

NEW DATA FOR JEREMEJEVITE

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ABSTRACT

Jeremejevite, found only at Mt. Sektuj, Transbaikal, U.S.S.R., and Cape Cross, Swakopmund, Namibia (South West Africa) and characteristically anomalous in its optical properties, is shown to contain major fluorine and minor amounts of hydroxyl. Synthetic OH-jeremejevite permitted comparison of the (F) and (OH) end-members. The formula $Al_6B_5O_{15}(F,OH)_3$ has been confirmed. Only minor amounts of Si, Ga, Be and Fe are present in addition to the major constituents. The cornflower blue coloration of Cape Cross jeremejevite may be due to trapped cations (*e.g.*, Fe) or inorganic-radical-trapped (*e.g.*, BO_3) electrons or holes. Single-crystal X-ray diffraction revealed no differences between uniaxial and biaxial portions of crystals from either locality. Jeremejevite from Mt. Sektuj consists of a biaxial core, $2V_x = 33^\circ$, and uniaxial rim, whereas material from Cape Cross has a uniaxial core and biaxial rim, $2V_x = 18^\circ$. Optical data for uniaxial F-jeremejevite are close to those of apatite, so that other occurrences of the mineral may have been overlooked. Hardness is $7\frac{1}{2}$, D_{meas} (Cape Cross) = 3.294, D_{meas} (Mt. Sektuj) = 3.29, D_{meas} (synthetic OH-jeremejevite) = 3.205 $g\ cm^{-3}$. D_{calc} (F) = 3.284, (OH) = 3.198 $g\ cm^{-3}$ for cell volumes (F) = 518.61, (OH) = 526.37 \AA^3 , $Z = 2$. The mineral does not fluoresce under ultraviolet radiation.

Keywords: jeremejevite, optical spectra, optical anomalies, Mt. Sektuj, Transbaikal, Cape Cross, Namibia.

SOMMAIRE

Les échantillons de jérémejevite du mont Sektuj (Transbaikal, U.R.S.S.) et du cap Cross (Swakopmund, Namibie) possèdent des propriétés optiques anormales; ils contiennent surtout du fluor et très peu d'hydroxyle. La jérémejevite-OH de synthèse permet de comparer les pôles F et OH de la série. On confirme la formule $Al_6B_5O_{15}(F,OH)_3$; Si, Ga, Be et Fe sont présents en quantités minimales seulement. La coloration bleu-bluet de l'échantillon du

cap Cross indiquerait des cations piégés (*e.g.*, Fe), ou des lacunes, ou encore des électrons piégés dans BO_3 . On ne décèle, par diffraction X sur cristal unique, aucune différence entre les portions uniaxe et biaxe des cristaux optiquement anormaux. Les cristaux provenant du mont Sektuj sont biaxes au centre ($2V_x = 33^\circ$) et uniaxes en bordure; ceux du cap Cross, uniaxes au centre et biaxes ($2V_x = 18^\circ$) à la périphérie. Les données optiques pour la jérémejevite-F uniaxe ressemblent à celles de l'apatite, de sorte que certaines localités nouvelles ont pu passer inaperçues. Dureté $7\frac{1}{2}$; densités mesurées: 3.294 (cap Cross), 3.29 (mont Sektuj) 3.205 (jérémejevite-OH de synthèse); densités calculées: 3.284 (pôle fluoré), 3.198 (pôle hydroxylé) à partir des volumes de la maille 518.61 (F) et 526.37 \AA^3 (OH), et de $Z = 2$. La jérémejevite ne montre aucune fluorescence en lumière ultraviolette.

(Traduit par la Rédaction)

Mots-clés: jérémejevite, spectres optiques, anomalies optiques, mont Sektuj, Transbaikal, cap Cross, Namibie.

