Uvite,

a New (Old) Common Member of the Tourmaline Group and Its Implications for Collectors

by
Pete J. Dunn, Daniel Appleman, Joseph A. Nelen and Julie Norberg
Department of Mineral Sciences
Smithsonian Institution
Washington, D.C. 20560

INTRODUCTION

Tourmaline is a name applied to a group of mineral species consisting of elbaite, dravite, schorl, buergerite and uvite. Although these species all have very similar crystal structures and appearance, they comprise a broad range of chemical compositions. Tourmalines are found in many different environments. They repose in most mineral collections and are popular with collectors because they occur in a variety of colors and because they frequently form euhedral crystals.

The chemistry of the tourmaline group was a cause of much bewilderment to early chemists and mineralogists. This early confusion led Ruskin (1891) to mention in discussing tourmaline, that "on the whole, the chemistry of it is more like a medieval doctor's prescription, than the making of a respectable mineral."

The tourmaline group, until recently, has usually been said to consist of only four species: elbaite, schorl, buergerite and dravite. These conform to the general formula for the tourmaline group: $Na(R)_3Al_6B_3Si_6O_{27}(OH,F)_4$. The above species designations have been made on the basis of the dominant element in the *R* position of the formula, which may be either lithium/aluminum (elbaite), ferrous iron (schorl), ferric iron (buergerite), or magnesium (dravite).

Inasmuch as there is broad and extensive substitution of elements in the tourmaline group, few tourmaline specimens have been found to be pure end-members. Most tourmaline crystals are, in fact, mixtures of two or more species. Iron can exist in either the ferrous or ferric state and is frequently found in both oxidation states within the same crystal. Both simple and coupled substitution mechanisms can also be present simultaneously.

Those tourmalines in which calcium occupies the site usually filled with sodium have been largely ignored.

Dravite crystals with a significant calcium content were reported as early as 1888 (Riggs) but chemists and mineralogists had not yet agreed on a satisfactory formula for tourmaline. High-calcium dravites were ignored in the quest for an ideal formula to encompass the majority of tourmaline analyses. The excellent analyses of Riggs (1888) and his insights into the chemistry of this complex group, coupled with the definitive work of Kunitz (1929), shed much light on tourmaline chemistry and gave us many of the species designations in use today.

In preliminary work, microprobe chemical analyses of many gem quality brown tourmalines showed that they were almost all calcium-rich, and many had little or no sodium. Considering that much dravite is formed in metamorphosed limestones where calcium is abundant, it seemed likely that other dravites might also be calcium-rich. A detailed examination of dravite appeared necessary so the present study was initiated.

Kunitz (1929) proposed a theoretical end-member, $H_8Ca_2Mg_6Al_{10}Si_{12}B_6O_{62}$, which may be rewritten as $\mathbf{CaMg_3(MgAl_5)B_3Si_6O_{27}(OH)_4}$ to conform to the general formula cited previously. Kunitz proposed this molecule to explain the existence of analyses of three calcium-rich magnesium tourmalines from Ceylon, Gouverneur, New York, and DeKalb, New York. He named this proposed theoretical end-member "uvite" for the province of Uva of Ceylon (Sri Lanka).

We have demonstrated that uvite does exist in nature and that is is a valid end-member in the tourmaline group. We have shown that there is complete miscibility between dravite and uvite and that uvite is the exact calcium analog of dravite.

Uvite was submitted to the IMA Commission on New Minerals and New Mineral Names for approval. It was the judgment of the Chairman of the Commission that the term "uvite" was already well-established in the literature, and thus was out of the jurisdiction of the Commisson.

PREVIOUS WORK

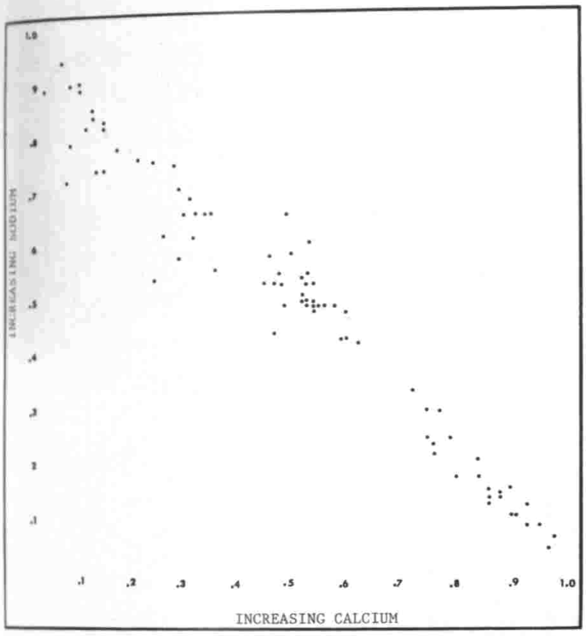
Various investigators have reported calcium-rich magnesium tourmalines. A tabulation of these is presented as Table 1. The analyses are arranged in order of decreasing calcium content. The analysis of Sargent (1901) is anomalous in view of its reported high sodium *and* calcium content.

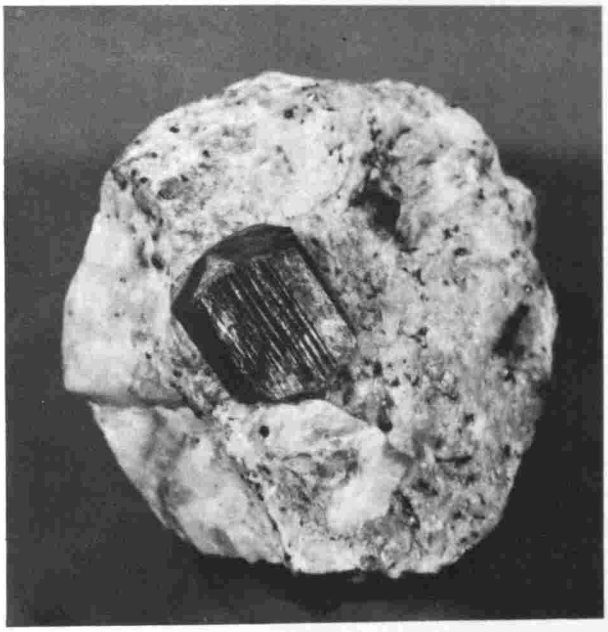
MORPHOLOGY

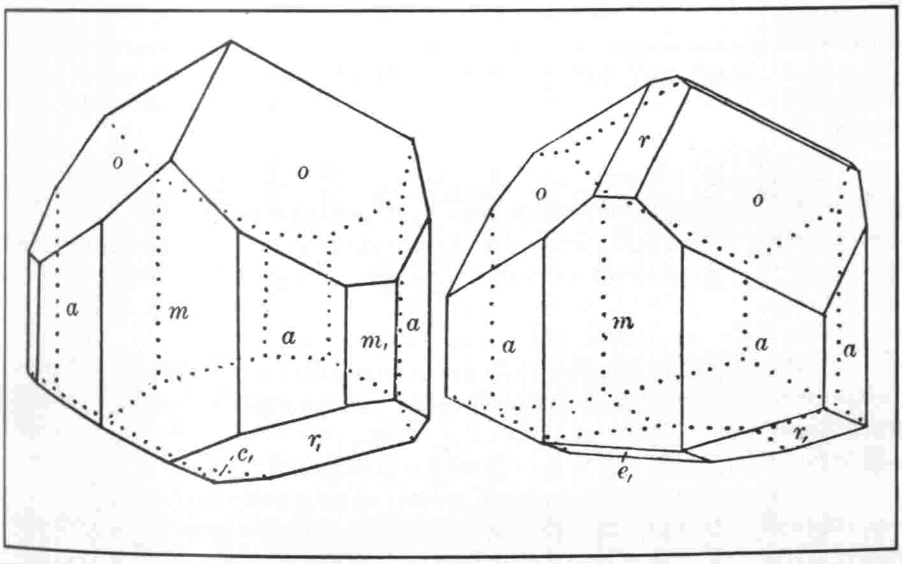
Crystals of uvite do not exhibit any peculiar or diagnostic morphology which might aid in their identification. Forms present, and their relative dominance, are not diagnostic for the species. Uvite crystals of both prismatic and pyramidal habit are found. Ceylon uvite crystals which are quite gemmy are, for the most part, tabular on {0001}, but uvite from Gouverneur, New York, is frequently elongate and pyramidal in habit. Franklin uvite is usually somewhat equant. The Ceylon uvites examined in this study were mostly stream pebbles of gem quality. Fine crystals of brown tourmaline from Ceylon were described by Worobieff (1900) as being very rich in forms, with one crystal having 59 different forms. Additional morphologic observations on magnesium tourmaline were made by Pfaffl and Niggemann (1967) who noted the predominance of the prism {11$\bar{2}$0} over the prism, {$\bar{1}$010} in 70 magnesium tourmalines from Bayrischer Wald, Bavaria, and a reverse relationship in iron-rich tourmalines from Drachselsrieder mine near Arnbruck.

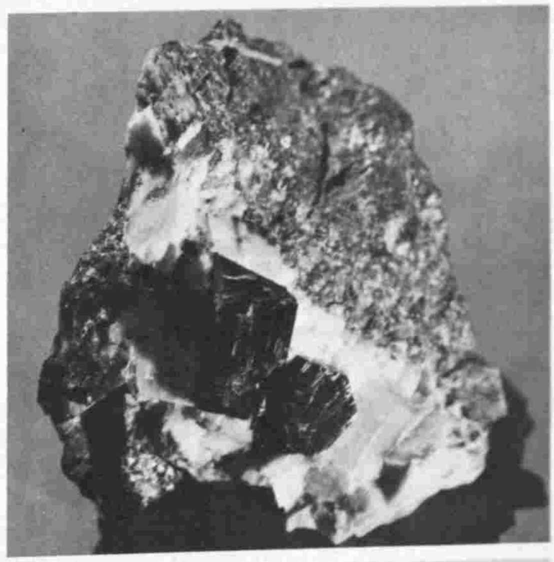
PHYSICAL AND OPTICAL PROPERTIES

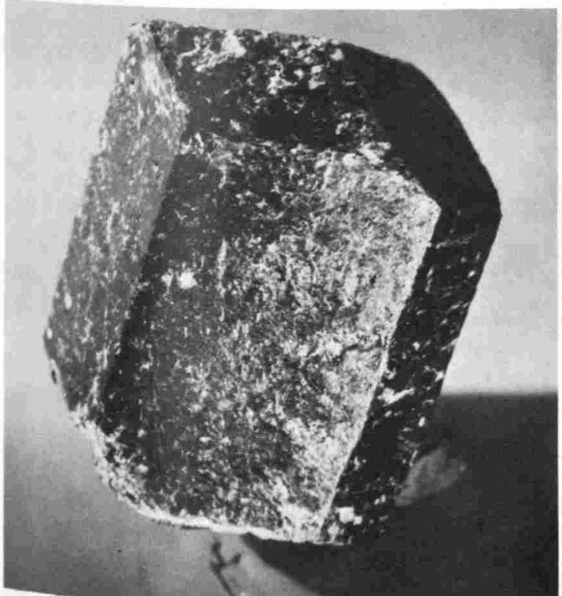
Uvite has a Mohs' hardness comparable to that of dravite (~7½). The density of the purest (most calcium-rich) uvite ranges unsystematically from 2.96 to 3.06. The range is the same for pure (most sodium-rich) dravite. Although calcium is nearly twice as heavy as sodium and one might expect an increase in the density with increasing calcium content (inasmuch as the cell volumes of end-member uvite and end-member dravite are very











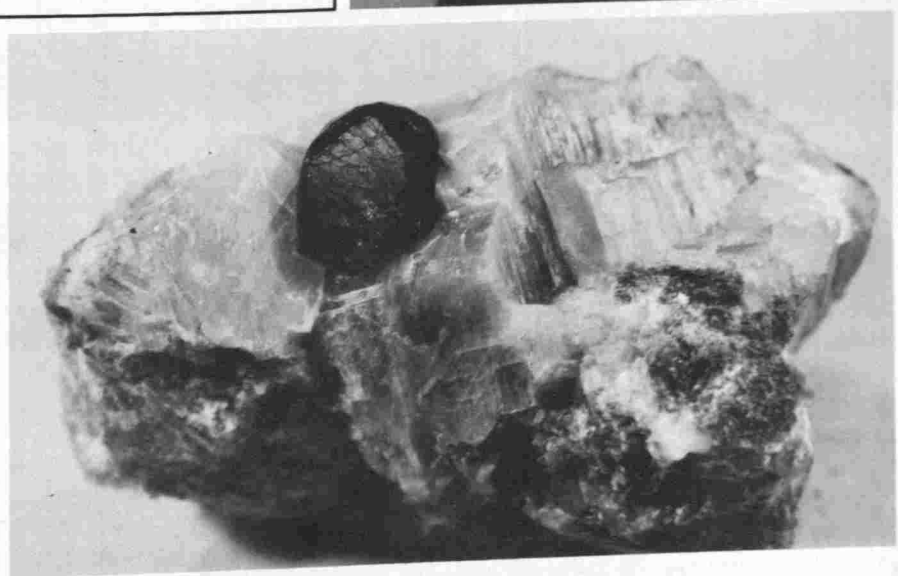


Figure 1. (top left) **Graph of calcium/sodium in atom percent from microprobe analyses.**

Figure 2. (top right) **Light green uvite from Franklin, New Jersey. The crystal is 20 mm in its maximum dimension (NMNH #C3283).**

Figure 3. (middle left) **Line drawings of Franklin uvites [from Palache, (1935)** ***The minerals of Franklin and Sterling Hill, Sussex County, New Jersey.*** **]**

Figure 4. (middle right) **Dravite from Franklin, New Jersey. This crystal has an uncommon habit for Franklin tourmaline, and is the only known dravite from Franklin. The largest crystal is ~ 25 mm (NMNH #R18133).**

Figure 5. (bottom left) **Dravite from Yinniethara, Western Australia (NMNH #R17274).**

Figure 6. (bottom right) **Uvite in calcite from Gouverneur, New York. The crystal is 14 mm in maximum dimension.**

