

*A second occurrence of lyndochite*By J. E. T. HORNE¹

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Summary. Lyndochite from Tura dukas, 35 miles north of Nanyuki, Kenya, agrees closely with the type material from Canada in its chemical analysis, in the distribution of the rare earths, and in X-ray diffraction data for powder after heat treatment. The mineral is compared and contrasted with aeschynite. Uranium-poor euxenite is intimately associated with lyndochite at the type locality.

Since its discovery over thirty-five years ago, lyndochite has remained unrecorded outside its type locality of Lyndoch Township in Ontario, Canada. Its distinctive chemical composition sets it apart from almost all other Ti-rich metamict niobates and, despite the many analyses that have been made on rare-earth niobate-tantalates, specimens that could have been regarded as similar to or approximating to lyndochite have rarely been mentioned. Its unusual characteristics include high ThO₂ (about 10 %) and appreciable rare-earth oxides (about 20 %) with a lanthanon assemblage showing a peak concentration of Nd (and Ce), rather than any of the heavy lanthanons. The proportions of TiO₂ (about 20 %) and (Nb,Ta)₂O₅ (about 40 %) are comparable to those in numerous niobate-tantalates, but are only associated with the percentages of ThO₂ and Re₂O₃ mentioned above in some members of the aeschynite-priorite series. The lyndochite now described is chemically very close indeed to the Canadian lyndochite, and both specimens give closely similar X-ray diffraction patterns (after suitable heat treatment) which are distinct from those of any other metamict mineral.

Field occurrence

THE mineral comes from one of a series of quartz reefs and pegmatites situated some 35 miles north of Nanyuki, Kenya. The exact locality was given as two miles from Tura dukas on a magnetic bearing of 62°, which corresponds to about 0° 31' N., 37° 05' E. The specimen was collected in 1957 by a prospector, Mr. T. P. de Bruin, and submitted to the Atomic Energy Division by Dr. R. W. R. Rutland, then at the United Kingdom Atomic Energy Authority's East African Office at Dodoma. Rutland had visited the area and reported as follows on the

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geology: 'The country rocks are gneisses of the basement system, with a regular strike, slightly west of north. The veins bearing radioactive minerals are apparently invariably transverse to this strike and have a nearly east-west trend. They are quite regular and parallel sided and the largest may be followed for a mile or more. There is a series of vein rocks in the area, varying from relatively fine-grained pegmatites with dominant feldspar, through coarse-grained pegmatites with dominant quartz, to almost pure, massive, quartz reefs. The pegmatites and quartz veins are of simple type without any banded structure. Radioactive minerals are to be found in all types, scattered sparsely and haphazardly through the rock. In the quartz reefs the radioactive mineral is associated with smoky quartz, which also has a patchy irregular distribution. There appear to be two chief radioactive minerals, which have been identified in various laboratory reports as euxenite and allanite. The two minerals occur together in some pegmatites, but a number of pegmatites contain only allanite. On the other hand euxenite-polycrase tends to become dominant to the exclusion of allanite in the quartz reefs.'

Although the earlier radioactive specimens received at A.E.D. were indeed euxenite and allanite, the new specimen was distinct from euxenite. It was identified as lyndochite from X-ray powder photographs, supported by a spectrographic analysis by Mr. C. O. Harvey. This revealed the high thorium/uranium ratio and the unusual association of cerium with yttrium, both of which had recently been shown to be characteristic of lyndochite from the type locality (Butler, 1957).

Physical properties

In hand specimen the mineral is dark brown on freshly fractured surfaces with a vitreous lustre and a conchoidal fracture. Weathered surfaces are reddish brown and include some rough crystal faces, but from the fragments available little can be deduced of the morphology. Apart from the outer skin, the mineral is fresh in appearance and examination under the ore microscope shows it to be essentially homogeneous and free from inclusions. The powder is buff-coloured. Before heating, X-ray diffraction shows the mineral to be completely metamict.