INTRODUCTION

As part of a study of anomalous biaxiality in "isometric" and "dimetric" crystals (Foord & Mills 1978, Foord & Cunningham 1978), the rare mineral jeremejevite was selected for reinvestigation of optical, chemical and physical properties. The mineral is known from only two localities: Mt. Sektuj, Transbaikal, U.S.S.R. (Damour 1883) and the recent discovery at Cape Cross, Swakopmund, Namibia (South West Africa; Strunz & Wilk 1974). Material from both localities shows anomalous optical properties related to growth-sector zoning. The few crystals known from Mt. Sektuj have a core of biaxial material (formerly termed eichwaldite) with a rim of uniaxial material. The situation is reversed in the Cape Cross jeremejevite, which has a small uniaxial core and a

biaxial rim. Furthermore, in contrast to the colorless crystals from Mt. Sektuj, the Cape Cross material is cornflower blue of varying intensity related to compositional zoning.

The more recent studies of jeremejevitte from these localities are those of Shafranovskii *et al.* (1952), Strunz & Wilk (1974) and Herting & Strunz (1978). The latter two investigations presented new chemical analyses that cast doubt upon the presence of hydroxyl in the mineral, as shown by the crystal-structure study of Golovastikov *et al.* (1955). Our microprobe and optical spectroscopic studies of jeremejevitte from Cape Cross and microprobe study of a single specimen from Mt. Sektuj (USNM # B12207) confirm the presence of a minor amount of OH and reveal the presence of major amounts of fluorine. Jeremejevitte has been synthesized in the system Al_2O_3 - B_2O_3 - H_2O (Michel-Lévy 1949, Reynaud & Iiyama 1967, Reynaud 1977, Capponi *et al.* 1972). Through the kindness of Dr. Camille Reynaud, who supplied us with her synthetic compound, we are able to compare here the F- and OH-jeremejevitte. Details concerning variation in observed $2V$, the relationship of optical properties to growth features, and origin of the anomalous optics will be treated in a subsequent paper.

CHEMISTRY

Polished thin sections cut normal to c (0.04–0.06 mm thick) of material from both localities were examined with an ARL-EMX electron microprobe. (Use of trade names in this report

is for descriptive purposes only and does not constitute endorsement by the U.S. Geological Survey.) Spectral scans and semiquantitative examination showed major aluminum, boron, fluorine and oxygen with minor amounts of iron, silicon and sodium. Major fluorine had not been previously reported for jeremejevitte; because of this fact, the material was analyzed quantitatively for Al, Fe, Si and F. Operating conditions were 15 kV accelerating voltage, 5 μ m spot diameter and 0.05 μ A sample current. The standards used were Al_2O_3 , Fe_2O_3 , CaF_2 and SiO_2 . Counting times of 10 seconds were used on samples and standards. Data were reduced using the MAGIC IV program of Colby (1968). Major boron was detected with a LOD (lead oxy-decanoate) analyzing crystal but, because of difficulty in mapping out the boron peak, final data-reduction was performed using the amount of boron calculated for the F end-member, $Al_6B_5O_{15}F_3$. The resulting analytical data are presented in Table 1; results of semiquantitative spectrographic analyses are given in Table 2.

The microprobe traverses were made from core to rim of crystals from both localities; averages for the core and rim areas are reported in Table 1. The analyses showing maximum Si content of the material from both localities are given for comparison.

TABLE 1. ELECTRON-MICROPROBE ANALYSES OF JEREMEJEVITTE

	Mt. Sektuj, U.S.S.R.			Cape Cross, South West Africa			Calc. Composition	
	Core	Rim	High Si	Core	Rim	High Si	F-end member	OH-end member
Al_2O_3	59.90	59.92	59.88	59.12	59.79	59.70	59.64	60.34
$Fe_2O_3^*$	0.01	0.01	0.01	0.02	0.14	0.02	---	---
SiO_2	0.03	0.02	0.23	0.01	0.17	0.25	---	---
$B_2O_3^{**}$	33.51	33.75	33.61	34.09	33.81	33.70	33.93	34.33
F	10.18	10.30	10.04	9.26	10.23	10.14	11.11	---
H_2O	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	---	5.33
	103.63	104.00	103.77	102.50	104.14	103.81	104.68	100.00
O=F	4.29	4.34	4.23	3.90	4.31	4.27	4.68	---
	99.34	99.66	99.54	98.60	99.83#	99.54	100.00	100.00

*Analyt., E. E. Foord. Reported in weight percent. Fe reported as Fe_2O_3 .

