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Aristarainite, $Na_2O \cdot MgO \cdot 6B_2O_3 \cdot 10\ H_2O$, a New Mineral from Salta, Argentina

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Abstract

Aristarainite is a new hydrous sodium magnesium borate found at the Tincalayu borax deposit, Salta, Argentina. It occurs as small crystals in a matrix of borax, kernite, and tincalconite.

The new mineral is monoclinic, $2/m$; space group, $P2_1/a$; a 18.869(2)Å, b 7.531(1)Å, c 7.810(1)Å, β 97°43.8(5)′; $a{:}b{:}c$ = 2.506:1:1.037; cell volume 1099.8(2)Å^3; cell content $2[Na_2O \cdot MgO \cdot 6B_2O_3 \cdot 10\ H_2O]$. The strongest lines in the X-ray powder photograph are (in Å): 7.74, I = 100; 5.40, 11; 3.869, 12; 3.037, 13; 2.579, 19; 2.400, 10. The mineral occurs in euhedral crystals elongated on [010] averaging 0.3 mm in length, and 0.05 by 0.05 mm in cross section. It also occurs in tabular crystals and as aggregates up to 1 mm. Common forms are $c\{001\}$, $a\{100\}$, $m\{110\}$; less common are $n\{210\}$, $x\{\bar{2}01\}$, $r\{\bar{3}01\}$, $s\{\bar{4}01\}$, $p\{211\}$, $o\{\bar{2}11\}$.

Aristarainite is colorless, with vitreous luster. In short-wave U. V. it shows cream-white fluorescence and slight phosphorescence. Cleavage: {001} and {100} perfect, {110} fair. The hardness is 3 1/2, the specific gravity 2.027(5) (meas), 2.102(calc). Optically biaxial (−), α 1.484(1), β 1.498(1), γ 1.523(1), $2V$ 70°, $r > v$ weak, $X = b$, $Y \wedge c$ = 38° in μ, $Z \wedge a$ = 46° in β.

A chemical analysis yields: Na_2O 7.3, K_2O 1.05, MgO 5.65, B_2O_3 59.5, H_2O 25.7, insol. 0.5, total 99.7 percent. The mineral is insoluble in water (66°C). The infrared spectrum shows broad absorption in regions 1100-1300 and 800-1100 cm^{-1}, indicating both 3- and 4- coordinated B; it also indicates both OH and H_2O.

The name is for Lorenzo Francisco Aristarain, Professor of Economic Geology, Universidad Nacional de la Plata, Argentina, in recognition of his contributions to borate mineralogy.

Introduction

During an examination of the Tincalayu mine, Salta, Argentina, in 1970 a systematic collection of mineral specimens was made throughout the deposit. Aristarainite was found in several of these specimens during the subsequent laboratory study.

The Tincalayu mine, the largest producer of borate minerals in South America, is located at the northern end of the Salar del Hombre Muerto which extends from lat. 25°10′ to 25°31′ S. and from long. 66°15′ to 67°15′ W. (Fig. 1). The deposit lies at an altitude of approximately 4000 m above sea level and can be reached by car from Positos Station on the G. M. Belgrano Railway, 146 km to the north.

Aristarainite (ä·rēs·tä·räēn′·īt) is named for Lorenzo Francisco Aristarain, Professor of Economic Geology, Universidad Nacional de la Plata, Argentina. This honor seems most fitting because of his past and continuing contributions to the mineralogy of South America, particularly that of the borate minerals. The name has been approved by the Commission on New Minerals and New Mineral Names of the International Mineralogical Association.

The type material (Harvard No. 109679) will be divided and deposited in the Smithsonian Institution (U.S. National Museum), Washington, D.C., and in the Harvard University Mineral Collection.

