % loss of weight
150	2 hr	0.09
300	1½ hr	0.09
370	1 hr	0.09
400	1 hr	0.09
410	1 hr	4.29
412	3 hr	7.59
415–450	9 hr	9.37
515	7 hr	10.48

differences between their ionic radii[1] or their behaviours as metallic ion. In fact, such an instance has not been known. Furthermore, the lead and copper are equal in molecular ratio in osarizawaite as well as in beaverite, while the ratios of ferric iron and aluminum are reversed."

In view of this suggestion it must be pointed out that to enable the structure of the alunite group to be preserved, the filling of the A^+ position with a divalent ion, must be balanced by replacement in the trivalent B^{3+} position by a divalent ion or as in the beudantite group by replacement of $(SO_4)^{2-}$ by $(PO_4)^{3-}$ or $(AsO_4)^{3-}$. The alunite structure proposed by Hendricks (1937) shows no position other than Al that the Cu can occupy.

X-RAY DATA

Powder diffraction patterns were taken using a Philips 114.59 mm camera, with asymmetric film mounting and both copper and iron radiation. Copper radiation gave the best resolution but despite variation in preparation of the specimen most of the reflections in the region with θ greater than 50° were diffuse and broad. This broadening is probably due to the presence of the biaxial phase in the sample.

The first few lines of the patterns were indexed on a Bunn chart after assuming an axial ratio close to that of alunite. Approximate cell dimensions obtained from these spacings were used to prepare charts for all possible values of $\mathrm{Sin}^2\theta$ for both FeKα and CuKα radiation, and hexagonal indices assigned to all measurable lines in the patterns.

The final value of a was obtained by extrapolation against

$$\frac{1}{2}\left(\frac{\mathrm{Cos}^2\theta}{\mathrm{Sin}\,\theta} + \frac{\mathrm{Cos}^2\theta}{\theta}\right)$$

and c was then calculated from the best reflections in the high angle

[1] Cu^{2+} 0.83 A Fe^{3+} 0.67 A Al^{3+} 0.50 A

TABLE 6. X-RAY POWDER DIFFRACTION DATA FOR OSARIZAWAITE

CuKα = 1.542 Å, Ni Filter. Camera diameter = 114.59 mm
Unit Cell Dimensions: Hexagonal $a = 7.050$ Å, $c = 17.025$ Å
Rhombohedral $a_{rh} = 6.984$ Å, $\alpha = 60°\ 38'$
Axial ratio $c/a = 2.415$

hk*l	hkl	d Å (calc.)	d Å (obs.)	I
101	100	5.7468	5.75	s
003	111	5.6745		
012	110	4.9614	4.97	vw
110	10$\bar{1}$	3.5250	3.52	ms
104	211	3.4915		
021	11$\bar{1}$	3.0046	3.00	vs
113	210	2.9943		
015	221	2.9737		
202	200	2.8735	2.874	m
024	220	2.4806	2.485	w
211	20$\bar{1}$	2.2867	2.284	m
205	311	2.2729		
122	21$\bar{1}$	2.2271	2.227	wm
116	321	2.2104		
300	2$\bar{1}\bar{1}$	2.0352	2.034	w
214	310	2.0287		
018	332	2.0094		
303〉	300〉	1.9157	1.917	m
033〉	22$\bar{1}$〉			
125	320	1.9103		
027	331	1.9022		
220	20$\bar{2}$	1.7625	1.762	wm
208	422	1.7457		
131	21$\bar{2}$	1.6850	1.684	wm
223	31$\bar{1}$	1.6831		
312	30$\bar{1}$	1.6606	1.661	vw
217	421	1.6740		
119	432	1.6668		
401	3$\bar{1}\bar{1}$	1.5173	1.520	vw
315	410	1.5162		
042	22$\bar{2}$	1.5024	1.502	m
01, 11	443	1.5003		
226	420	1.4972		
404	400	1.4368	1.438	vw
321	30$\bar{2}$	1.3959	1.396	w
045	33$\bar{1}$	1.3928		
137	430	1.3897		
309〉	522〉	1.3855		
039〉	441〉			
140〉	21$\bar{3}$〉	1.3323		
410〉	3$\bar{1}\bar{2}$〉			
324	41$\bar{1}$	1.3305		
318	521	1.3250	1.333	vw