The reflectivity has been determined by Dr. M. J. Gallagher as 13.6 % in white light and 12.1 % at 589 $m\mu$. A Schott continuous band interference filter was used to provide monochromatic light and measurements were made with a selenium barrier-layer cell against a carborundum standard with a reflectivity taken as 20.2 % in both cases.

The values for lyndochite may be slightly low owing to fine scratches on the surface. Gallagher also determined the microindentation hardness of lyndochite as $720 \text{ VHN} \pm 28$ (standard error of mean of 20 observations).

X-ray diffraction data

The similarity in chemical composition of the two specimens under discussion is reflected in the close correspondence between the X-ray diffraction data for powder heated at 1000°C and 1420°C (table I, cols. 1, 2, and table II, cols. 6, 7). The data relate to powder heated in a neutral atmosphere, but similar results were obtained after heating in air. At 1000°C the main difference between the two patterns is that certain peaks given by the Kenya mineral are stronger, indicating a greater proportion of a cubic phase. The patterns of material heated at 1420°C agree even more closely.

A difficulty in using diffraction patterns of heated material for identifying metamict minerals is the considerable variation often shown by specimens of the same species heated under the same conditions. The process of metamictization reduces a mineral to an essentially glassy state. On heating under dry conditions, whether in an oxidizing or a neutral atmosphere, the glass recrystallizes, but not, in general, to the original crystalline phase, but rather to two or more new phases, the proportions of which reflect variations in the composition of the original material. Thus whereas the original mineral would have given a single-phase diffraction pattern in which the peaks differed little from specimen to specimen in Bragg angle and intensity (corresponding to solid-solution differences in a single crystal structure), the recrystallized powder gives a complex pattern representing several phases, the nature and proportions of which are liable to be critically dependent on the exact composition of the unheated mineral. Nevertheless, comparison of powder photographs of the Ontario and Kenya minerals, after heating, with those of a large number of metamict titanoniobates after similar treatment fails to produce a match and thus supports the view that lyndochite should be classed as a distinct species. Representative data for aeschynite and euxenite are listed in tables I and II, cols. 3, 4, 8, 9. In both cases some lyndochite lines can be matched, indicating the presence of one or more common phases, but the patterns as a whole are distinct.

On re-examining the Lyndoch specimens during the preparation of this paper, it became apparent that two separate metamict species were present. One of these was lyndochite (in the sense of Butler, 1957). Powder photographs of the other have not been matched exactly, but

TABLE 1. X-ray diffraction data for powders heated at 1000° C. After heating in nitrogen or argon, the specimens were dusted onto collodion membranes (Gude and Hathaway, 1961) and scanned in a diffractometer at $\frac{1}{2}^\circ 2\theta$ per minute with Cu K_α radiation using pulse energy discrimination and logarithmic recording. The relative peak-height intensities are approximate; B = broad peak

¹		²		³		⁴		⁵	
$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0
5.50	20	5.53	18	5.49	20	7.30	6		
				4.82	6	5.20	2	5.26	6
4.43	16	4.45	19	4.44	17				
4.33	6	4.34	5	4.36	6				
4.03	9	4.04	11	4.05	10				
3.81	4	3.83	2	3.83	1				
3.74	6	3.75	6						
						3.67	15	3.70	14
3.40	3	3.41	4	3.42	3	3.38	6	3.39	7
3.30	4	3.31	9						
3.28	4								
3.15	3, B	3.17	7, B			3.13	2, B		
3.09	25	3.10	30	3.10	30				
3.02	100	3.03	100	3.03	55	3.00	100	3.02	100
2.97	20	2.97*	100	2.97	100				
2.95	100	2.96	100			2.94	15	2.96	20
2.797	15	2.801	19	2.805	17	2.788	11	2.815	8
2.748	2	2.755	4	2.742	< 1	2.755	< 1		
2.660	20	2.659	25	2.678	17				
						2.632	2	2.648	2
						2.600	11	2.600	6
2.575	10	2.571*	30	2.575	9	2.558	2	2.559	6
						2.549	2		
2.523	1	2.536	5						
								2.472	2
				2.455	2	2.454	3	2.449	5
						2.434	5		
2.443	6	2.449	6	2.442	3				
				2.402	< 1				
2.355	1, B	2.356	5	2.362	1				
								2.34	< 1, B
						2.315	3		
				2.289	4			2.294	< 1
2.280	6, B	2.274	8	2.270	2				
2.256	2	2.255	4						
								2.233	< 1
2.216	8	2.219	8	2.220	5	2.214	3	2.209	2
						2.191	2		
2.150	4	2.151	4	2.159	3				
						2.118	4	2.123	1
				2.096	< 1				
				2.076	3				