Occurrence

Aristarainite is a rare mineral found in small crystals in a matrix of borax and kernite (Hurlbut, Aristarain, and Erd, 1973). In addition it is associated with small amounts of rivadavite, ezcurrite (Hurlbut and Aristarain, 1967a,b), ameghenite and

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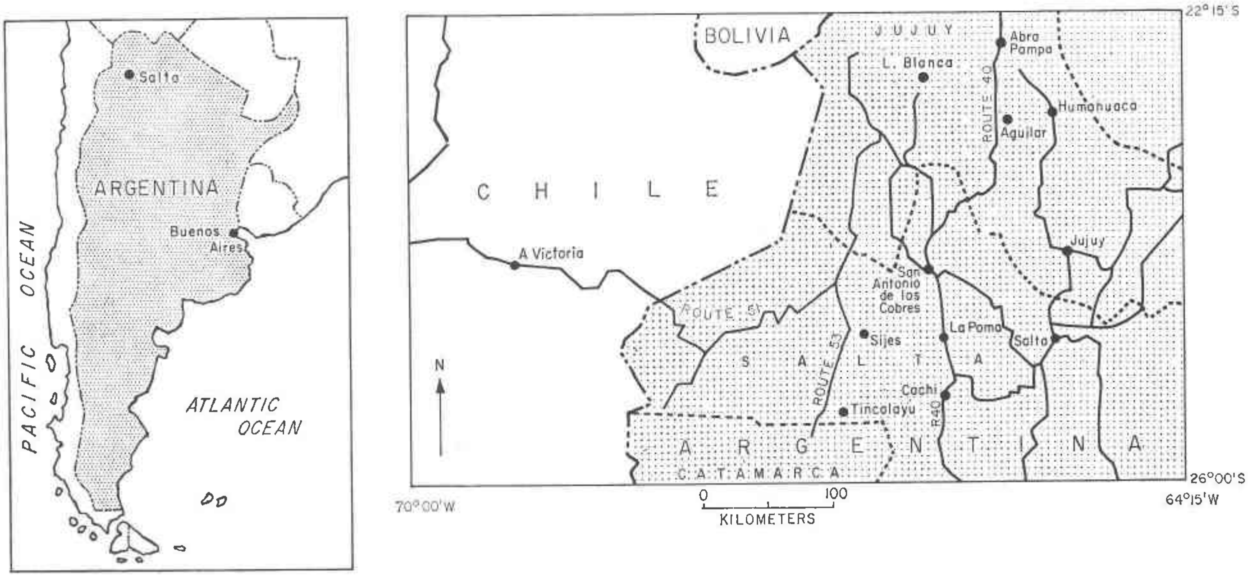

FIG. 1. Location of the Tincalayu Mine, Salta, Argentina.

macallisterite (Aristarain and Hurlbut, 1967a,b), kurnakovite, searlesite, probertite, ginorite, ulexite, tincalconite, halite, and magnesite.

The Tincalayu deposit is composed mainly of borax partly transformed to kernite with only a minor content of the rare borates and other minerals mentioned above. The deposit is interpreted as an old playa accumulation concordantly intercalated in the Sijes Formation and deformed by folding and faulting along a predominantly north-south direction. The Sijes Formation is composed principally of variously colored fine-grained sandstones and claystones interbedded with tuffs, limestones, evaporites, and conglomerates (Catalano, 1964; Turner, 1964; Muessig and Allen, 1957). The age of the sediments was considered Pliocene by Turner, post-Pliocene by Catalano, and Pleistocene or Holocene by Pratt (1961).