TABLE 1. PREVIOUS ANALYSES OF UVITE

		SiO_2	TiO_2	Al_2O_3	B_2O_3	Fe_2O_3	FeO	MgO	CaO	MnO	K_2O	Na_2O	H_2O	F	Total	Less O≡F	Total	Reference
McAfee, New Jersey		33.72		25.88	10.00	1.82	3.23	14.07	6.92		0.20	2.52	1.80		100.16			Sargent (1901)
Renfrew, Ontario		35.29	0.025	28.93	10.56	2.35	0.70	14.53	5.49		0.22	1.72	0.70	0.84	101.35	0.355	101.00	Bruce (1917)
Dnieper Basin, U.S.S.R.		34.54	0.77	29.05	9.70	4.45	1.0	10.42	5.36		0.12	0.40	4.26		100.07			Dadko (1969)
U.S.S.R.	*u*	36.20	0.34	25.25	10.12	5.32	4.66	10.01	5.33	0.01	0.18	0.36	1.99	0.23	100.00	0.09	99.91	Kornetova (1975)
Ceylon (Sri Lanka)		35.46		29.58	11.36		0.45	14.04	5..13		0.20	0.23	3.55		100.00			Wulfing *et al* (1913)
Hamburg, New Jersey		35.25	0.65	28.49	10.45		0.86	14.58	5.09		0.18	0.94	3.10	0.78	100.37	0.33	100.04	Riggs (1888)
Hnusta, Czechoslovakia	*a,u*	40.20	0.50	25.62	9.65		2.03	12.34	4.85	0.03	0.02	1.47	2.20	0.95	99.89	0.40	99.49	Bouska *et al* (1973)
New Zealand		36.3	2.2	23.1	9.6		12.3	7.8	4.5			1.0			96.8			Black (1971)
Uzbekistan, U.S.S.R.	*b*	37.70	0.15	34.40	10.78	0.71	0.89	10.67	3.60			0.23	0.60		99.89			Dzhamletdinov (1973)
Ceylon (Sri Lanka)	*f,u*	36.51		30.00	10.57		0.74	12.84	3.91		0.54	0.72	4.17		100.00			Wulfing *et al* (1913)
Gouverneur, New York	*c*	35.94	0.79	28.92	10.94	0.43		14.43	3.82	0.01	0.06	1.09	3.07	1.15	100.65	0.48	100.17	Rath (1959)
Uzbekistan, U.S.S.R.	*d*	38.55	0.12	33.28	10.44	0.68	0.92	10.53	4.20			0.40	0.64		99.86			Dzhamaletdinov (1973)
DeKalb, New York		36.88	0.12	28.87	10.58		0.52	14.53	3.70		0.18	1.39	3.56	0.50	100.83			Riggs (1888)
DeKalb, New York	*e,u*	36.72	0.05	29.68	10.81		0.22	14.92	3.49		0.05	1.26	2.98	0.93	101.11	0.39	100.72	Penfield *et al* (1899)
Pierrepont, New York		35.61	0.55	25.29	10.15	0.44	8.19	11.07	3.31	tr	0.20	1.51	3.34	0.27	99.93			Riggs (1888)
Pierrepont, New York		35.86	0.70	22.91	11.46	2.56	6.08	11.06	3.04		0.20	1.19	2.99	0.72	98.77			Dittrich *et al* (1913)
Macomb, New York		37.05	0.56	28.61	10.28	0.44	1.31	13.66	2.97		0.31	1.45	3.05	1.20	100.89			Wulfing *et al* (1913)
Pierrepont, New York		36.64		27.18	9.55		9.08	10.13	2.91		tr	1.50	3.01		100.00			Dana (1892)
Gouverneur, New York	*u,f*	35.96	0.14	30.85	10.73		0.76	13.67	2.41		0.09	1.63	4.16		100.40			Kunitz (1929)
India		36.01	0.77	32.70	10.66		2.59	10.99	2.28	0.03	0.06	1.09	2.72	0.41	100.31	0.17	100.14	Jacob (1938)

a-Contains 0.031 P_2O_5
b-Contains 0.10 V_2O_5 and trace of Li_2O
c-Contains trace of Li_2O
d-Contains 0.01 V_2O_5 and trace of Li_2O
e-Average of two analyses
f-Given in mole percent, recalculated here as weight percent
u-Reported as uvite

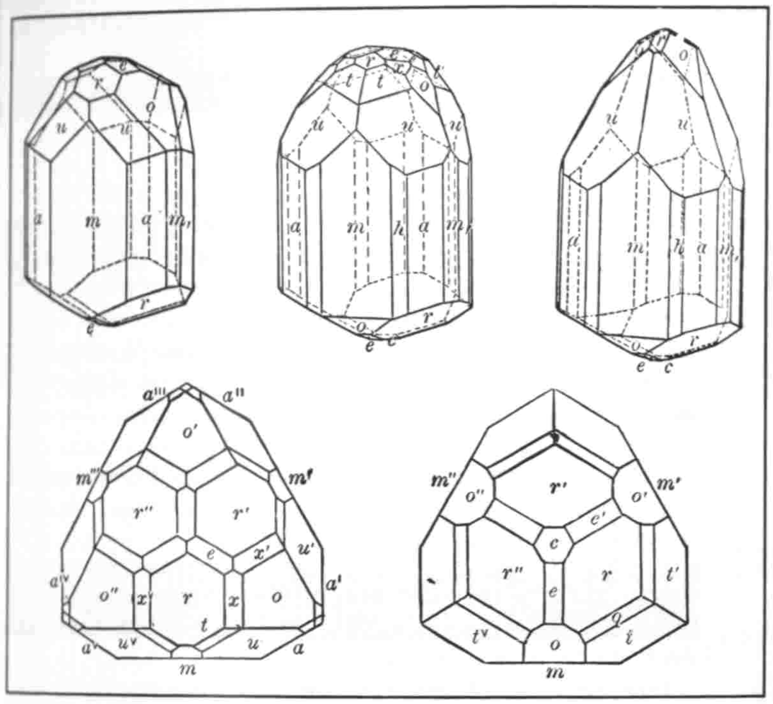


Figure 7. **Line drawings of uvites from Gouverneur, New York [from Dana, (1892)** ***The System of Mineralogy*****, p. 552].**

Figure 8. **White tremolite with brown uvite, Gouverneur, New York. The tremolite crystal is 8.5 cm long. The uvite is 4 cm in its maximum dimension (NMNH #C3287).**

similar), the concomitant substitution of magnesium for aluminum balances this. The net result is that *specific gravity is of no use in the determinative process.* The calculated value for uvite, NMNH C5212, is 3.01 compared with the observed value of 2.97.

The color of uvite is variable. Most uvite, like dravite, is brown. Notable exceptions to this are the colorless DeKalb, New York, material and the light green crystals from Franklin, New Jersey, both of which have very low iron content. In general, brown uvites demonstrate a correlation between color and iron content, the color darkening with increasing iron to near opacity when the iron content exceeds 0.8%. The same relationship exists in dravite, supporting the observations of Slikvo (1957), who suggested that the chromophore causing brown color in tourmaline was Fe^{+3}.

Uvite is uniaxial negative, absorption $\omega > \epsilon$. The streak is variable; light green, light brown, or white. The refractive indices of uvite do not differ from those of dravite and are thus of no use in determining the species. Although Kunitz (1929) did present a graph of variation of refractive indices with increasing calcium/sodium ratio, his observations have not been supported by the present study and his observed range in values may have been influenced by iron substituting for magnesium or aluminum in his samples. Since the refractive indices of tourmalines increase with increasing iron and manganese content (Deer *et al.*, 1962), samples were chosen for optical examination which had a very low iron content (<0.41%FeO) and which varied from 95% to 51% of the uvite end-member. Dravites with comparable low-iron contents were not found. The refractive indices of these uvites are presented in Table 2.

Both uvite and dravite, when low in iron content, fluoresce a weak mustard yellow color under short-wave ultraviolet radiation. There is no response in long-wave ultraviolet, and no phosphorescence in either wavelength.

Uvite and dravite, therefore, are indistinguishable on the basis of their physical and optical properties.

CHEMISTRY

General

Uvite, $CaMg_3(Al_5Mg)B_3Si_6O_{27}(OH,F)_4$, is the calcium analog of dravite, $NaMg_3Al_6B_3Si_6O_{27}(OH,F)_4$, and is thus an end-member in the tourmaline group.

The substitution of divalent calcium (Ca^{+2}) for monovalent sodium (Na^{+1}) in magnesium tourmaline requires a coupled substitution. There is a concomitant increase in divalent magnesium (Mg^{+2}) substituting for trivalent aluminum (Al^{+3}) to provide electrostatic charge balance. Magnesium tourmalines with Ca > Na are thus uvite and those with Na > Ca are dravite.

Eighty magnesium tourmalines in the mineral collection of the National Museum of Natural History (Smithsonian Institution) were partially analyzed with an ARL-SEMQ electron microprobe utilizing an operating voltage of 15 kV and a sample current of 0.15 μA and NMNH microprobe standards of high reliability. Of the 80 samples analyzed, 43 were uvite and 37 were dravite. This ratio is not necessarily indicative of the natural abundance of these species as the samples were chosen in a search for the calcium-rich member. These are partial analyses. The boron, water and fluorine contents were not determined. All iron is calculated as FeO since it was determined as total iron. The analyses are presented as Table 3, in order of decreasing calcium content. Three samples were subjected to complete wet-chemical analysis and the results of these analyses are presented as Table 4. These compare closely with the theoretical values given in Table 5 for end-member uvite. Following the suggestion of Barton (1969) the "excess" boron over 3.0 atoms per formula unit is assumed to be substituting for Si in the tetrahedral six-membered rings; the total of silicon plus excess boron should be 6.0 atoms per formula unit in the ideal structure. The numbers of atoms per formula unit (Table 4) have been computed directly from the analyses, including OH and F, on the basis of 31 (O, OH, F) per formula unit. However, the errors in the H_2O and F determinations are probably sufficient to allow for enough adjustment of the O:(OH, F) ratios to achieve complete charge balance.