TABLE I (cont.)

1		2		3		4		5	
$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0	$d, \text{Å}$	I/I_0
2.067	4	2.067	3						
						2.035	< 1	2.05	< 1, B
2.031	4	2.036	3						
				2.024	13				
2.012	12	2.014	13						
						1.976	1	1.982	1
1.961	8	1.965	8	1.960	9				
						1.940	1	1.945	1
1.922	4, B	1.924	6, B	1.926	4				
						1.900	6	1.910	2
						1.884	< 1	1.893	< 1
1.872	14	1.870	17	1.878	11				
1.848	5	1.850	7	1.850	5	1.833	7	1.848	4
1.820	8	1.814*	40	1.816	4				
				1.801	1	1.800	4	1.811	4
1.781	3	1.783	4	1.775	4	1.776	6	1.781	4
								1.750	2
				1.733	3	1.735	4	1.742	3
						1.727	5		
1.725	3	1.719	5						
1.701	9	1.702	10	1.705	7				
						1.683	1		
1.645	3	1.649	3	1.652	2	1.644	6	1.658	1
						1.626	1		
						1.613	2	1.615	1
				1.601	1				
1.589	13, B	1.590	17, B	1.594	12	1.590	< 1		
				1.577	4	1.565	3	1.566	1
1.55	4, B	1.548*	25	1.546	8				
1.54	4, B	1.53	6, B	1.537	2	1.536	2	1.542	2
				1.520	1				
1.508	3	1.509	5	1.502	3	1.507	1	1.504	3
						1.495	1		
1.484	1					1.492	5		
1.475	4	1.480	7	1.476	3	1.464	1	1.471	< 1

1. Lyndochite, Lyndoch Township, Renfrew County, Ontario, Canada. U.G. 42. Heated in N_2 .
2. Lyndochite, Tura dukas, 35 miles north of Nanyuki, Kenya. U.G. 5651. Heated in N_2 . Peaks marked *, which are accentuated with respect to col. 1, represent the first four lines of a face-centred cubic phase with $a = 5.14 \text{ Å}$.
3. Aeschynite, Ilmen Mts., near Miask, U.S.S.R. From British Museum (Natural History) specimen B.M. 39211. Heated in Ar.
4. Euxenite, northern Mozambique. U.G. 7002. Heated in Ar.
5. Uranium-poor euxenite, Lyndoch Township, Renfrew County, Ontario, Canada. U.G. 42. Heated in Ar.

TABLE II. X-ray diffraction data for powders heated at 1420° C. The specimens were heated in argon; instrumental conditions as for table I. *B* = broad peak

6		7		8		9		10	
<i>d</i> , Å	<i>I</i> / <i>I</i> ₀	<i>d</i> , Å	<i>I</i> / <i>I</i> ₀	<i>d</i> , Å	<i>I</i> / <i>I</i> ₀	<i>d</i> , Å	<i>I</i> / <i>I</i> ₀	<i>d</i> , Å	<i>I</i> / <i>I</i> ₀
				5.98	5	5.89	5		
4.65	4	4.64	2			4.58	1		
				3.89	< 1				
				3.55	3				
3.31	40	3.31	40			3.31	15	3.35	30
				3.23	35				
3.19	65	3.18	45						
				3.12	1	3.13	8	3.14	20
3.08	2	3.07	2			3.06	2		
3.02	50	3.01	30						
2.98	100	2.97	100	2.99	100	2.94	100	2.96	100
2.805	16	2.797	14	2.797	12				
				2.757	8	2.754	2	2.754	4
2.703	13	2.694	6						
						2.648	1	2.655	2
2.578	20	2.576	20	2.592	16				
2.557	5	2.550	3	2.567	11	2.544	18	2.564	16
2.527	18	2.533	12			2.525	6	2.535	14
				2.410	1				
2.362	3	2.360	2	2.374	6			2.367	2
2.338	2	2.344	1			2.335	6	2.351	1
2.264	2	2.256	1						
2.221	3	2.226	2	2.219	7	2.221	2	2.233	2
2.204	2	2.197	1						
2.092	1	2.095	1	2.100	1				
2.051	2	2.047	1	2.058	1				
				2.022	1	2.02	< 1, <i>B</i>	2.025	1
2.007	1	2.004	< 1						
1.978	1	1.977	1	1.979	10	1.956	1	1.973	< 1
1.945	10	1.940	5	1.947	1				
1.934	7	1.932	5						
				1.903	< 1	1.907	1	1.912	4
1.887	9	1.883	6						
						1.858	1	1.864	2
1.820	25	1.817	30	1.830	25				
						1.797	20	1.812	25
1.785	4	1.780	2						
				1.750	< 1	1.756	< 1	1.765	1
						1.718	3	1.730	6
1.715	11	1.719	11						
1.680	5	1.676	3	1.686	9			1.674	2
1.663	3								
1.654	7	1.656	6, <i>B</i>			1.655	1	1.654	1
						1.630	< 1	1.636	1
				1.614	1				
1.591	9	1.588	5	1.589	1				
				1.569	1	1.56	< 1, <i>B</i>	1.57	1, <i>B</i>
1.552	16	1.549	20	1.561	14	1.534	11	1.545	13

TABLE II (cont.)

6		7		8		9		10	
$d, \text{\AA}$	I/I_0	$d, \text{\AA}$	I/I_0	$d, \text{\AA}$	I/I_0	$d, \text{\AA}$	I/I_0	$d, \text{\AA}$	I/I_0
1.534	1	1.530	1						
1.526	3	1.523	2			1.50	< 1, B		
1.504	2	1.501	2			1.481	< 1	1.499	2
1.485	5	1.483	4	1.493	3	1.467	2	1.478	2

6. Lyndochite, Lyndoch Township, as for table I, col. 1.

7. Lyndochite, Tura dukas, as for table I, col. 2.

8. Aeschynite, Ilmen Mts., as for table I, col. 3.

9. Euxenite, Nansoke, Uganda. U.G. 2902.

10. Uranium-poor euxenite, Lyndoch Township, as for table I, col. 5.

they correspond closely to euxenite. X-ray spectrographic analysis shows that, compared with lyndochite, this mineral is richer in Nb, Yt, Yb, and Er, and poorer in Ti, Ta, Th, La, Ce, Pr, Nd, and Sm. As in Lyndoch lyndochite, uranium is low, about 0.5 % U_3O_8 . It appears to be best described as uranium-poor euxenite. X-ray diffraction data are listed in tables I and II, cols. 5, 10.

It is rare to find two metamict species closely associated together in the same specimen, though this may be partly attributed to the difficulty of recognizing a mixture of two minerals of very similar appearance neither of which gives a crystalline X-ray pattern before heating. Certainly it could explain some of the anomalies encountered from time to time in the study of metamict minerals. There is no means of knowing if the material Ellsworth (1927) used was pure lyndochite, but the discrepancies between his analysis and later work suggest that it was admixed with the associated euxenite. The relationship between the two minerals has not been studied in detail and will be described in a later note. The uncertainty still surrounding lyndochite from the type locality makes it all the more fortunate that another example, uncomplicated by mineral intergrowths, has been found in Kenya.