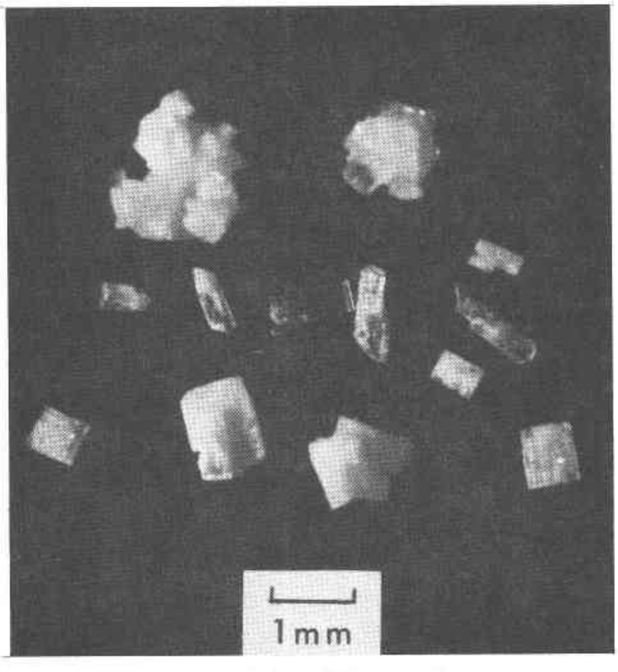

FIG. 2. Aristarainite crystals.

The folding and faulting processes elevated parts of the Sijes Formation that now form the high ground

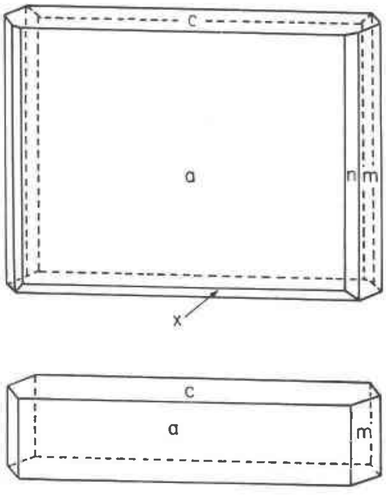

FIG. 3. Common habits and forms of aristarainite.

TABLE 1. Aristarainite Angle Table

Monoclinic; Prismatic - 2/m..

$a:b:c = 2.506:1:1.307$; $\beta = 97°44'$; $p_o:q_o:r_o = 0.4138:1.0275:1$

$r_2:p_2:q_2 = 0.9732:0.4027:1$; $\mu = 82°16'$

$p'_o = 0.4176$, $q'_o = 1.0370$, $x'_o = 1.358$

Forms		ϕ	ρ	ϕ_2	$\rho_2 = B$	C	A
c	001	90°00'	7°44'	82°16'	90°00'	.....	82°16'
a	100	90 00	90 00	0 00	90 00	82°16'	.....
m	110	21 56	90 00	0 00	21 56	87 07	68 04
n	210	38 51	90 00	0 00	38 51	85 09	51 09
x	$\bar{2}01$	-90 00	34 58	124 58	90 00	42 42	124 58
r	$\bar{3}01$	-90 00	47 23	137 23	90 00	55 07	137 23
s	$\bar{4}01$	-90 00	56 55	146 55	90 00	64 39	146 55
p	211	43 07	54 51	45 50	53 23	49 47	56 02
o	$\bar{2}11$	-34 00	51 22	124 58	49 38	55 57	115 54

TABLE 2. Unit Cell Data for Aristarainite

a(Å)	18.869(2)	Mol. Weight	700.164*
b	7.531(1)	Z	2
c	7.810(1)	Space group	$P2_1/a$
β	97°43.8(5)'	sp.gr. (meas.)	2.027(5)**
V(Å³)	1099.8(2)	ρ(calc. gcm^{-3})	2.102***
$a:b:c$	2.506:1:1:037		

*For: $Na_2O \cdot MgO \cdot 6B_2O_3 \cdot 10H_2O$
**Measured by suspension in bromoform-acetone
***Using the chemical analysis of Table 5

TABLE 3. X-ray Powder Diffraction Data for Aristarainite

	Calculated*	Observed**	
hkl	d_{hkl}Å	d_{hkl}Å	I
200	9.349	9.36	6
001	7.739	7.74	100
110	6.985	6.99	3
$\bar{2}01$	6.400	6.40	7
210	5.864	5.87	6
201	5.603	5.60	5
011	5.397	5.40	11
$\bar{1}11$	5.320	5.33	6
111	5.060	5.06	6
$\bar{2}11$	4.877		
310	4.802	4.802	6
400	4.675	4.675	7
211	4.495	4.497	6
$\bar{3}11$	4.284	4.287	8
$\bar{4}01$	4.264		
410	3.972	3.972	8
311	3.903		
002	3.870	3.869	12
401	3.782	3.782	9
020	3.765		
$\bar{2}02$	3.759	3.760	6
$\bar{4}11$	3.710	3.712	5
120	3.691	3.687	5
220	3.492		
$\bar{1}12$	3.460		
012	3.442		
202	3.417	3.415	5
021	3.386		
411	3.380	3.375	5
$\bar{1}21$	3.366}	3.361	5
$\bar{2}12$	3.363}		
510	3.349		
112	3.315	3.314	8
121	3.298		
$\bar{2}21$	3.245		
320	3.223		
$\bar{5}11$	3.219		
$\bar{4}02$	3.200		
$\bar{3}12$	3.178	3.180	6
221	3.125		
600	3.116	3.116	8
212	3.111		
$\bar{3}21$	3.051		
$\bar{6}01$	3.036	3.037	13
$\bar{4}12$	2.945	2.944	4
420	2.932	2.930	3
312	2.871	2.871	4
$\bar{6}11$	2.816	2.814	4
402	2.801	2.801	6
601	2.765	2.766	3
$\bar{5}12$	2.699}	2.702	4
022	2.698}		
$\bar{2}22$	2.660	2.659	4
$\bar{6}02$	2.605	2.607	5
003	2.580	2.579	19
710	2.518	2.516	4
$\bar{7}11$	2.489}	2.487	3
130	2.488}		
$\bar{6}12$	2.462}	2.460	3
$\bar{1}13$	2.460}		
013	2.440}	2.440	3
521	2.439}		
$\bar{2}13$	2.438}		
$\bar{4}22$	2.438}		
620	2.401}	2.400	10
$\bar{4}03$	2.400}		
113	2.381}	2.379	6
$\bar{1}31$	2.381}		
$\bar{3}13$	2.378}		
800	2.337}	2.337	3
$\bar{2}31$	2.337}		
711	2.309	2.309	3
213	2.291}	2.290	5
231	2.291}		
602	2.282	2.282	7
621	2.228	2.227	3
720	2.179	2.179	3
$\bar{6}03$	2.133	2.133	4
530	2.084	2.084	3
$\bar{6}13$	2.053	2.053	2
$\bar{9}11$	2.003}	2.001	2
910	2.003}		
		1.948	7
		1.879	2
		1.863	7
		1.841	1
		1.820	2
		1.813	2
		1.773	1
		1.764	2
		1.712	1
		1.658	1
		1.601	1
		1.558	1

* All calculated hkl's listed for $d_{hkl} \geq 3.000$ Å. All $d_{hkl} \geq 2.000$ Å are indexed. Indices and d(calc) from the least-squares analysis of X-ray powder data using the digital computer program of Appleman and Evans (1973).

** X-ray diffractometer conditions are: Chart No. X-3591; Cu/Ni radiation, Cu$K\alpha_1$ = 1.54051 Å; Si used as internal standard; scanned at 1/4°2θ per minute.

TABLE 4. Optical Properties of Aristarainite

α = 1.484(1)*
β = 1.498(1)
γ = 1.523(1)
$\gamma-\alpha$ = 0.039
2V = 70°**

Optically positive
$r > v$ weak
Orientation:
$X = b$
$Y\Lambda c$ -38°, $Z\Lambda a$ 46°

* Indices determined with Na light at 25°C. Values in parentheses represent estimated standard deviations in terms of the least units cited.
**Measured with spindle stage.