Wet Analytical Procedures

Reduction of sample size was done first in an iron percussion mortar to -40 mesh, followed by further grinding in a tungsten carbide mill to -160 mesh.

Moisture, SiO_2, Al_2O_3, FeO, CaO and MgO were determined on 0.5 g portions by classical chemical methods. (Peck, 1964).

Prior to filtration of silica, boron was volatilized by repeated dehydration with a HCl-methanol mixture (Hillebrand *et al*, 1953). Iron in the R_2O_3 portion was determined using O-phenanthroline, titanium as the tiron complex; aluminum was precipitated with 8-hydroxyquinoline (Jarosewich, 1966).

For total water the Penfield method (Peck, 1964) was used, the H_2O^+ being the difference between total water and moisture.

For fluorine 0.2 g samples were fused with ZnO-Na_2CO_3 flux and filtered (Grimaldi *et al*, 1955). The fluorine in the filtrate was distilled using a constant temperature distilling apparatus (Huckabay *et al*, 1947) and titrated with thorium nitrate.

Alkali content was determined flame photometrically after sample decomposition with HF-H_2SO_4.

Boron was titrated with NaOH and mannitol after removal of interfering substances and neutralization. Precision of the method was $\pm 0.2\%$ B_2O_3 on NBS 93 (a 12.76% borosilicate glass).

Miscibility

Within the tourmaline group there is miscibility between schorl and elbaite and between schorl and dravite (Epprecht, 1953). Little evidence exists for miscibility between dravite and elbaite. The dravite analyses of this study support earlier evidence of miscibility between schorl and dravite. The analyses of Tables 3 and 4 clearly demonstrate that there is complete miscibility between uvite and dravite. The CaO content varies smoothly from 5.86% to 0.03% (1.00 to 0.05 calcium in atom percent) while the Na_2O content sympathetically varies from 0.08% to 2.92% (0.02 to 0.94 sodium in atom percent). The concomitant adjustment in aluminum and magnesium, although not as gradual, is also clearly demonstrated. The less-smooth variation in the aluminum-magnesium ratios is likely due to the fact that available iron can substitute in either the divalent or trivalent site. Figure 1 is a graph of calcium vs. sodium (in atom percent) for the uvite and dravite analyses of this study. This graph demonstrates complete miscibility between the end-members, with no gaps in the solid solution series.

TABLE 2
OPTICAL DATA FOR SELECTED LOW-IRON UVITES

NMNH #	Locality	ϵ	w	% Uvite
C5212	Ceylon (Sri Lanka)	1.619	1.638	98
B14707	DeKalb, New York	1.620	1.638	90
C3290	DeKalb, New York	1.620	1.634	72
B14698	DeKalb, New York	1.620	1.634	54
R3958	DeKalb, New York	1.620	1.636	53

All observations in sodium light (± 0.003). Samples arranged in order of decreasing calcium content. All samples have less than 0.41 % FeO.

CRYSTALLOGRAPHY

Uvite fragments from sample C5212 were studied by single-crystal x-ray diffraction techniques. Long-exposure zero-level, upper-level and cone-axis precession photographs showed no deviation from space group *R3m*, the usual tourmaline symmetry. Cell dimensions were determined from single-crystal measurements to be: a = 15.88 Å, c = 7.17 Å. These parameters were adjusted by least-squares indexing and refinement of powder-diffraction data. Using the program of Appleman *et al*, (1973). The refined parameters are a = 15.981 ± 0.002 Å, c = 7.207 ± 0.001 Å (Si standard). These values fall precisely on the schorl-dravite series cell-dimension plots (Epprecht, 1953). Uvite cannot, therefore, be distinguished readily from dravite by x-ray diffraction methods, short of a complete structure determination. Indexed X-ray powder diffraction data for uvite (#C5212) has been deposited with the *Joint Committee on Powder Diffraction Standards* (JCPDS).

NEOTYPE UVITE

The uvite examined by Kunitz, if he did indeed examine a specific specimen, has long been lost. Therefore, one of the samples in this study has been designated as neotype uvite. The neotype material is a gem fragment from Ceylon (C5212) and is half of a gemstone originally weighing 20.05 carats. This specimen is one of the three which have been wet-chemically analyzed. It was chosen because it is from Ceylon, whence uvite was named, because its composition is similar to the analysis (Wulfing, 1913) cited by Kunitz, and because it is a single crystal, ideally suited to further mineralogical and crystallographic studies. Fragments of neotype uvite will be distributed to the British Museum (Natural History) and the major part will be deposited in the National Museum of Natural History, Smithsonian Institution, Washington, D.C., under catalog number C5212.

NOTES FOR COLLECTORS AND CURATORS ON SPECIFIC LOCALITIES

FRANKLIN, NEW JERSEY

Fine specimens of both brown and light green magnesium tourmaline have been found at this locality for many years, and are in most major mineral collections today. Although the tourmalines are not found in the zinc orebody, they are common in the white calcite marble of the Franklin area, and especially at the Fowler quarry (Palache, 1935). They are notable for their size, development of forms (Figures 2 and 3), and the lovely specimens resulting from the contrast with the white marble in which they repose.

Fifteen specimens from Franklin were examined in this study and were chosen to represent the various colors and habits of the Franklin material. Fourteen of the fifteen specimens are uvite and contain 75 to 100% of the uvite end-member. The light brown, dark brown, light green, and rich green crystals are all calcium-rich, but no one color more so than the others. The light green Franklin uvites have a much lower iron content than the brown crystals, but the cause of the green color is unexplained.

The only sodium-rich crystal (dravite) from Franklin is a rather unique specimen on exhibit in the Hall of Minerals at the Smithsonian (R18133). This crystal (Figure 4) has a very dark brownish-green color and notable morphology; the crystal is comprised of a trigonal prism {10$\bar{1}$0} and pedion {0001} with only slight pyramidal modifications. This crystal is quite unlike the common Franklin uvites which are highly modified and frequently equant in habit.

Inasmuch as zinc is found in most Franklin minerals, it was sought for in the analyses of this study. Zinc impurities were negligible and did not exceed 0.05% in any of the specimens. This is not too surprising as the uvites are not found in the zinc orebody but in the marbles of the area.

HAMBURG, NEW JERSEY

This uvite locality was known as Rudeville in the older literature and crystals from here are referred to by Palache (1935). Here, as at Gouverneur, New York, the uvites are associated with tremolite crystals, in calcite. Crystals from Hamburg were described by Eakle (1894). Six specimens from this locality were analyzed and all have calcium greater than sodium and are thus uvite.

YINNIETHARA, WESTERN AUSTRALIA

Sizable brown crystals, up to 15 cm, of equant to prismatic habit from this locality, have been on the specimen market for many years now. (Figure 5). The 3 analyses of this study demonstrate that these brown crystals have Na>Ca and are thus dra-