TABLE 6.—(*continued*)

hk*l	hkl	d Å (calc.)	d Å (obs.)	I
143 ⎫ 413 ⎭	32$\bar{2}$ ⎫ 40$\bar{1}$ ⎭	1.2971	1.298	vw
407	511	1.2929		
051	22$\bar{3}$	1.2180	1.218	vw-w
327	520	1.2138		
502	4$\bar{1}\bar{1}$	1.2087	1.208	vw-w
146 ⎫ 416 ⎭	43$\bar{1}$ ⎫ 510 ⎭	1.2060		
330	30$\bar{3}$	1.1750	1.175	vw-w
054	33$\bar{2}$	1.1737		
241	31$\bar{3}$	1.1512	1.151	vw-w
333	41$\bar{2}$	1.1506		
422	40$\bar{2}$	1.1434	1.143	vw-w
31, 11	632	1.1424		
244	42$\bar{2}$	1.1136	1.114	vw
511	41$\bar{2}$	1.0943	1.094	vw
425	51$\bar{1}$	1.0928		
057	44$\bar{1}$	1.0913		
10, 16	655	1.0483	1.045	vw
155	43$\bar{2}$	1.0438		
247	53$\bar{1}$	1.0425		
060 ⎫ 600 ⎭	22$\bar{4}$ ⎫ 4$\bar{2}\bar{2}$ ⎭	1.0176	1.017	vw
428	620	1.0143		
253 ⎫ 523 ⎭	42$\bar{3}$ ⎫ 50$\bar{2}$ ⎭	.9635	.963	vw
345	52$\bar{2}$	.9628		
50, 11	722	.9587	.959	vw
32, 13	742	.9566		
01, 17	665	.9566		
437	62$\bar{1}$	.9278	.926	vvw
612	5$\bar{1}$2	.9256		
42, 11	731	.9251		
256 ⎫ 526 ⎭	53$\bar{2}$ ⎫ 61$\bar{1}$ ⎭	.9243		
440	40$\bar{4}$	.8813	.881	vvw
701	5$\bar{2}\bar{2}$	.8711	.871	vw
351	41$\bar{4}$	.8711		
443	50$\bar{3}$	.8708		
167	54$\bar{2}$	.8695		
01, 20	776	.8431	.843	vvw
262	42$\bar{4}$	.8425		
34, 11	740	.8421		
624	60$\bar{2}$	.8304	.8305	vvw
05, 16	772	.8022	.8013	vvw
173 ⎫ 713 ⎭	43$\bar{4}$ ⎫ 6$\bar{1}$2 ⎭	.8006		
627	71$\bar{1}$	.7996		

TABLE 7. *X*-RAY POWDER DATA FOR OSARIZAWAITE FROM TAGUCHI (1961) TABLE 2

CuKα (Ni filtered) 35 kV., 10 mA. Scale factor: 16, multiplier: 1 time constant: 4 sec., divergence slit: $2\frac{1}{2}°$, receiving slit: 0.2 m/m, scatter slit: $2\frac{1}{2}°$, scanning speed: 1°/min.

hkl	I	d(obs.)	d(calc.)[1]
0 0 3 1 0 1	70	5.79 Å	5.74 Å 5.75
0 1 2	5	4.98	4.98
1 0 4, 1 1 0	60	3.52	3.52
0 1 5, 1 1 3	100	3.00	3.00
0 0 6 2 0 2	60	2.87	2.87 2.88
0 2 4	20	2.49	2.49
1 0 7 2 0 5, 1 2 1	60	2.28	2.28 2.29
1 1 6, 1 2 2	30	2.23	2.23
2 1 4, 0 1 8, 3 0 0	10	2.03	2.03
0 0 9 0 2 7 1 2 5 0 3 3	30	1.918	1.915 1.916 1.917 1.918
2 0 8 2 2 0	20	1.762	1.760 1.762
1 1 9 2 1 7 2 2 3, 1 3 1	20	1.683	1.682 1.683 1.685
1 0 10 0 3 6 3 1 2	5	1.660	1.658 1.660 1.661
0 1 11 3 1 5, 4 0 1	10	1.519	1.517 1.520
0 2 10 2 2 6 0 4 2	30	1.500	1.501 1.502 1.503
0 0 12 4 0 4	5	1.436	1.436 1.439
2 0 11, 0 3 9 1 3 7 0 4 5, 3 2 1	10	1.397	1.394 1.395 1.396
1 1 12 3 1 8 3 2 4, 1 4 0	5b	1.332	1.330 1.331 1.332
1 0 13 1 2 11 2 2 9, 4 0 7 2 3 5, 1 4 3	10b	1.298	1.295 1.296 1.297 1.298

