New occurrences of duftite.

(With Plate XVI.)

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DURING an examination of the mineral bayldonite,

$$(Pb,Cu)_7(AsO_4)_4(OH)_2.H_2O,$$

for the purpose of obtaining standard X-ray powder data to compare with supposed single crystals of this species, it was found that a specimen purchased in 1948 as bayldonite from Ojuela mine, Mapimi, Durango, Mexico (B.M. 1948,267) gave a powder pattern related to those of members of the descloizite group and fairly close to but not identical with conichalcite, $CuCaAsO_4OH$. It chanced that about the same time a specimen of a green botryoidal mineral from Brandy Gill, Caldbeck Fells, Cumberland, sent in by Mr. W. F. Davidson for determination was photographed and showed similar variations from the conichalcite pattern. Qualitative spectrographic comparison of the Mapimi and Brandy Gill materials with several conichalcites suggested that the differences in the powder photographs might be due to the presence of lead in the former. A powder photograph of duftite[1] from the type locality, Tsumeb, South-West Africa (B.M. 1939,225), was then obtained and found to agree closely with that of the Mapimi mineral, while that of Brandy Gill showed some characters of both duftite and conichalcite. All the earlier patterns showed traces of contamination with associated lead minerals, and only after very careful hand-picking under the high-power binocular microscope could samples be obtained which gave really satisfactory agreement. Very careful sampling of further specimens from Cumberland yielded pictures of slightly varying pattern, some of which are closer to the type Tsumeb pattern than the first examined.

It was felt necessary to prove the diagnostic value of the small differences in the powder patterns of duftite and conichalcite by establishing chemically the presence of reasonable quantities of lead in the new duftite specimens, but as the mineral from Mapimi is intimately

[1] O. