Bismutotantalite, a new mineral, from Uganda.

By E. J. Wayland, A.R.C.S., M.I.M.M.
Director, Geological Survey of Uganda,
and L. J. Spencer, M.A., Sc.D., F.R.S.
Keeper of Minerals, British Museum of Natural History.

[Read June 11, 1929.]

1. *Discovery.*—The discovery of tin-ore in Ankole (south-western Uganda) led to a great deal of prospecting on the part of qualified and unqualified, experienced and inexperienced, individuals, not only in the vicinity of the original discoveries, but also in many other parts of the Protectorate. One of the results of this activity was the finding, by a prospector, of a deposit of alleged coal at a spot rather less than 25 miles WNW. (approx.) of Kampala and about 35 miles NW. of Entebbe. With reference to this, the discoverer was told by the Geological Survey that his hoped-for fuel was in reality tourmaline, but inasmuch as it was associated with a pinkish-buff mica characteristic of the stanniferous pegmatites of Ankole, further search might disclose the presence of tinstone.

Some laboratory tests subsequently made by the writer on the supposed coal-bearing rock, proved it to contain a little finely divided cassiterite, and partly in consequence of this some field assistance was given to the prospector, who was advised to put down a trial hole at a spot where it was anticipated that a pegmatite would be revealed near the surface; for, on analogy with some occurrences elsewhere, it was deemed not altogether unlikely that, if found, the pegmatite would prove to carry tin. A pegmatite was struck; moreover it was found to be metalliferous, but the ore it carried was not that of tin. It was found to be decidedly heavy (specific gravity rather more than 8); moderately hard (H. $5\frac{1}{2}$ approx.); grey-black to pitch-black in colour, except for some thin yellowish to pinkish veinlets running through it or coating it in places; and without cleavage, except for parting planes. It was a puzzling mineral, and none of us could name it at sight, though it suggested tantalite more than anything

else. Such tests as could be applied at the time more or less convinced us that we had a new mineral to deal with; and for convenience, and pending a detailed knowledge of its nature, we referred to it as 'ugandite'. E. J. W.

2. *Preliminary Analysis.*—At the time of the discovery of this new mineral our laboratory was out of action, being in the hands of the Public Works Department, and possessing but three walls and half a roof; but Mr. W. C. Simmons, Chemist and Petrologist to the Survey, concluded, as a result of such investigations as he was able to make under trying and difficult circumstances, that the new mineral was in all probability a tantalate of bismuth—a compound with which mineralogists were hitherto unacquainted. Its crystallography, however, was not determinable from the samples available. An attempt to discover, by photographic methods, whether the new mineral was perceptibly radioactive or not, gave a negative result. The same may be said of similar experiments carried out in the Geophysical Laboratory at Washington, by Dr. C. N. Fenner, and by the chemists of the Imperial Institute in London; but Professor Arthur Holmes informs me that a specimen submitted to him proved to contain radioactive streaks. E. J. W.

3. *Occurrence and Geological Setting.*—The site of the discovery is a place called Gamba Hill (32° 10′ E., 0° 30′ N.) in Busiro County, lying between the Kampala–Mubendi and the Kampala–Hoima roads, and to the north of the Myanja river at the junction of Native-owned and European-owned lands, and just within the latter. Topographically the area lies within the limits of the well-developed Buganda peneplain. The solid geology is greatly obscured by elephant-grass, surface soils, and lateritic ironstone, and is but little known. In the vicinity, however, it consists essentially of mica-schists belonging, it is believed, to the basal (pre-Cambrian) complex, intruded by acid dikes, a few of which are highly tourmalinized (quartz-tourmaline- or tourmaline-quartz-rocks), but most of which are quartz dikes and more normal pegmatites. It is, according to Mr. Simmons, in an irregular pipe-like intrusion of the latter (consisting of quartz, felspar—often highly kaolinized—and mica, as very large crystals) that the bismuth mineral has been found. A characteristic feature of the pegmatite appears to be the occurrence of large buff-coloured flakes of muscovite that resemble leaves, owing to the presence of what appears to be a twin-plane across the centre of the

flakes, thus separating two systems of parallel striations that impinge upon each other like the limbs of chevrons. The limits of the pegmatite are (or were a month or two ago) unknown, and the whole is covered by 6 to 8 feet of surface soil and quartz rubble. The mineral occurs as large misshapen crystals up to several pounds in weight, and its distribution seems to be patchy and irregular. Too little is known at present to permit one to say whether any persistent body of ore is likely to be found or not. It is most probable, however, that well-directed search will reveal other and similar dikes; and the possible presence of other minerals in the neighbourhood must not be overlooked. It might be mentioned in passing that colours of gold have been found in the alluvial deposits of the Myanja river in this area. E. J. W.