**Boron standard and samples treated as the F end member. Raw data reduced using 33.93 weight percent B_2O_3 .

#Gives the calculated formula:

$Al_6.00Fe_{0.01}B_{4.97}Si_{0.01}O_{15}F_{2.76}(OH)_{0.24}$ (based on 15 oxygens with 0.43 weight percent H_2O assumed for charge balance).

TABLE 2. SPECTROGRAPHIC ANALYSES OF JEREMEJEVITTE

	Mt. Sektuj* U.S.S.R.		Cape Cross South West Africa	
	(wt. %)**		blue rim	colorless core
Al	major		major	major
B	>10.0		>10.0	>10.0
Si	0.7		0.7	0.7
Na	0.003		0.02	0.003
K	<1.0		<1.0	<1.0
Ca	0.003		0.003	0.003
Mg	0.015		0.015	0.015
Fe	0.05		0.2	0.015
Ti	0.015		0.007	0.03
	(ppm)#			
Ba	5		15	5
Be	5		300	15
Cr	20		7	15
Cs	<10		<10	<10
Cu	20		7	3
Ga	500		200	200
Li	5		70	20
Mn	15		50	50
Nb	50		<30	70
Ni	10		7	7
Pb	100		<15	30
Rb	<2		2	<2
Sc	20		<15	15
Sn	30		15	70

*U.S.N.M. No. B12207 (whole crystal).

**Analyt., N. M. Conklin. Six-step semiquantitative spectrographic analyses made on approximately 10-mg samples.

#In alphabetical order. Also looked for, but not detected, were: Ag, As, Au, Bi, Cd, Ce, Co, La, Mo, P, Pd, Pt, Te, U, V, W, Zn, and Zr.

In addition, several crystals of jeremejevite from Cape Cross were examined for variation in iron content. Pale blue to darker cornflower blue rims showed a maximum content of about 0.3 wt. % iron (as Fe_2O_3 , determined spectrographically), with somewhat less iron in the colorless cores. Microprobe determinations show somewhat less (0.1 wt. % Fe_2O_3) and may be due to the use of Fe_2O_3 as an iron standard. In contrast with our results, analyses of jeremejevite from this locality by Mr. H. Napióntek (in Strunz & Wilk 1974 and in Herting & Strunz 1978) show substantially more Fe_2O_3 (2.2 and 1.35 wt. %, respectively, for bulk crystals). We also find Na and K to be

virtually absent in the Cape Cross material, whereas H. Napióntek reports tenths of a percent to several percent of these elements, expressed as oxides. These discrepancies may perhaps be due to the small sample size (20 mg) used in his analysis.

Additional information on the composition of jeremejevite, especially regarding the OH content, is provided by the optical spectroscopic study reported below.

OPTICAL SPECTROSCOPIC DATA

Spectra of blue and colorless natural specimens and a colorless synthetic jeremejevite sam-

TABLE 3. MID-INFRARED (250-4000 cm^{-1}) SPECTRUM

NATURAL JEREMEJEVITE ⁽⁶⁾		INTERPRETATION	SYNTHETIC JEREMEJEVITE	
Band position (cm^{-1}) and description			Band position (cm^{-1}) and description	
275	v. sharp; v. weak	Lattice modes	275	v. sharp; v. weak
300	v. sharp; v. weak		300	v. sharp; weak
325	v. sharp; side band	A1-O ⁽¹⁾	325	v. sharp; side band
340	sharp; medium		340	sharp; medium
368	sharp; side band		350	v. sharp; side band
----		A1-O-H ⁽¹⁾ bend (?)	385	m. sharp; strong
425	m. sharp	A1-O ⁽¹⁾ stretch	425	m. sharp
462	m. sharp		460	m. sharp
495	medium		500	m. sharp
525	m. broad		535	medium
600	broad; strong	A1-F ⁽²⁾ stretch	----	
680	m. sharp; medium	B-O ⁽³⁾ degenerate stretch	635	m. sharp; medium
725	m. sharp; strong	B-O ⁽³⁾ out-of-plane bend (degenerate)	700	m. sharp; strong
770	side band		762	m. sharp; strong
950	sharp; m. weak	B-O ⁽³⁾ symmetric stretch (forbidden)	960	sharp; v. weak
1035	medium; v. v. weak	A1-O-H ⁽¹⁾ bend	1030	medium; m. strong
----		Absence of broad, very intense bands in this region indicate no SiO ⁽⁴⁾	----	
1100	broad; v. v. weak	(?)	1150	medium; weak
1230	medium	B-O ⁽³⁾ degenerate stretch (degeneracy resolved in natural specimen)	----	
1305	medium		1300	v. broad
1354	medium		----	v. strong
1385	v. v. sharp; weak	Impurity in KBr(?)	1385	v. v. sharp; weak
----		Absence of B-F ⁽⁵⁾ stretch	----	
2850	v. sharp; v. v. weak	CH stretch; impurity in KBr(?)	----	
2920	v. sharp; v. weak		----	
3430	v. broad; weak	OH-fundamental stretch	3490	m. sharp; v. strong
3665	v. sharp; v. weak	OH stretch	----	