TABLE 3. PARTIAL MICROPROBE ANALYSES OF UVITE AND DRAVITE

	NMNH #	SiO_2	Al_2O_3	FeO	MgO	CaO	Na_2O	TiO_2	TOTAL %	UVITE	COLOR	LOCALITY
Uvite	C5212	36.08	27.02	0.54	15.39	5.50	0.23	0.58	85.34	98	Brown	Sri Lanka (Ceylon)
Uvite	B14687	35.28	27.48	0.21	15.63	5.46	0.14	0.28	84.48	97	Green	Franklin, New Jersey
Uvite	C6735	36.16	25.33	0.52	15.71	5.30	0.28	0.59	83.89	95	Brown	Franklin, New Jersey
Uvite	R18132	35.39	27.30	0.44	15.34	5.21	0.41	0.49	84.58	93	Brown	Franklin, New Jersey
Uvite	82273	35.80	26.52	0.11	15.61	5.19	0.28	0.09	83.60	93	Green	Franklin, New Jersey
Uvite	C6726	35.25	27.05	0.21	15.28	5.08	0.33	0.19	83.55*	91	Green	Franklin, New Jersey
Uvite	B14707	36.27	27.18	0.33	15.54	5.06	0.49	0.19	85.06	90	Brown	De Kalb, New York
Uvite	B14682	35.12	28.09	0.29	15.00	5.04	0.35	0.35	84.24	90	Brown	Franklin, New Jersey
Uvite	B14688	35.76	26.74	0.80	15.50	4.96	0.46	0.29	84.51	88	Brown	Hamburg, New Jersey
Uvite	R18134	35.62	28.23	1.23	14.31	4.93	0.47	0.36	85.15	88	Brown	Hamburg, New Jersey
Uvite	106906	35.98	27.21	0.79	14.64	4.84	0.43	0.22	84.27*	86	Brown	Horicon, New York
Uvite	134441	35.45	26.28	0.81	14.72	4.82	0.40	0.20	82.84*	86	Brown	Franklin, New Jersey
Uvite	C6728	34.81	28.83	0.48	14.47	4.80	0.51	0.17	84.07	86	Brown	Gouverneur, New York
Uvite	118110	34.97	27.51	0.41	14.76	4.71	0.56	0.16	83.08	84	Brown	Horicon, New York
Uvite	B14684	35.81	28.42	0.28	14.40	4.54	0.65	0.28	84.38	81	Green	Franklin, New Jersey
Uvite	B14691	35.42	26.92	0.33	15.38	4.50	0.56	0.19	83.30	80	Brown	Franklin, New Jersey
Uvite	C6729	35.49	27.62	0.90	14.51	4.42	0.77	0.20	83.17*	79	Brown	Hamburg, New Jersey
Uvite	118651	35.77	27.54	0.22	14.51	4.32	0.92	0.21	85.49	77	Green	Franklin, New Jersey
Uvite	C6730	34.63	29.85	1.00	13.42	4.25	0.74	0.46	84.51*	76	Brown	Hamburg, New Jersey
Uvite	C6727	34.86	28.95	0.19	14.09	4.24	0.69	0.28	83.30	76	Green	Franklin, New Jersey
Uvite	C6731	33.74	30.27	1.06	13.18	4.22	0.77	0.40	83.6	75	Brown	Hamburg, New Jersey
Uvite	B14686	36.20	27.10	2.34	13.13	4.18	0.92	0.56	84.43	75	Brown	Franklin, New Jersey
Uvite	C3290	36.51	27.81	0.21	15.12	4.06	1.05	0.15	84.91	72	White	De Kalb, New York
Uvite	B14700	35.90	28.96	0.42	13.86	3.40	1.31	0.18	84.03	61	Brown	Macomb, New York
Uvite	134439	36.28	28.33	0.33	14.27	3.35	1.48	0.72	84.76	60	Brown	Gouverneur, New York
Uvite	104379	36.08	27.65	0.30	14.59	3.34	1.33	0.59	83.88	60	Brown	Gouverneur, New York
Uvite	R18135	36.02	27.73	0.40	14.14	3.31	1.35	0.69	83.64	59	Brown	Hamburg, New Jersey
Uvite	R18116	35.75	29.35	0.22	13.77	3.25	1.53	0.09	83.96	58	White	De Kalb, New York
Uvite	B14694	36.05	30.32	0.20	13.81	3.15	1.54	0.09	85.16	56	White	De Kalb, New York
Uvite	B14696	36.07	29.15	0.24	13.78	3.12	1.49	0.10	83.95	56	White	De Kalb, New York
Uvite	R18136	36.54	27.76	0.35	14.45	3.07	1.54	0.97	84.68	55	Brown	Gouverneur, New York
Uvite	R14705	36.12	30.46	0.22	13.45	3.03	1.54	0.09	84.91	54	White	De Kalb, New York
Uvite	R3453	35.93	28.78	7.83	10.39	3.01	1.58	0.33	87.85	54	Black	Pierrepont, New York
Uvite	B14698	35.85	30.13	0.23	13.25	3.00	.156	0.09	84.11	54	White	De Kalb, New York
Uvite	134440	35.67	27.26	1.69	13.07	2.99	1.71	0.64	83.13	53	Brown	Macomb, New York
Uvite	R3958	35.69	29.72	0.19	13.66	2.97	1.54	0.10	83.87	53	White	De Kalb, New York
Uvite	C3290-2	36.55	30.12	0.21	13.34	2.96	1.51	0.09	84.78	53	White	De Kalb, New York
Uvite	82279	35.98	28.60	0.36	13.91	2.95	1.58	1.08	84.46	53	Brown	Gouverneur, New York
Uvite	B16254	34.00	23.42	12.16	7.93	2.95	1.89	0.98	83.33	53	Black	Santa Cruz., Sonora, Mexico
Uvite	116996	34.79	24.14	8.84	9.71	2.93	1.55	0.66	82.62	52	Black	Pierrepont, New York
Uvite	C6733	35.71	25.95	7.58	10.35	2.91	1.56	0.34	84.40	52	Black	Pierrepont, New York
Uvite	B14680	36.46	27.54	0.36	13.83	2.89	1.67	1.21	83.96	52	Brown	Gouverneur, New York
Uvite	116454	36.82	28.32	0.58	14.15	2.83	1.83	0.31	84.84	50	Brown	Canton, New York
Dravite	80879	36.15	28.12	0.32	14.21	2.74	1.74	1.21	84.49	49	Brown	Gouverneur, New York
Dravite	78719	36.25	27.26	0.37	13.95	2.73	1.53	1.21	83.30	49	Brown	Gouverneur, New York
Dravite	B14681	35.97	28.87	0.49	13.69	2.70	1.65	1.48	84.85	48	Brown	Gouverneur, New York
Dravite	48280	36.58	28.36	1.66	12.87	2.67	1.71	0.74	84.59	48	Brown	Macomb, New York
Dravite	48279	35.39	25.70	7.70	10.41	2.66	1.66	0.46	83.98	47	Black	Pierrepont, New York
Dravite	48283	36.82	28.61	0.85	13.87	2.54	1.81	0.39	84.89	46	Brown	De Kalb, New York
Dravite	C6733	35.13	25.88	7.29	10.31	2.53	1.67	0.32	83.13	45	Black	Pierrepont, New York
Dravite	103488	36.06	31.89	0.31	11.49	2.48	1.45	0.65	84.48**	44	Brown	Texas, Maryland
Dravite	R3959	36.28	31.99	0.64	11.73	2.04	1.73	0.49	84.90	36	Brown	Kingsbridge, New York
Dravite	R7084	34.74	21.71	13.43	7.95	1.98	2.05	1.29	82.65	35	Black	Snarum, Norway
Dravite	R18118	34.85	21.14	13.05	8.01	1.90	2.04	1.36	82.35	34	Black	Snarum, Norway
Dravite	R17268	35.14	30.13	4.24	9.65	1.86	1.91	0.11	83.04	33	Black	Yinniethara, Australia
Dravite	R16248	35.44	26.72	9.62	8.41	1.79	2.06	0.63	84.67	32	Black	Santa Cruz, Sonora, Mexico
Dravite	R18117	35.20	26.08	11.25	7.26	1.73	2.13	0.63	84.28	31	Black	Kjenlid, Arundel, Norway
Dravite	R17267	33.92	26.93	10.52	6.60	1.70	2.05	1.01	85.73	30	Black	Yinniethara, Australia
Dravite	R18133	35.86	30.73	0.91	11.88	1.63	1.81	0.20	84.18*	29	Green	Franklin, New Jersey
Dravite	R7083	35.92	23.58	13.03	8.10	1.61	2.21	1.18	85.63	29	Black	Fredriksvarn, Norway
Dravite	4025	34.50	26.48	9.20	8.23	1.56	2.32	0.92	83.21	28	Green	Lambertville, New Jersey
Dravite	B20711	35.65	31.72	1.95	10.65	1.44	1.90	0.30	83.61	26	Brown	Sri Lanka (Ceylon)
Dravite	80575	35.38	32.32	2.66	9.88	1.36	2.36	0.78	84.74	24	Brown	Colfax, California
Dravite	B14539	34.10	31.94	7.91	5.62	1.32	1.69	1.03	83.77*	24	Black	Cyrilov, Moravia, Czechoslovakia
Dravite	44572	35.54	32.41	1.68	9.95	1.16	2.35	0.47	83.56	21	Brown	Orford, New Hampshire
Dravite	B14566	34.69	27.03	9.95	7.06	0.96	2.42	0.83	83.04	17	Black	Simplon Tunnel, Switzerland
Dravite	133607	35.57	28.66	5.89	9.42	0.81	2.57	0.51	83.63	14	Black	Bjordam, Bamble, Norway
Dravite	96761	35.97	32.73	4.81	8.20	0.79	2.29	0.30	85.09	14	Gray	Alabama
Dravite	103791	36.12	33.26	0.23	11.59	0.76	2.53	0.27	84.76	14	Brown	Dobrawa, Carinthia, Austria
Dravite	C3282	35.20	31.06	5.34	8.35	0.72	2.30	0.42	83.39	13	Black	Warren, New Hampshire
Dravite	122399	35.86	30.89	2.77	10.08	0.70	2.61	0.85	83.76	12	Brown	Baltimore County, Maryland
Dravite	B14541	36.55	33.25	0.30	11.08	0.69	2.63	0.27	84.77	12	Brown	Prevali, Carinthia, Austria
Dravite	B14708	36.68	32.95	0.20	11.20	0.56	2.62	0.23	84.44	10	Brown	Dobrawa, Carinthia, Austria
Dravite	B14542	36.76	33.17	0.28	11.22	0.52	2.69	0.30	84.94	9	Brown	Prevali, Carinthia, Austria
Dravite	R17272	35.44	31.29	0.61	11.28	0.52	2.69	0.79	82.62	9	Brown	Yinniethara, Australia
Dravite	92824	35.69	32.96	3.52	8.60	0.42	2.46	0.21	83.86	7	Brown	Carinthia, Austria
Dravite	R17274	36.24	32.36	0.46	11.05	0.38	2.80	0.81	84.10	7	Brown	Yinniethara, Australia
Dravite	R10375	34.96	32.02	9.98	4.86	0.34	2.24	0.28	84.68	6	Black	Plumas County, California
Dravite	R17273	36.85	32.57	0.38	11.45	0.28	2.92	0.77	85.22	5	Brown	Yinniethara, Australia
Dravite	126030	36.47	31.75	4.17	9.27	0.03	2.77	0.25	84.71	1	Red	Narok District, Kenya