[1] Calculated on the basis of $a = 7.05$ Å, $c = 17.23$ Å.

TABLE 8. X-RAY POWDER DATA FOR BEAVERITE

(From Table II R. Van Tassel (1958))

| Kipushi, Katanga | | Beaver County, Utah[1] | |
| CoKα Fe Filter 5.7 cm camera | | FeKα Mn Filter 11.4 cm camera | |
d_{hkl}	I	d_{hkl}	I
5.79 Å	M	5.88 Å	VS
—		5.07	W
3.59	M	3.62	S
—		3.55	W
3.03	S	3.06	VS
2.92	W	2.945	M
2.82	W	2.866	M
2.51	M	2.533	M
2.33	W	2.343	M
2.26	S	2.284	S
—		2.246	W
—		2.080	VW
1.952	M	1.964	M
1.807	M	1.810	M
1.766	W	1.770	W
—		1.730	W
—		1.699	W
1.680	W	1.686	W
—		1.658	W
1.536	W	1.544	W
—		1.529	W
1.501	W	1.507	W
1.477	VW	1.469	W
—		1.433	W
+ Nine other lines.			

[1] Results by A. Pabst on analysis 3, Table 4.

range. Finally a chart was made for all possible values of $Sin^2 \theta$ for $CuK\alpha = 1.542$ Å and d spacings calculated from these figures.

Reflections were present only when $(k - h + l) = 3n$, a condition satisfying the obverse setting of the rhombohedron indexed on hexagonal axes. Intensities were estimated visually.

The d spacings of the West Australian mineral agree closely with those reported by Taguchi (Table 7) but the cell dimensions derived from these values while identical for a, differ by 0.2 Å for the c axis. with a consequent variation in the calculated d spacings and other unit cell constants.

TABLE 9. PHYSICAL AND OPTICAL PROPERTIES OF OSARIZAWAITE AND BEAVERITE

(Column 2 & 3 from Taguchi (1961) Table 4)

	Osarizawaite Western Australia	Osarizawaite Japan (Taguchi)	Beaverite Utah (Dana)
Crystal System	Hexagonal-R —	Hexagonal-R, pyramidal (?)	Hexagonal-R, ditrigonal pyramidal
Space group	—	—	$R3m$
a c c/a	7.05 Å 17.025 2.415	7.05 Å 17.23 2.444	7.203 Å 16.94 2.351
Habit	earthy and friable aggregates	earthy and friable masses	earthy and friable masses
Color	"Veronese Green"	greenish yellow	canary yellow
Specific gravity	4.037 4.167 (calc.)	3.89–4.02 4.20 (calc.)	4.36 4.31 (calc.)
Optical properties	$n = 1.72$ $\omega \approx 1.714$ birefringence moderate	$n = 1.735–1.757$ birefringence strong	ω variable 1.85 ± 0.02 birefringence strong
Solubility	insol in water, NH_4OH. Slightly soluble in conc boiling HNO_3. Readily soluble in HCl and H_2SO_4 (hot).	insol in water HNO_3, $NH_4C_2H_3O_2$ Sol in HCl or H_2SO_4 (Conc boil)	Sol in HCl (boil)

X-ray powder data for beaverite do not appear in the 1961 Edition of the Powder Data File, and are quoted from Van Tassel (1958) in Table 6.

A comparison of the data for alunite (ASTM 4-0865) with those of osarizawaite reveals a close correspondence in the positions of the lines but a considerable variation in the intensities. Jarosite may be similarly compared with beaverite with the exception that the strong line at 3.06 Å (Pabst, Table 6) in beaverite is not resolved as two lines as in jarosite.

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