(1) A1-O frequencies estimated from corundum Al_2O_3 ; spinel MgAl_2O_4 ; gibbsite $\text{Al}(\text{OH})_3$ (Sadtler 1973).

(2) A1-F frequencies determined from cryolite Na_3AlF_6 (Sadtler 1973).

(3) B-O frequencies determined from those of rare earth borates (see Steele & Decius 1956, Weir & Lippincott 1961).

(4) Si-O stretching modes produce most intense features in the 1000 cm^{-1} region. Absence of bands here argues strongly

against any significant amounts of Si.

(5) B-F: the strongest band in BF_3 occurs near 1460 cm^{-1} . The absence of a feature here argues against F in the

natural jeremejevite being associated with boron.

(6) The mid-infrared spectrum of the blue and the colorless natural jeremejevites are identical.

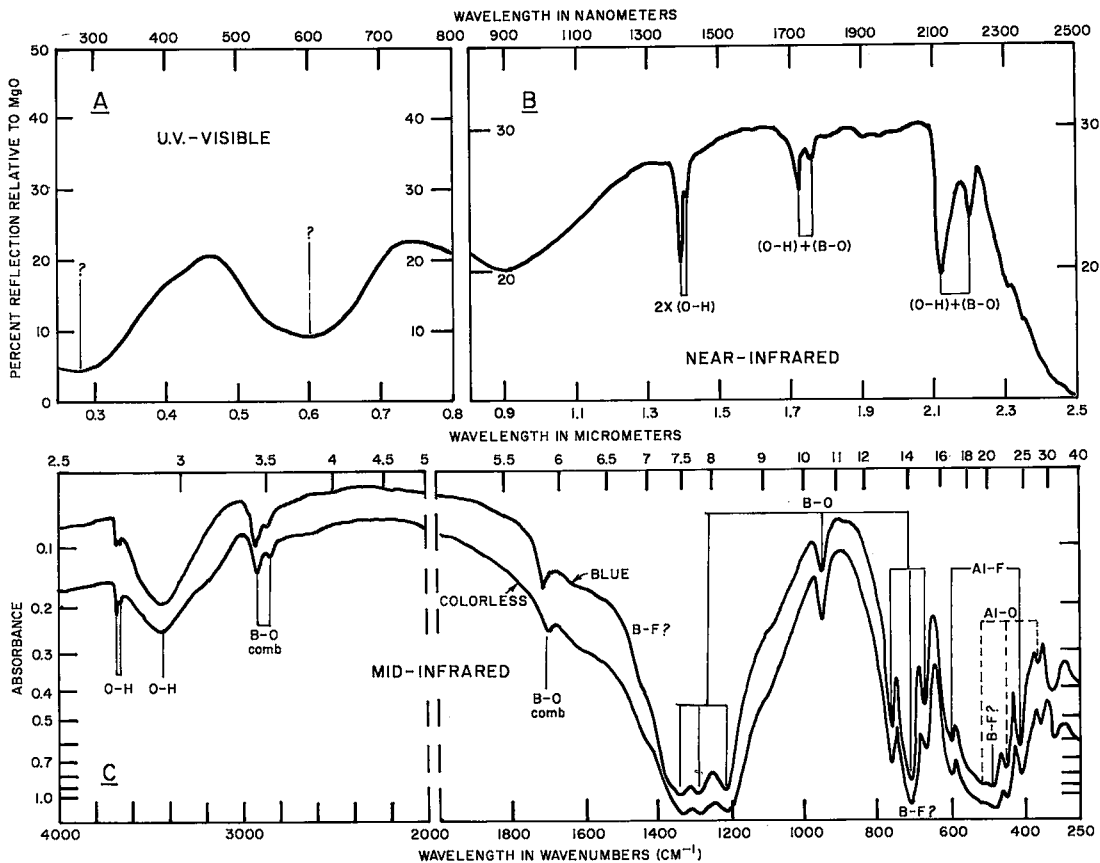


FIG. 1A. Ultraviolet-visible region, reflection spectrum for blue jeremejevite from Cape Cross, Namibia. B. Near-infrared region, reflection spectrum for blue jeremejevite from Cape Cross. C. Mid-infrared region, transmission spectra for blue and colorless jeremejevite from Cape Cross.

ple were recorded from the UV through the mid-infrared inclusive, covering the entire range of 250 to 40,000 nm ($40,000\text{--}250\text{ cm}^{-1}$). Reflection spectra were recorded from 250 to 2500 nm; transmission spectra of crushed samples embedded in KBr pellets were recorded from 4000 to 250 cm^{-1} .

The spectra presented here do not provide an unambiguous structural analysis for the mineral, but the bands that appear in the spectra can be interpreted in a manner that is consistent with the other data and with the formula proposed in the conclusion. Although some of the assignments can be made with considerable confidence, others must be regarded as tentative. The interpretation is based largely on analogical arguments that relate features due to well-identified group-vibrations of known minerals in the near- and far-infrared spectra to those in the jeremejevite spectrum. In the UV and visible

spectrum, the interpretation is more speculative.

Most of the bands in the mid-infrared spectrum are caused by the excitation of specific fundamental vibrational modes of the groups of atoms in the crystal. The number, locations, intensities and patterns of the bands are used to confirm tentatively the presence of the major components of jeremejevite, namely, B, Al, O, F and some H, while at the same time excluding the possibility of the presence of significant amounts of Si and H_2O .