Chemical composition

The compositions of the two lyndochite specimens are given in table III, together with those of aeschynite specimens from Russian localities. The constituents CaO , RE_2O_3 , TiO_2 , and ThO_2 are closely similar in the two lyndochite specimens, but there is an appreciable difference in their $(Nb, Ta)_2O_5$ and U_3O_8 contents. The Nb/Ta ratios are not dissimilar so the difference cannot be accounted for in this way; the lyndochite from Canada was seen to have a few per cent (below 4 %) of columbite as an impurity (Butler, 1957), but even allowing for this

contribution the $(\text{Nb,Ta})_2\text{O}_5$ content remains appreciably higher than that of the lyndochite from Kenya. The difference in the U_3O_8 values of the lyndochite specimens is relatively large but the actual contents are only 0.4 and 2.8 % U_3O_8 . It is clear that it is not a very important constituent and it was probably not essential to the pre-metamict structure.

TABLE III. Composition of lyndochites and aeschynites

	1	2	3	4	5
CaO ...	(3)	4.4	2.34	2.50	4.82
RE_2O_3 ...	21.05	21.35	27.48	22.51	28.17
TiO_2 ...	19.1	22.0	23.88	21.20	18.73
ThO_2 ...	10.77	10.13	11.27	17.55	2.52
$(\text{Nb,Ta})_2\text{O}_5$...	42.50	32.50	30.93	32.51	41.41
U_3O_8 ...	0.4	2.8	—	—	—
Ignition loss	2.1	3.3	0.98	—	0.45

1. Lyndochite, Lyndoch Township, Renfrew County, Ontario, Canada. $\text{CaO}(\pm 0.2\%)$ by optical spectrography using No. 2 as standard; Fe between 0.5 and 1 %; Nb/Ta (at.) ratio about 10; U_3O_8 here and in anal. 2 by difference from radio-metric assay by K. W. Richardson.
2. Lyndochite, Tura dukas, 35 miles north of Nanyuki, Kenya. Fe between 2 and 5 % by X-ray fluorescence methods; Nb/Ta (at.) ratio about 10.
3. Aeschynite, Urals, U.S.S.R. (Chernik, 1930). $\text{MnO} = 0.03\%$, $\text{MgO} = 0.01\%$, $\text{FeO} = 2.20\%$, $\text{SnO}_2 = 0.15\%$.
4. Aeschynite, Miask, Urals, U.S.S.R. (Rammelsberg, 1877). $\text{FeO} = 3.34\%$.
5. Aeschynite, Vishnevy Mts., U.S.S.R. (Zhabin *et al.*, 1961, anal. M. E. Kazakova). $\text{Fe}_2\text{O}_3 = 2.75\%$, $\text{SiO}_2 = 0.35\%$, $\text{Al}_2\text{O}_3 = 0.35\%$.

Only members of the aeschynite–priorite series seem to match the CaO , RE_2O_3 , TiO_2 , ThO_2 , and $(\text{Nb,Ta})_2\text{O}_5$ contents of the two lyndochites at all closely. Nevertheless there is an appreciable variation in the percentage of major constituents in the three analysed aeschynites (table III) with ThO_2 showing the greatest range (from 2.5 to 18 %) and $(\text{Nb,Ta})_2\text{O}_5$ varying from 31 to 41 %—about the same range as is found in the two lyndochites. TiO_2 varies from 19 to 24 % and the total rare earths, RE_2O_3 , from 23 to 28 %, which is slightly higher than RE_2O_3 in the lyndochites. It is, however, the distribution pattern of the rare earths that provides the unifying feature of these Russian examples and aeschynite from other localities. All are distinctive in showing rare-earth distribution patterns dominated by the light lanthanons (La to Sm inclusive) rather than Yt and the heavy lanthanons. Thus the distinction between aeschynite and priorite is not in their CaO , RE_2O_3 , TiO_2 , and $(\text{Nb,Ta})_2\text{O}_5$ contents but in the relative importance of their light lanthanons on the one hand and of Yt and the heavy lanthanons on the other. Priorite is necessarily rich in Yt, Dy, and Er and poor in

La and Ce. It is probable that there is a tendency for U to be higher and Th lower in priorite compared with aeschynite but this is a measure of the geochemical association of Yt, Dy, and Er with U^{+4} , which is closer than that of La and Ce with Th. Most rare-earth niobate-tantalates are enriched in Yt and the heavy lanthanons rather than the light lanthanons and whereas priorite can be readily confused (chemically) with members of the euxenite-polycrase series, aeschynite remains distinctive.