4. *Chemical Composition.*—Two chemical analyses were made at the Imperial Institute and are here published by permission of the Director. They were made by Mr. W. O. R. Wynn, and the mineralogical observations made on the same material by Mr. G. E. Howling are also recorded below. Another analysis was made by a commercial firm and I have permission to publish the results.

The average of the three analyses gives for the mineral rather more than 50 % of bismuth oxide, and about 47 % of tantalic and niobic oxides, which confirms Mr. Simmons's results, and shows the mineral to be chemically analogous with stibiotantalite. For this reason the tentative name of 'ugandite' has been abandoned and *Bismutotantalite* has been adopted in its stead.

The following is taken from the report furnished by the Imperial Institute:

'Two pieces of the new bismuth mineral which differed somewhat in lustre and shape were selected for analysis and specific gravity determinations. One (*a*) was an irregular, lustrous lump, the other (*b*) was tabular and somewhat duller in appearance. These were broken up and carefully freed as far as possible from adherent gangue, the chemical analyses, specific gravities, and the optical observations being made on the cleanest material obtainable.

'Very thin flakes under the microscope were brownish and translucent, but tapered away and became on the thinest edges smoke-grey to almost colourless and transparent. Optical observations with high power on these thin edges gave the following results: Birefringent, extinction parallel to elongation of fragments and to straight

edges when present; refractive index very high and greater than 2·2. The mineral may be orthorhombic.

'The specific gravities of the two selected pieces were (*a*) 8·44, and (*b*) 8·03. The results of a fairly complete analysis of (*a*) and of a partial analysis of (*b*) are given as follows:

		Large fragment (*a*).	Small fragment (*b*).
Bismuth oxide,	Bi_2O_3 ...	52·26°	49·86°
Tantalic oxide,	Ta_2O_5 ...	40·12	41·15
Niobic oxide,	Nb_2O_5 ...	6·63	6·46
Manganous oxide,	MnO ...	0·12	0·12
Ferric oxide, Alumina,	Fe_2O_3, Al_2O_3 ...	0·11	0·30
Zirconia,	ZrO_2 ...	trace	—
Titanium dioxide,	TiO_2 ..	trace	—
Stannic oxide, Antimony oxide,	SnO_2, Sb_2O_3 ...	0·04	—
Rare earths,	ThO_2, &c. ...	not detected	—
Uranoso-uranic oxide,	U_3O_8 ...	not detected	—
Loss on ignition	...	0·33	1·05
		99·61	98·94

'It will be seen from the above chemical analyses that the two fragments were closely similar in composition, but that in specimen (*b*) the ratio of bismuth oxide to the oxides of niobium and tantalum was somewhat lower than in specimen (*a*). The analysis of sample (*a*), which consisted of somewhat fresher looking material than sample (*b*), when calculated to a 100 % basis and neglecting impurities gave the following results:

Bismuth oxide, Bi_2O_3	52·78 %
Tantalic oxide, Ta_2O_5	40·52
Niobic oxide, Nb_2O_5	6·70

'This composition corresponds very closely with that required by the formula $Bi_2O_3.(Ta,Nb)_2O_5$. So far as can be ascertained no mineral having the chemical and physical characters of this black mineral from Uganda has been previously described.—*28th March*, 1929.'