The spectra of the blue and colorless natural specimens differ only in the visible range. Comparison of the spectra of the natural samples and the synthetic OH-jeremejevite shows that they are similar in most respects, indicating the same basic structure; however, there are significant differences in the mid-infrared range (Table 3, Fig. 1C), indicating that the natural samples contain F rather than OH. The major

differences occur (1) in the bands at 385 and 1030 cm^{-1} , which appear strongly in the synthetic jeremejevite and indicate the presence of Al-O-H, (2) in the 3490 cm^{-1} band, which is extremely strong in the synthetic specimen owing to the fundamental OH-stretch, and (3) in the 600 cm^{-1} band, which occurs only in the natural samples and is assigned to the Al-F-stretching mode.

Throughout the near-infrared (Table 4, Fig. 1B), the spectra of the natural and synthetic samples differ considerably. The spectrum of the synthetic sample is completely consistent with the presence of significant amounts of OH, whereas the spectrum of the natural sample indicates that although some OH is present (the 1400 nm band), the rest of the spectrum can best be interpreted in terms of combinations involving B-O rather than OH. Information concerning the presence or absence of F does not occur in the near-infrared range.

The UV and visible spectrum of a blue natural sample shown in Figure 1A and Table 2 displays two well-defined broad minima at 280 and 600 nm; these provide a maximum between them at 465 nm that is responsible for the blue color of the mineral. At present we do not have a satisfactory explanation for the origin of these two bands. The blue specimen contains 0.2% Fe, and the colorless specimen contains 0.15% Fe. These facts, together with the general appearance and relative intensities of the features, argue against a cause by crystal-field transition in Fe; there are no other chromophoric ions present in sufficient quantities to provide such

bands. A charge transfer of the $\text{Fe}^{2+} \leftrightarrow \text{Fe}^{3+}$ type seems an equally unlikely cause. An explanation based on transitions between the $\pi - \pi$ electron levels of the BO_3 triangles, offered to account for a similar though slightly shifted pair of bands in dumortierite by Hunt & Salisbury (1970), also seems unlikely, because the mid-infrared spectra of both the blue and the colorless samples are essentially identical. An explanation involving electron-hole centres, due to either cation-trapped (*e.g.*, Fe) or inorganic-radical-trapped (BO_3) electrons or holes, appears to be more compatible with the other evidence, but further study is required to confirm this.