TABLE IV. Percentage compositions (wt.) of rare-earth oxides in total rare earths or total lanthanons in lyndochites and aeschynites. A dash (—) indicates where Yt, Ho, and Tm were not sought; an asterisk (*) indicates Tm and Lu were sought but not detected

	1	2	3	4	5
Yt ₂ O ₃	21	28	—	—	3
La ₂ O ₃	2.4	2.0	14	2.2	14
Ce ₂ O ₃	21	15	48	13	42
Pr ₂ O ₃	2.6	3.5	7.3	6.7	9
Nd ₂ O ₃	27	28	22	22	25
Sm ₂ O ₃	7.1	7.3	3.1	17	3.1
Eu ₂ O ₃	*	0.3	0.1	2	0.4
Gd ₂ O ₃	8.7	6.6	1.8	13	1.3
Tb ₂ O ₃	0.8	0.9	0.2	2.5	0.2
Dy ₂ O ₃	4.7	3.7	1.8	11	1.2
Ho ₂ O ₃	—	—	0.4	1.5	0.3
Er ₂ O ₃	1.8	1.8	0.9	5.5	0.3
Tm ₂ O ₃	0.8	—	*	0.8	*
Yb ₂ O ₃	1.9	2.9	0.4	2.2	0.2
Lu ₂ O ₃	0.3	0.3	*	0.5	*

1. Lyndochite, anal. 1 in table III, Canada.
2. Lyndochite, anal. 2 in table III, Kenya.
3. Aeschynite, Ilmeny Mts., U.S.S.R. (Semenov and Barinskii, 1958).
4. Aeschynite, Tatarka, Enisei Range, U.S.S.R. (Semenov and Barinskii, 1958).
5. Aeschynite, anal. 5 in table III, Vishnevye Mts., U.S.S.R. (Zhabin *et al.*, 1961, anal. R. L. Barinskii).

Table IV shows that the rare-earth distribution patterns of the lyndochites are similar to each other and that they are characterized by high concentrations of Nd, Ce, and Yt. Yt is at a much lower tenor than it is in rare earths from members of the euxenite-polycrase series and other rare-earth minerals rich in the heavy lanthanons, when it almost invariably accounts for over half the total rare-earth oxides on a weight per cent basis (Butler, 1958). Conversely, Nd and Ce, especially, are much higher than in all other rare-earth niobate-tantalates except aeschynite. The rare-earth distribution pattern in lyndochite may be usefully compared and contrasted with that in the commonest rare-

earth mineral monazite (e.g. Murata *et al.*, 1953, 1957, 1958; Vainshtein, 1956; Vainshtein *et al.*, 1955; Rose *et al.*, 1958; Flinter *et al.*, 1963). Typically, the rare earths in monazite are light-lanthanone assemblages dominated by Ce which frequently exceeds 40 % Ce_2O_3 in the total rare earths; La is usually about half as abundant as Ce but the ratio Ce/La may range from 1 to 4.6; Nd is also usually about half as abundant as Ce but it has not yet been reported as equalling Ce, the ratio Ce/Nd ranging from 1.3 to 5.5. The Yt content of monazite is generally 4 % or less in the total rare earths; higher values up to 12 % have been reported but in monazite relatively rich in Yt, the dearth of heavy lanthanones remains. The oxides Er_2O_3 and Yb_2O_3 are invariably below 1 % and Dy_2O_3 has only been recorded at over 1 % (1.5 %) in a U-rich variety of monazite.