TABLE 5. Chemical Analysis of Aristarainite*

	Wt%	Wt% recalculated to 100	Wt% calc. comp**
Na_2O	7.3	7.36	8.85
K_2O	1.05	1.06	
MgO	5.65	5.69	5.76
B_2O_3	59.5	59.98	59.66
H_2O	25.7	25.91	25.73
Insol.	0.5		
Total	99.7	100.00	100.00

*Dr. Jun Ito, analyst, Harvard University. A spectrographic analysis showed traces of Si, Al, Ca, Fe, Cu, Mn and Zn.
**For: $Na_2O \cdot MgO \cdot 6B_2O_3 \cdot 10H_2O$

at the margins of the present playa and rise as islands within it. This elevation initiated the present erosion cycle with the deposition of clastic and chemical sediments (halite and ulexite).

Crystallography

Morphology

The new mineral occurs chiefly in well-formed isolated crystals elongated on [010] or tabular parallel to {100}. The elongate crystals average 0.3 mm in length and 0.05 × 0.05 mm in cross section. The dimensions of the largest tabular crystals are 0.4 × 0.4 × 0.1 mm. Rosette-like aggregates of tabular crystals that reach a maximum dimension of 1 mm are also found (Fig. 2).

Seven crystals were measured on the two-circle goniometer. The common forms on all crystals are: *c* {001}, *a* {100}, *m* {110}; less common are: *n* {210}, *x* $\{\bar{2}01\}$, *r* $\{\bar{3}01\}$, *s* $\{\bar{4}01\}$, *p* {211} and *o* $\{\bar{2}11\}$ (Fig. 3). The angles given in Table 1 were refined using the unit-cell dimensions of Table 2. The morphological axial ratios agreed well with those of Table 1 calculated from the unit-cell data.

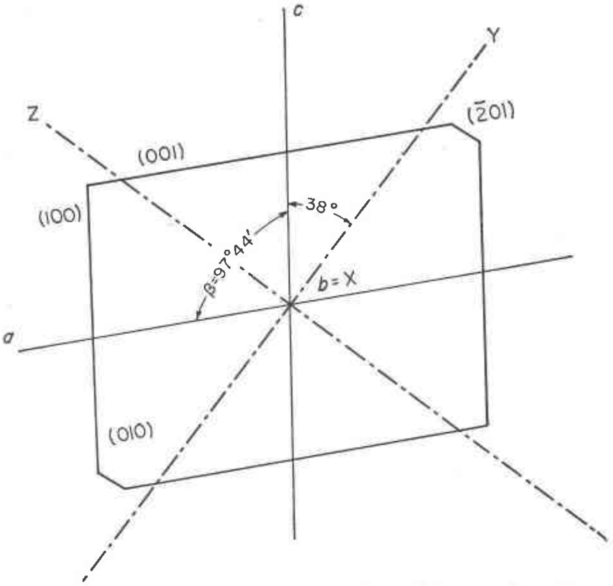

FIG. 4. Optical orientation of aristarainite projected on (010).

X-ray Data

Unit-cell dimensions were determined using precession photographs (Mo radiation, Zr filter) with *a*, *b*, and *c* as precession axes for zero-, first-, and second-level photographs. Systematic extinctions indicate the space group as $P2_1/a$. The dimensions were refined by a least-square analysis of X-ray powder data using the digital computer program of Appleman and Evans (1973). The resulting data are given in Table 2.

The X-ray powder diffraction data for aristarainite are listed in Table 3.

Physical and Optical Properties

Aristarainite has perfect cleavage on {001} and {100} causing the mineral to break into splinters parallel to [010]. It also has fair {110} cleavage. The mineral is colorless with vitreous luster. The hardness is 3½; the specific gravity, measured by suspension in bromoform-acetone at 25°C, is 2.027(5). In short-wave U.V. radiation, it shows moderate cream-white fluorescence and slight phosphorescence.

The optical properties are summarized in Table 4, and the optical orientation is shown in Figure 4. The mean calculated index of refraction obtained with the Gladstone and Dale relationship is 1.500; this agrees well with 1.502, the arithmetic average of the measured refractive indices.