X-RAY-DIFFRACTION DATA

Single-crystal fragments of both uniaxial and biaxial portions of jeremejevite from the U.S.S.R. and Namibia were examined by Laue and precession methods. The $hk0$, $hk1$, $h0l$ and hhl nets for each fragment were examined with Zr-filtered Mo radiation. In agreement with previous studies (Shafranovskii *et al.* 1952, Herting & Strunz 1978), we could find no differences between the uniaxial and biaxial sectors by X-ray methods. Despite a positive test for piezoelectricity reported by C. Frondel (pers. comm. in Palache *et al.* 1951), jeremejevite appears to be centrosymmetric (space group $P6_3/m$) from the crystal structure determination by Golovastikov *et al.* (1955). Furthermore, Herting & Strunz (1978) reported that no piezoelectric effect was obtained in a new test conducted for this property.

Unit-cell data are given (Table 5) for both the cores and rims (corresponding to uniaxial and biaxial portions) of the naturally occurring F-rich jeremejevites, together with data obtained from the synthetic (OH) end-member. The effect of composition (OH *versus* F) may be seen by comparing the cell volumes and c/a ratios of Table 5 with the compositions shown in Table 1. As expected, cell volume increases with increasing (OH) content, with the expansion being slightly larger in the c direction.

X-ray powder-diffraction data for jeremejevite from the U.S.S.R., Namibia and the synthetic (OH) end-member are given in Table 6. The synthetic compound, which forms as minute basal plates, shows moderate effects of preferred orientation for $00l$ and $h0l$ reflections.

PHYSICAL PROPERTIES

We determined the Mohs hardness of jeremejevite from both localities to be $7\frac{1}{2}$, in agree-

TABLE 4. VISIBLE AND NEAR-IR (250-2500 nm) SPECTRUM

NATURAL JEREMEJEVITE Band position (nm) and description	INTERPRETATION	SYNTHETIC JEREMEJEVITE Band position (nm) and description
280 broad; strong ⁽¹⁾	See text	----
[465 maximum] ⁽¹⁾	This maximum is responsible for blue color when present	----
600 broad; strong ⁽¹⁾	See text	----
1394 sharp; m. strong	Combination of OH's at 3665 + 3430 cm^{-1}	----
1412 shoulder		----
----	First overtone of O-H fundamental at 3490 cm^{-1}	1425 sharp; medium
----		1500 broad; weak
1730 medium; weak	Very unusual bands?	----
1760 med.; v. weak		----
1900 broad; v. weak	OH + HOH band combination; typical of presence of molecular H_2O	----
2130 m. sharp; strong	80 combination, <i>i.e.</i> , 3 x 1300 + 770; may be contribution from OH	----
2148		----
----	Typical O-H + AlO-H combinations	2220 sharp; v. strong
----	Combinations involving OH	2370 medium; weak
----		2400

⁽¹⁾ These bands only appear in blue-colored natural samples.