Rare earths in lyndochite compare with those in monazite in their substantial Ce and Nd contents (RE_2O_3 basis). The Nd/Ce and Ce/La ratios differ sharply, however. In monazite, Nd never exceeds Ce as it does in lyndochite, nor is La as low either relative to Ce or in absolute abundance. Yt in lyndochite rare-earth oxides exceeds that in the rare-earth oxides of monazite, and the heavy-lanthanone associates of Yt which occur in lyndochite are scarcely allowed into the monazite structure. The interest in contrasting rare earths in lyndochite, monazite, and other rare-earth minerals is perhaps enhanced when the roles of U and Th are recalled. Thus in monazite it is clear that there is little correlation between the rare-earth distribution pattern and the variation of ThO_2 (from below 1 % to above 10 %); this is because Th^{+4} and the ions of light lanthanones are much the same size and all well suited to the monazite structure. The appearance in monazite of appreciable percentages of the smaller U^{+4} ion can probably be correlated with a tendency to take up small amounts of heavy lanthanones like Dy. In members of the euxenite–polycrase series, U is normally a substantial constituent and it is frequently more abundant than Th; Yt and the heavy lanthanones with ionic sizes comparable to that of U^{+4} are much more abundant than the larger-sized light lanthanones. It might be expected that an increase of Th in minerals of the euxenite–polycrase series would be correlated with any increase in the uptake of the light lanthanones. There are, however, no Th-rich members of the euxenite–polycrase series for which rare-earth distribution patterns are known and, moreover, it seems likely that minerals tentatively labelled as belonging to the series will be re-labelled aeschynite if the light lanthanones are found to predominate in the rare earths.

Bearing this in mind, the few data for rare earths in aeschynites may now be considered. Seminov and Barinskii (1958) determined the lanthanons (only) in three aeschynites and results for two of them are shown in table IV, cols. 3 and 4; the lanthanon concentrations in their third aeschynite were very close to those in the Ilmeny aeschynite (table IV, col. 3). The lanthanon distribution in the latter is almost monazite-like except for the small amount of Tb and heavier lanthanons; that in the Tatarka specimen (table IV, col. 4) is again weighted in favour of the light lanthanons but the heavy lanthanons (Gd and heavier) constitute 37 % of the total. With reference to the aeschynite–priorite series the Ilmeny specimen is evidently nearer the aeschynite ‘end member’ than the Tatarka specimen. There are, unfortunately, no data on the Yt, Th, U, or other major constituents in these aeschynites. We have determined ThO_2 , total RE_2O_3 and U_3O_8 in a related specimen described as aeschynite from Lake Ilmen, Urals, U.S.S.R., kindly presented by the British Museum (Natural History) and part of B.M. 1810. Respective values for the oxides are 17.30, 24.94, and below 0.5 %; it should be noted that the oxides of Ce, Pr, and Tb were in their air-ignited oxidized state and corrections have not been applied to the figure of 24.94 %. In the rare earths Yt_2O_3 is approximately 4.5 %, and the lanthanon distribution pattern is quite close to that quoted by Seminov and Barinskii for the Ilmeny specimen. The most complete analysis for aeschynite is given by Zhabin *et al.* (1961) and quoted in tables III and IV, col. 5. This specimen from the Vishnevye Mts. contrasts with that from Lake Ilmen in having a much lower ThO_2 content. On the other hand the rare-earth assemblages are very similar and the two specimens must be considered to be near the aeschynite ‘end member’ of the aeschynite–priorite series. There is thus as little correlation between Th and the rare-earth distribution pattern in aeschynite as there is in monazite. Despite the differences in Th, the Th/U ratio remains high and any effect of U on the rare-earth distribution pattern must be small with U_3O_8 below 0.5 % for the Lake Ilmen specimen and, presumably, also below 0.5 % for the Vishnevye Mts. specimen, since the analytical total is 99.55 and no mention is made of U.

The lanthanon distribution in the mineral from Tatarka is much more like that in the two lyndochites than in the other aeschynites and it may well be that this mineral is lyndochite rather than aeschynite. Figures for Yt and the major elements are lacking for the Tatarka aeschynite, however, as are diffraction data, so this suggestion remains tentative.

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