Unless otherwise noted, all analyses contain less than 0.05 ZnO or MnO and less than 0.10 K_2O or Cr_2O_3.
*Contains 0.10 to 0.18 Cr_2O_3.
**Contains 0.15% K_2O.
Analyst: Pete J. Dunn

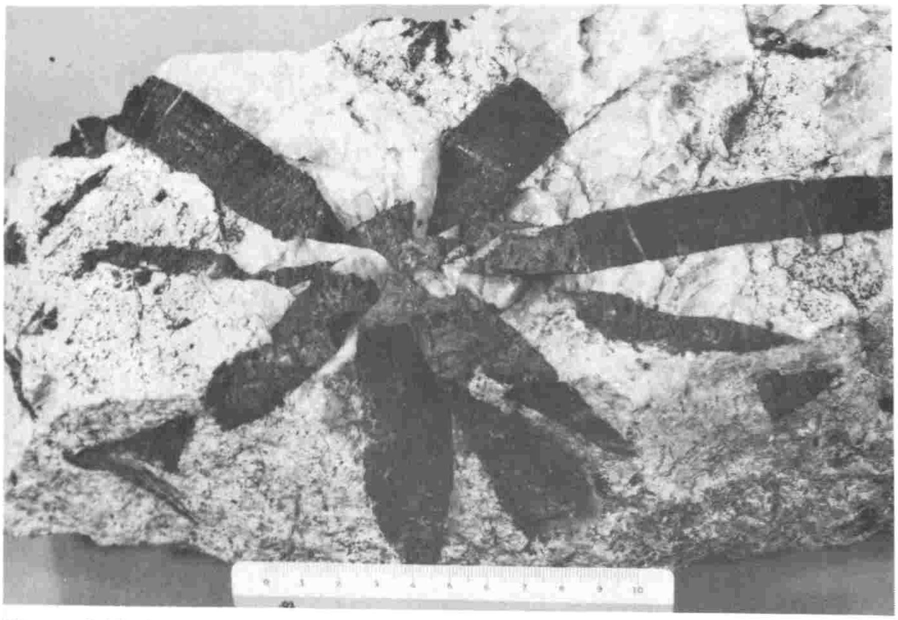


Figure 9. **Radiating dravite from near DeKalb, New York. The scale is in centimetres. The crystal is 7.5 cm long (NMNH #48283).**

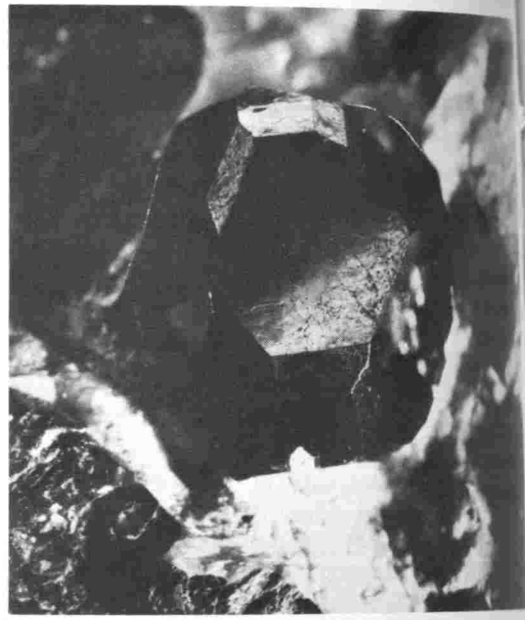


Figure 10. **Uvite from Pierrepont, New York. The crystal is 28 mm in its maximum dimension. (NMNH #C6733).**

vite, and that the composition varies only slightly from crystal to crystal.

GOUVERNEUR, NEW YORK

Next to Franklin, the locality that has produced the most prodigious amount of excellent uvite specimens is Gouverneur, New York. The locality is an old one and was noted by Beck (1842). The uvite crystals, (Figures 6,7 and 8) are found associated with tremolite, apatite, and scapolite in calcite and attain sizes in excess of 10 cm. The tremolite is noteworthy as the crystals are of simple morphology and range from microscopic to lengths exceeding 8 cm (Figure 8). Nine specimens of brown tourmaline from this locality were examined. Six of the nine examined are uvite, as are the two previously reported analyses in the literature (Table I). The remaining three, although they have sodium greater than calcium, are near the midpoint in the series, containing between 48% and 49% of the uvite end-member.

DEKALB, NEW YORK

Long noted for the colorless to light brown tourmaline that is found here, DeKalb has also the added distinction of producing the most iron-free uvites known. Nine specimens of the colorless to white tourmaline were analyzed and all have Ca>Na. The samples contain from 53% to 90% of the uvite end-member. The two previous analyses from the literature (Table I) are also of calcium-rich members.

One sample, #48283, reported to be from DeKalb, is quite unlike the common DeKalb colorless uvites. This specimen consists of radiating sunbursts of 10-15 cm brown crystals in limestone (Figure 9). This material is dravite.

HORICON, NEW YORK

Located at the northwest end of Branch Lake, this locality has produced some exquisite specimens of uvite in calcite. The rich dark brown crystals are stout, prismatic and average about 1 x 10 cm. Two samples from the U.S. National Collection were analyzed and have 86% of the uvite end-member.

NOTES ON BLACK TOURMALINE FROM SPECIFIC LOCALITIES

Black tourmaline from several classic localities, known for calcium minerals, was examined in search of a possible calcium-rich iron tourmaline. None was found, but purported schorl from some localities is magnesium-rich and thus dravite or uvite. Comments on some of these localities follow. "Schorls" from albitic pegmatites were not analyzed in the study as they should be sodium-rich.