TABLE 5. UNIT-CELL AND OPTICAL DATA FOR JEREMEJEVITE

	Mt. Sektuj U.S.S.R.		Cape Cross South West Africa		Synthetic (OH) End Member
	Core	Rim	Core	Rim	
a (Å)	8.5580(1)*	8.5570(2)	8.5591(3)	8.5571(2)	8.5954(3)
c	8.1831(3)	8.1785(3)	8.1814(6)	8.1763(2)	8.2268(4)
Vol. (Å ³)	519.04(2)	518.61(2)	519.06(4)	518.49(2)	526.37(3)
c/a	0.9562	0.9558	0.9559	0.9555	0.9571
Cell contents	2[Al ₆ B ₅ O ₁₅ (F,OH) ₃]		2[Al ₆ B ₅ O ₁₅ (F,OH) ₃]		2[Al ₆ B ₅ O ₁₅ (OH) ₃]
Optical character	biaxial (-)	uniaxial (-)	uniaxial (-)	biaxial (-)	uniaxial (-)
α or c	1.637**	1.637	1.637	1.637	1.670
β	1.646			1.644	
γ or ω	1.647	1.647	1.644	1.645	1.690
$2V_{\alpha}$ (meas.)	33±1°	0°	0°	18±1°	0°
Dispersion	$r > v$, distinct			$r > v$, distinct	
Optical orientation	X = c Y \wedge a_2 = 10° Z \wedge a_1 = 10°			X = c Y = a_2 Z = a_1	
Color and pleochroism	colorless	colorless	r = pale blue-violet ω = colorless	X = pale blue-violet Y, Z = colorless	colorless

*Data obtained from refinement of X-ray powder data (Table 6) using the least-squares program of Appelman & Evans (1973). Error in parentheses is one standard deviation in the last decimal quoted.

**Determined in Na light; precision is ± 0.001 .

ment with the Vickers hardness of 1287 to 1377 determined by Shafranovskii *et al.* (1952). A value as low as 6½ has been cited by some workers. The specific gravity of the African material was determined to be 3.294 (± 0.010) by measurement in a methylene iodide-acetone mixture, checked with a Westphal balance. This is in excellent agreement with the value of 3.29 (± 0.01) measured by Dunn (in White 1975). Strunz & Wilk (1974) obtained a value of 3.313, but this may have been due to a higher iron content in the material that they measured. Our specific gravity of 3.29 (± 0.01) for the Russian jeremejevite agrees reasonably well with the values of 3.28 reported by Damour (1883) and 3.27 by M. E. Mrose (pers. comm. in Palache *et al.* 1951). The specific gravity of the synthetic (OH) end-member is 3.205 (± 0.010). The calculated densities (in g cm⁻³) for the pure end-members are 3.284 (F) and 3.198 (OH).

Jeremejevite from both localities shows no response to short- or long-wave ultraviolet radia-

tion. The material from Cape Cross is slightly cathodoluminescent under the electron beam, possibly owing to the Fe content.

OPTICAL PROPERTIES

The optical properties of jeremejevite have been the subject of extensive discussion since the discovery of the mineral. Because a separate paper on the subject is in preparation by one of the authors (E.E.F.), we present only a summary of the principal numerical data (Table 5). Calculation of the compatibility of our optical, chemical and specific gravity data, using the Gladstone-Dale relationship (Mandarino 1979), gives a range of 0.005–0.015 ("superior" on Mandarino's scale) for all specimens investigated.

It should be noted that the optical data for the uniaxial F-jeremejevite are close to those of apatite (as an example of the confusion possible, see King 1978). It seems possible that other occurrences of jeremejevite may have been