The other analysis referred to above was reported as follows. In this analysis the tantalum and niobium were separated by the selenium oxychloride method:

Bi_2O_3.	Ta_2O_5.	Nb_2O_5.	SiO_2.	Fe_2O_3 and Mn_3O_4.	Total.
50·46	31·14	14·76	2·16	1·36	99·88

E. J. W.

5. *Crystallography and other Physical Characters.*—Specimens of the new mineral, generously sent by the Director of the Geological Survey

of Uganda for preservation in the British Museum collection, include some of the best and largest crystals yet found. These had been selected from large quantities (about 200 lb.) of the mineral, and they range in size from $2 \times 1\frac{1}{2} \times 1$ cm. to $10 \times 6 \times 6$ cm., the latter weighing 1,058 grams. A further lot of material, kindly furnished for study by Mr. Bruce Taplin, of Minerals Separation, Limited, consists of a number of fragments showing indications of crystalline form, which had been selected from a 30 lb. parcel of the picked ore. Finally, a small lot of specimens more recently presented to the Museum by Mr. G. C. Barnard, contained the best crystal of all.

Unfortunately, all these crystals and fragments are very irregularly bounded by rough and weathered surfaces, and they are not suitable for any precise determination of the crystallographic characters. Some of the specimens show a good parting in one or generally two directions; the two partings, when both present, being of equal quality. Such specimens show a lamellar structure with steps on the broken surfaces. Between these steps the mineral breaks with a sub-conchoidal fracture without any indications of cleavage. The surfaces of the partings are tolerably smooth and bright, sufficient to give approximate measurements on the reflecting goniometer. The mean of many readings of the angle between the two sets of parting is 82° 42′, with a range of 82° to 83°. A third much less distinct parting at approximately 90° to the other two is only rarely evident. These partings were of great assistance in orientating the irregular and misshapen crystals, and they suggest that the mineral may be orthorhombic.

The crystal ($4 \times 2\frac{1}{2} \times 2\frac{1}{4}$ cm.) presented by Mr. G. C. Barnard is more regularly developed. It is short-prismatic in habit, with some resemblance to columbite. This crystal (fig. 1) shows no partings, but the single well-formed face δ (011) has the same direction as one of the better partings on other crystals. With this orientation the third parting previously mentioned then becomes a (100). Measurement with the contact-goniometer gave the following angles (the angle $\delta\delta' = 97° 18'$ being the value determined from the parting planes on other crystals):

		Measured.	Calculated.	Stibiotantalite.
$mm''' = (110):(1\bar{1}0)$	...	76°	—	77° 18′ m (110)
$gg' = (130):(\bar{1}30)$	...	47	46° 12′	45 16 g (130)
$ww' = (133):(\bar{1}33)$	...	36	35 30	34 38 w (4.12.9)
$ww''' = (133):(1\bar{3}3)$	...	93	91 16	91 6 w (4.12.9)
$\delta\delta' = (011):(0\bar{1}1)$	...	97 18′	—	96 48 δ (043)
$gx = (130):(141)$	...	13	13 2	—

The axial ratios calculated from these angles are:

$$a : b : c = 0{\cdot}7813 : 1 : 1{\cdot}1363.$$

The lower end of this crystal is rounded, and shows indications of pyramids in the zone [110,001]. Several indefinite rounded faces are present on other crystals; but, in addition to the five forms noted above, only a (100) and k (103) were determined with certainty. Some of the rough planes on the crystals are perhaps only surfaces of contact with the other minerals in the pegmatite.

Forms of Bismutotantalite and the normal angles of each to the three axial planes.

Forms.			Angle to a (100).	b (010).	c (001).
a (100)	...	...	—	90° 0′	90° 0′
m (110)	...	...	38° 0′	52 0	90 0
g (130)	...	...	66 54	23 6	90 0
δ (011)	...	...	90 0	41 21	48 39
k (103)	...	...	64 8	90 0	25 52
w (133)	...	...	72 15	44 22	51 1
x (141)	...	...	72 39	21 15	78 7

As shown in the first table above, the angles of bismutotantalite correspond very closely with those of stibiotantalite. When δ (011) is given the indices (043), as was done by Penfield and Ford [1] for stibiotantalite, the axial ratios for both minerals show a close relation to those of columbite and tantalite. With this change in the axial ratios from those here adopted for bismutotantalite, the common form w (133) becomes (4.12.9), and x (141) becomes (4.16.3). It must be remarked that the values for bismutotantalite are only approximate and will need revision when better crystals are available.