PIERREPONT, NEW YORK

Exquisite, sharp, and well-formed crystals of black tourmaline (Figures 10 and 11) have been found here since the original description of 3 inch black crystals by Finch (1830). The crystals are quite lustrous, frequently tabular on {0001}, and have a morphology complex enough to have warranted a description by Solly (1884). Five crystals from the Smithsonian collection were analyzed. The magnesium content is greater than the iron content and thus Pierrepont black tourmalines are not schorl. The three analyses from the literature, and three of the five analyses of this study have Ca>Na. The preponderance of analyzed Pierrepont black tourmalines are uvites and, for consistency, it is recommended that all Pierrepont black tourmaline be labelled uvite.

The oxidation state of the iron in Pierrepont uvite is not definitively resolved as the microprobe cannot distinguish between Fe^{+2} and Fe^{+3}. However, the analyses of Dittrich *et al.* (see Table 1) and Kalb (see Doelter *2*, 2, page 751, Anal. 11) of Pierrepont uvite contain 2.56% and 3.90% Fe_2O_3 respectively, plus appreciable ferrous iron. An assumption that the iron content of Pierrepont uvite is partially ferric is also supported by the relatively low aluminum content of the analyses of this study. This low aluminum content strongly suggests that part of the iron is held in the trivalent position in substitution for aluminum.

SNARUM, NORWAY

Four crystals from two specimens of black tourmaline associated with calcite were analyzed. The specimens have Na>C[a] and are magnesium-rich. They are dravite. As in the Pierrepont uvite, the aluminum content is very low, suggesting that part of the iron is ferric.

YINNIETHARA, WESTERN AUSTRALIA, AUSTRALIA

Fine black euhedrons imbedded in mica have come from th[is] classic Australian locality in recent years. Although less abu[n]dant on the specimen market than the more common brown dr[a]vites, they are available in adequate supply. Two crystals fro[m] the Smithsonian collections were analyzed and both are ma[...]

nesium-rich and thus are ferroan dravites. The iron content of these crystals varies considerably but the calcium:sodium ratio is about the same. These black dravites have a higher calcium content than the brown dravites from the same locality. A representative crystal is shown in Figure 12.

SUMMARY

In summation, uvite is a rather common mineral. It is abundant at various localities and fine specimens already grace most major, and many minor, mineral collections. In general, brown tourmalines from metamorphosed limestones are usually uvite.

Although the above statements might sit somewhat uncomfortably with collectors long since used to the convention wherein all black tourmalines are schorl, and all brown tourmaline is dravite, mineral names represent chemical compositions, and the correct nomenclature is as follows:

Dravite - magnesium tourmaline with sodium greater than calcium.

Uvite - magnesium tourmaline with calcium greater than sodium.

In terms of attractive mineral specimens, dravite is considerably less abundant than uvite. Most of the famous American localities for magnesium tourmaline contain uvite and not dravite as was formerly understood.

Table 4. Wet Chemical Analyses of Uvite

	Franklin, N.J. B14687	Ceylon C5212	Franklin, N.J. C3285
SiO_2	35.45	35.96	36.52
Al_2O_3	27.30	26.80	26.76
FeO	0.07	0.41	0.38
MgO	15.16	15.20	15.29
CaO	5.86	5.50	5.18
Na_2O	0.08	0.13	0.17
K_2O	0.00	0.00	0.00
H_2O^+	2.53	2.70	2.68
H_2O^-	0.02	0.04	0.02
TiO_2	0.30	0.62	0.32
Li_2O	0.00	0.00	0.00
B_2O_3	11.39	11.49	11.34
F	2.10	1.49	1.79
Total	100.26	100.34	100.45
Less O = F_2	0.88	0.63	0.75
	99.38	99.71	99.70

Number of Atoms on the Basis of 31 (O, OH, F)

	B14687		C5212		C3285	
Si	5.688		5.784		5.847	
B	3.155		3.190		3.134	
Al	5.163	8.834	5.081	8.856	5.050	8.789
Fe	0.009		0.055		0.051	
Mg	3.626		3.645		3.649	
Ti	0.036		0.075		0.039	
Ca	1.007	1.032	0.948	0.989	0.889	0.942
Na	0.025		0.041		0.053	
H	2.707	3.773	2.896	3.654	2.862	3.768
F	1.066		0.758		0.906	
Si+(B-3.00)	5.84		5.97		5.98	

Analysts: J. Nelen
J. Norberg

TABLE 5. THEORETICAL COMPOSITIONS OF UVITE AND DRAVITE

	Uvite	Dravite
SiO_2	37.07	37.62
Al_2O_3	26.19	31.90
B_2O_3	10.72	10.88
MgO	16.56	12.62
CaO	5.76	
Na_2O		3.23
H_2O	3.70	3.75
TOTAL	100.00	100.00

It is hoped that the above correct species designations for magnesium tourmalines from specific localities will be of assistance to collectors and curators alike. It is neither possible nor desirable, however, to examine specimens of magnesium tourmalines for collectors to ascertain correct species designations for obscure localities. In general, *most* brown tourmaline associated with calcium minerals is uvite, and *most* brown tourmaline associated with schist and non-pegmatite micas, is dravite.

The authors are indebted to great mineral collectors. Without the Canfield, Roebling, and Bosch mineral collections of the Smithsonian Institution, this study might have taken many years of specimen gathering, instead of one week. Of the 89 specimens analyzed in this study, 59 came from the above mentioned collections. Their contributions were invaluable. The authors are also indebted to Akira Kato for calling their attention to the work of Bouska *et al*, Dadko, and Dzhamaletdinov, and to John S. White, Jr., for a critical reading of the manuscript. Thanks are also due Michael Fleischer for a translation of Kornetova's work, and Clifford Frondel for helpful suggestions.

REFERENCES

APPLEMAN, D.E., EVANS, H.T. Jr., and HANDWERKER, D.S. (1972) Job 9214; Indexing and least squares refinement of powder diffraction data. *U.S. Geological Survey Computer Contr. 20: Springfield, Virginia.* National Technical Information Service.

BARTON, R. (1969) Refinement of the crystal structure of buergerite and the absolute orientation of tourmalines. *Acta. Cryst.* **B25**, 1524-1533.

BECK, L.C. (1842) *Mineralogy of New York.* D. Appleton & Co. and Wiley & Putnam, New York, 356-360.

BLACK, P.M. (1971) Tourmalines from Cuvier Island, New Zealand. *Min. Mag.* **38**, 374-376.

BOUSKA, V., POVONDRA, P., LISY, E. (1973) Uvit z Hnuste. *Acta. Univ. Carolinae*, #3, 163-170.

BRUCE, E.L. (1917) Magnesian tourmaline from Renfrew, Ontario. *Min. Mag.* **18**, 133-135.

DADKO, A.D. (1969) Tourmaline from the weathering crust of ultrabasic rocks of the Dneiper Basin. *Min. Sbornik*, **23**. 192-195.

DANA, E.S. (1892) *The System of Mineralogy*, 6th Ed., 554, Analysis #35.

DARRAGH, P.J., GASKIN, A.J. and TAYLOR, A.M. (1967) Crystal growth: gemstones. Commonwealth Sci. Industr. Res. Organization, Australia. *Divn. Appl. Min. Ann. Rept.* (1966-1967)8.

DEER, W.A., HOWIE, R.A., and ZUSSMAN, J. (1962) *Rock Forming Minerals,* **1**, 300-319, Longman, London.