Chemical Composition

Aristarainite occurs enclosed in borax and kernite or in tincalconite altered from them. The crystals

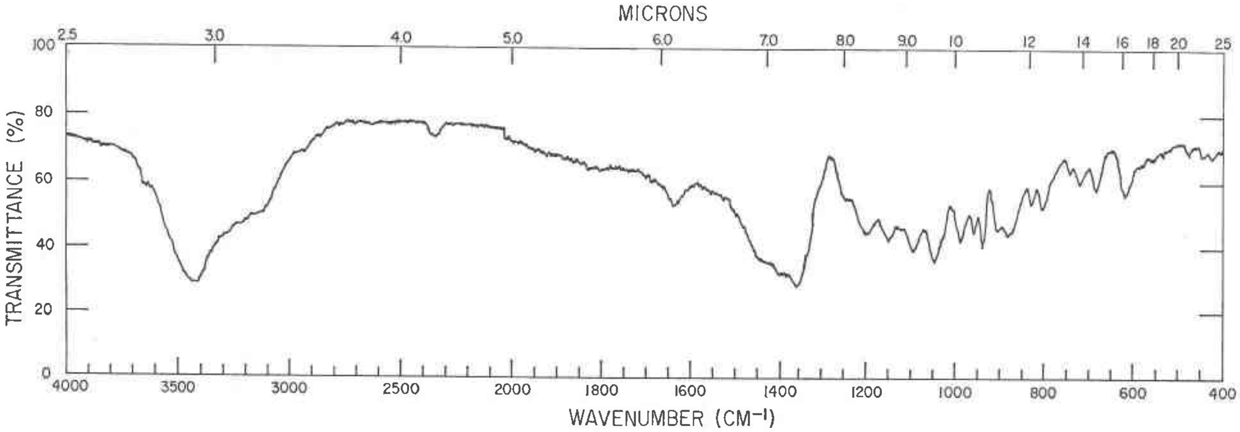

FIG. 5. Infrared absorption spectrum of aristarainite.

used in this study were obtained by dissolving the host minerals with warm water. The total amount thus obtained was approximately half a gram. The chemical analysis was carried out by Dr. Jun Ito of Harvard University on 95.4 milligrams of material. The analysis (Table 5), if we assume 6 B_2O_3, yields the formula $(Na_{1.65}K_{0.16})O_{0.91}(MgO)_{0.98} \cdot 6\,B_2O_3 \cdot 10\,H_2O$. The idealized formula is $Na_2O \cdot MgO \cdot 6\,B_2O_3 \cdot 10\,H_2O$.

The new mineral is not soluble, or only slightly soluble, in hot water (66°C) but very soluble in cold 1:1 HCl. The form {100} shows a slight natural etching, but other faces have not been etched. The mineral fuses easily to a clear glass with $n = 1.510$.

The infrared absorption spectrum of aristarainite is given in Figure 5. The wave number in cm^{-1} and the characteristics of the peaks are given in Table 6. The 3640 peak is due to the presence of OH^- and the broad peak at 3420 to the presence of H_2O. The band from 1150 to 1450 indicates boron in triangular coordination, whereas the bands from 805 to 1095 indicate boron in tetrahedral coordination.

TABLE 6. Infrared Absorption Spectra of Aristarainite

Wavenumber (cm^{-1})		Wavenumber (cm^{-1})		Wavenumber (cm^{-1})	
3640	msh*	1150	mb	805	m
3420	svb	1095	mb	745	w
3120	wsh	1045	s	720	w
1635	mb	990	m	685	w
1450	ssh	960	m	620	wb
1405	ssh	940	s	475	vw
1355	s	905	m	445	vwb
1250	wsh	880	mb	425	vwb
1195	mb	830	m		

*Key to letters following wave number: s strong, v very, b broad, m medium, sh shoulder.

Acknowledgments

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