		a : b : c.
Bismutotantalite,	$Bi_2O_3.Ta_2O_5$	0·7813 : 1 : 0·8522
Stibiotantalite,	$Sb_2O_3.Ta_2O_5$	0·7995 : 1 : 0·8448
Tantalite,	$FeO.Ta_2O_5$	0·8285 : 1 : 0·8898

The crystals are sometimes fractured and penetrated by narrow irregular veinlets from the matrix. This suggests a cause for the development of the planes of parting. The material is pitch-black with sub-metallic lustre, but on some crystals the black is mottled with areas of a pinkish-yellow colour with dull lustre, while a few smaller

[1] S. L. Penfield and W. E. Ford, Amer. Journ. Sci., 1906, ser. 4, vol. 22, p. 61.

and fragmentary crystals consist entirely of this material. A fragment parallel to a plane of parting, and showing the black and pink areas with a sharp dividing line, was ground down as thin (40 μ) as possible without tearing up. The pinkish-yellow material was then translucent and cloudy and appears to be mainly isotropic with some

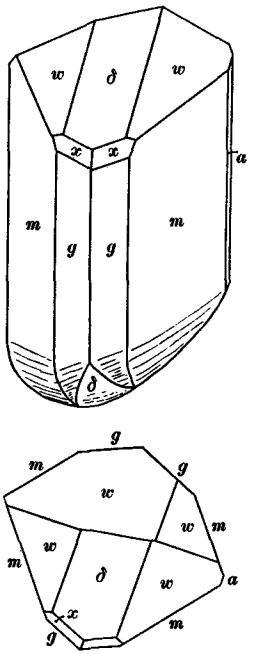

FIG. 1. Crystal of bismutotantalite. Clinographic drawing with the *b*-axis in front; and plan.

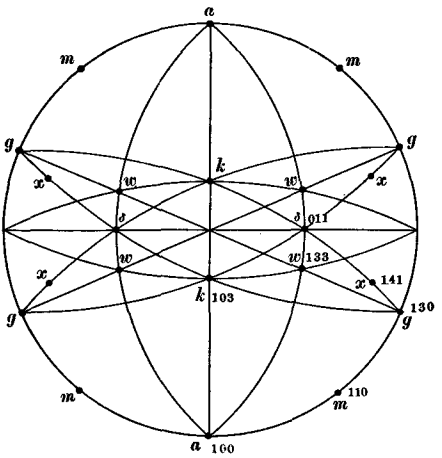

FIG. 2. Stereographic projection of the forms of bismutotantalite.

birefringent flakes or grains; but the black mineral remained quite opaque. In this thin section both areas show a rectangular network (parallel to the other two partings): in the meshes of the pink portion there are small particles of the unaltered black mineral; and in the black portion the network is marked out by veinlets and nodes of the pink material. The pink material is evidently an alteration product of the bismutotantalite. Heated in a bulb-tube it gave off abundant water and became yellow.

Analyses made by Mr. Max H. Hey in the Mineral Department of

the British Museum on separate portions of the pink mineral gave the following results:

	Bi_2O_3.	$(Ta,Nb)_2O_5$.	Fe_2O_3.	SiO_2.	H_2O.	Total.	Sp. gr.
I.	32·93	64·31	0·42	1·19	2·01	100·86	—
II.	42·82	52·13	0·64	0·62	2·10[1]	98·31[1]	—
III.	24·05	62·88	0·71[2]	2·00	8·65	98·29	6·99

[1] Water probably low. [2] $Fe_2O_3+Mn_3O_4$ 0·71.

He reports that the pink mineral is finely granular and consists of a mixture of optically isotropic and strongly birefringent materials. The mineral is not attacked by hydrochloric or nitric acids; but it is decomposed by hydrofluoric acid, bismuth going into solution and the tantalic acid remaining insoluble.

The black bismutotantalite finely crushed in oil was also examined optically by Mr. Hey. Very thin splinters are transparent and smoke-grey to colourless. The fragments give straight extinction and are optically biaxial. The refractive index is very high and the birefringence about 0·1 to 0·15. Specific gravity 8·15. Hardness about 5. Streak black. Not attacked by acids (HF, &c.).

The bismutotantalite was tested for pyro-electricity, but with negative results. [Some very remarkable pyro-electric effects were obtained by Penfield and Ford on crystals of stibiotantalite.]

L. J. S.