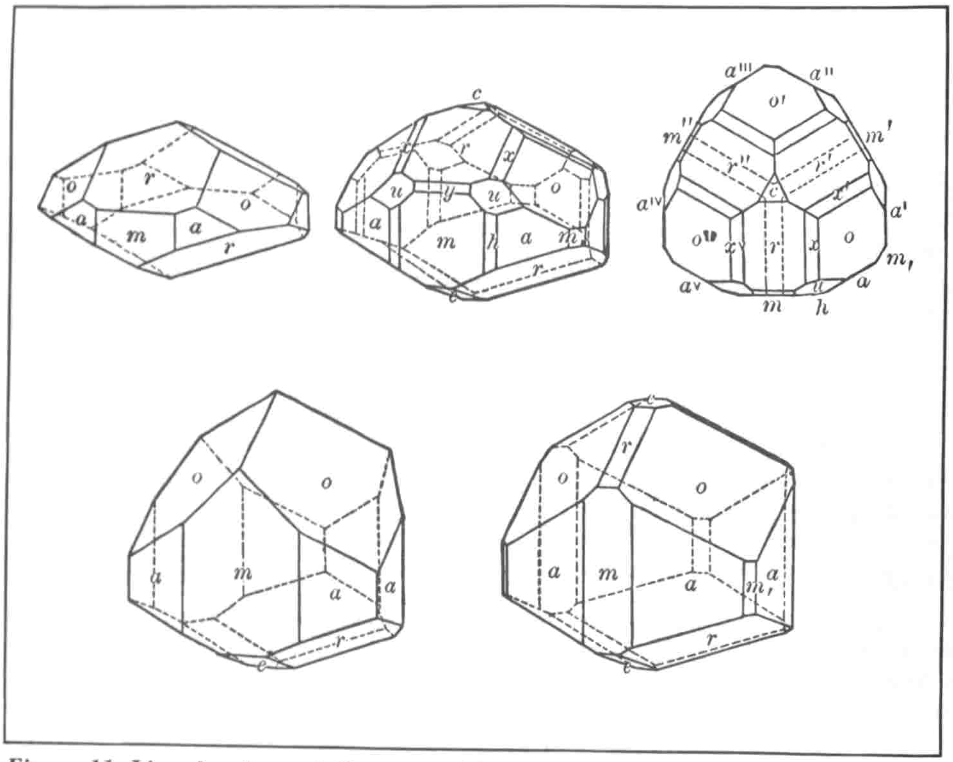


Figure 11. **Line drawings of Pierrepont, New York uvite [from Dana, (1892), *The System of Mineralogy*, p. 551].**

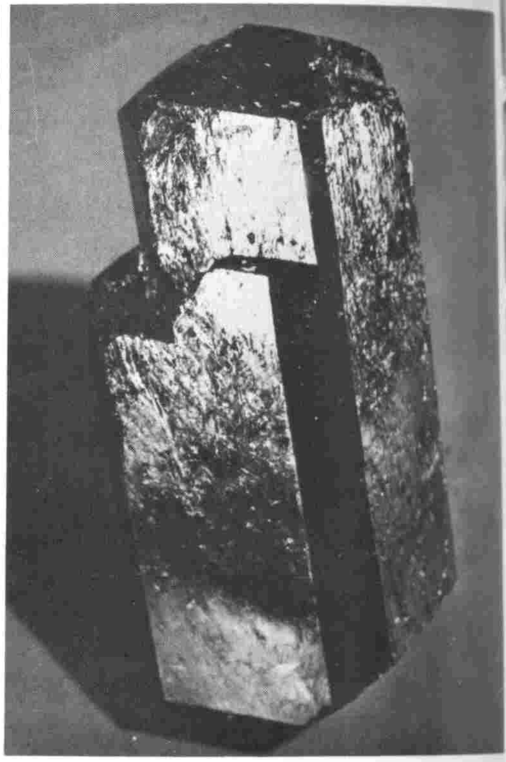


Figure 12. **Black dravite from Yinniethara, Western Australia, Australia. The crystal is 9 cm long (NMNH #R17267).**

DITTRICH, M., NOLL, F., and REINER, P. (1913) Inaug. Diss. (Heidelberg) See Doelter (1917) 2, 2, 754, Anal. #34.

DOELTER, C. (1917) *Handbuch der Mineralchemie II*, 2, 754.

DUNN, P.J., AREM, J.E. and SAUL, J. (1975) Red dravite from Kenya. *Journal of Gemmology* **14**, #8, 386-387.

DZHAMALETDINOV, N.K. (1973) New occurrence of dravitic tourmaline mineralization in Western Uzbekistan. *Uzb. Geol. Zh.* **17**, (4), 50-54.

EAKLE, A.S. (1894) Ueber Allanit und Turmalin aus New Jersey. *Zeit. Kryst.* **23**, 209-211.

EPPRECHT, W. (1953) Die Gitterkonstanten der Turmalin. *Schweiz. Mineral. Petrog. Mitt.* **33**, 481.

FINCH, J. (1830) Essay on the mineralogy and geology of St. Lawrence County, state of New York. *Am. Jour. Sci.* **19**, 220-228.

FRONDEL, C., BIEDL, A., and ITO, J. (1966) New type of ferric iron tourmaline. *Amer. Min.* **51**, 1501-1505.

GRIMALDI, F.S., INGRAM, B. and CUTTITA, F. (1955) Determination of small and large amounts of fluorine in rocks. *Analytical Chemistry*, **27**, 918-921.

HILLEBRAND, W.F., LUNDELL, G.E.F., BRIGHT, H.A. and HOFFMAN, J.I. (1953) *Applied Inorganic Analysis*, (Second Ed.). John Wiley.

HUCKABAY, W.B., WELCH, E.T. and METLER, A.V. (1947) Constant-temperature steam-distillation apparatus for isolation of fluorine. *Industrial and Engineering Chemistry*, Analytical Ed., **19**, 154-156.

JACOB, J. (1938) Der Turmalin von Kaharia Stream, Kodarma, Britisch Indien. *Schweiz. Min. Petr. Mitt.* **18**, 605-606.

JAROSEWICH, E. (1966) Chemical analyses of ten stony meteorites. *Geochimica et Cosmochimica Acta*, **30**, 1261-1265.

KOENIG, G.A. (1876) Hexagonite, Goldsmith, a variety of tremolite. *Proc. Acad. Nat. Sci. Phila.*, 180-181.

KORNETOVA, V.A. (1975) Classification of the minerals of the tourmaline group. *Zap. Vses. Mineral Obsh.* **104**, 332-336.

KUNITZ, W. (1929) Beiträge zur Kenntnis der magmatischen Assoziationen. I. Die Mischungsreihen in der Turmalingruppe und die genetischen Beziehungen zwischen Turmalinen und Glimmern. *Chemie der Erde* **4**, 208.

MANNING, P.G. (1969) An optical absorption study of the origin of color and pleochroism in pink and brown tourmalines. *Can. Min.* **9**, 678-690.

PALACHE, C. (1935) The minerals of Franklin and Sterling Hill, New Jersey. *USGS Professional Paper 180*, 111-113.

PECK, L.C. (1964) Systematic analysis of silicates. *Bulletin U.S. Geological Survey, 1170.*

PENFIELD, S.L., and FOOTE, H.W. (1899) Chemical composition of tourmaline. *Amer. Journ. Sci.*, 1899, [iv], **VII**, 97-125.

RATH, R., and PUCHECT, H. (1959) Dravite von Gouverneur. *Neues Jahrb. Min., Monatsch.*, 22-24.

RIGGS, R.B. (1888) The analysis and composition of tourmaline. *Am. Journ. Sci.*, Series #3, **35**, 35-51.

RUSKIN, J. (1891) *The Ethics of the Dust. Ten Lectures to Little Housewives on the Elements of Crystallization.* Charles E. Merril & Co., New York, 180.

SARGENT, G.W. (1901) Die qualitative Bestimmung der Borsäure in Turmalin. *Zeit. Kryst.* **34**, 205.

SLIVKO, M.M. (1957) Examples of changes of the color of tourmaline and its geochemical significance. *Min. Mag. Lvov Geol. Soc.* #11, 81-88 (in Russian.)

SOLLY, R.H. (1884) On the tetartohedral development of a crystal of tourmaline. *Min. Mag.* **6**, 80-82.

WANG, S., and XUE-YEN, H. (1966) A new variety of dravite and its significance in mineralogy. *Kexue Tongbao* (foreign language edition) **17**, 2, 91-96.

WOROBIEFF, V. (1900) Krystallographische Studien über Turmalin von Ceylon und einigen anderen vorkommen. *Zeit. Kryst.* **33**, 263-454.

WULFING, E.A., and BECHT, K. (1913) Beiträge zur Kenntnis der Magnesiaturmalin Diss. Heidelberg 1913, Uber neue Turmalinanalysen Sitzber, *Ak. Heid. cf. Doelter* **2**, 2 (1917) p. 751. Anal. 6 & 7.