TABLE 6. X-RAY POWDER-DIFFRACTION DATA FOR JEREMEJEVITE

hkl	Mt. Sektuj**				Cape Cross+		Synthetic (OH) End Member++	
	$d_{calc}^{\text{\AA}}$	$d_{meas}^{\text{\AA}}$	I	$d_{meas}^{\text{\AA}}$	I	$d_{meas}^{\text{\AA}}$	I	
100	7.411	7.41	18	7.41	17	7.45	9	
101	5.492	---	---	---	---	5.52	2	
110	4.278	4.282	100	4.285	100	4.305	76	
002	4.089	4.091	17	4.094	22	4.118	90	
111	3.791	3.791	57	3.791	55	3.811	43	
200	3.705	3.705	7	3.701	5	3.721	6	
102	3.580	3.580	19	3.578	20	3.603	49	
201	3.375	3.375	8	3.374	7	3.391	5	
112	2.956	---	---	---	---	---	---	
210	2.801	2.801	27	2.801	43	2.813	24	
202	2.746	2.749	2	2.745	3	2.760	6	
211	2.650	2.650	33	2.651	53	2.662	29	
103	2.559	2.558	12	2.558	15	2.573	44	
300	2.470	2.470	30	2.471	23	2.481	16	
301	2.365	---	---	---	---	---	---	
212	2.311	---	---	---	---	---	---	
113	2.299	2.299	14	2.299	20	2.311	30	
203	2.196	2.196	35	2.196	53	2.207	100	
220	2.139	2.139	5	2.139	4	2.148	4	
302	2.114	2.114	26	2.114	49	2.125	23	
221	2.070	2.070	8	2.069	12	2.079	6	
310	2.055	2.055	44	2.056	64	2.065	52	
004	2.045	---	---	---	---	---	---	
104	1.971	1.971	3	---	---	1.982	4	
213	1.954	1.954	21	1.953	55	1.964	38	
222	1.896	1.895	6	1.895	13	1.904	4	
400	1.853	1.852	6	1.853	9	1.860	4	
114	1.845	---	---	---	---	1.855	6	
312	1.836	1.836	3	1.836	4	1.845	4	
303	1.831	1.831	3	---	---	1.841	4	
401	1.807	1.807	5	1.807	5	1.816	3	
320	1.700	1.700	6	1.700	9	1.708	5	
223	1.683	1.683	26	1.683	54	1.691	32	
321	1.664	---	---	---	---	1.672	5	
214	1.651	---	---	---	---	1.660	1	
313	1.641	1.641	3	1.641	3	1.650	5	
410	1.617	1.617	5	1.617	8	1.625	2	
105	1.597	1.598	2	---	---	1.606	4	
411	1.586	1.586	9	1.586	11	1.594	5	
304	1.575	1.575	5	1.575	6	1.584	6	
115	1.528	1.528	6	1.527	8	1.536	21	
412	1.504	1.504	7	1.504	8	1.511	4	
314	1.450	1.450	2	1.449	2	---	---	
323	1.443	1.442	5	1.442	17	1.449	6	
330	1.426	1.426	6	1.426	15	1.433	4	
215	1.412	1.412	2	1.412	2	1.420	2	
420	1.400	1.401	6	1.400	7	1.406	3	
413	1.391	1.391	30	1.391	41	1.397	25	
305	1.364	---	---	---	---	---	---	
006	1.363	1.363	5	1.363	15	1.371	39	
332	1.347	1.347	7	1.347	13	1.353	5	

Plus additional lines, all with $I \leq 12$ *All calculated spacings (Mt. Sektuj) listed for $d \geq 2.000\text{\AA}$.**U.S.N.M. Specimen No. B12207; uniaxial rim of crystal; Chart No. X4097. Diffractometer conditions (for all specimens in this table) are: Cu/K α radiation, $\lambda\text{CuK}\alpha_1=1.540598\text{\AA}$; silicon used as internal standard; scanned at $1/8^\circ$ per minute from $5-120^\circ 2\theta$.

+Specimen No. J5; biaxial rim of crystal; Chart No. X3868.

++Synthetic (OH)-end member; uniaxial; Chart No. X4567.

overlooked on account of these similarities. The indices of refraction of OH-jeremejevite are similar to those reported for some svabites.

SUMMARY

Up to now the chemical composition of natural jeremejevite has been in doubt, with conflicting reports of the presence or absence

of water. Even the B_2O_3 content has been stated to be as much as 6 wt. % higher than is actually present (Strunz & Wilk 1974, Herting & Strunz 1978). Our study shows that most of the confusion arose from the lack of recognition of major fluorine in the mineral. However, we have also established that some hydroxyl ion is indeed present in the mineral. Studies of the synthesis of the mineral are of interest in this connection. It has been known for some time that jeremejevite could not be synthesized in the anhydrous system $Al_2O_3-B_2O_3$ (Gielisse & Foster 1962, Kim & Hummel 1962, Reynaud & Iiyama 1967). We are not aware of any attempt to synthesize F-jeremejevite. On the other hand, jeremejevite had been synthesized in the hydrous system as early as 1949 by Michel-Lévy. Other successful syntheses in the hydrous system are referred to in the introduction to this paper.

Although OH-jeremejevite has not yet been found in nature, there is no reason why it should not occur. Temperatures on the order of $450-700^\circ\text{C}$ and pressures of 4000 kg/cm^2 are required for its synthesis. These temperature and pressure conditions are typical of those encountered in pegmatite systems (Taylor *et al.* 1979).

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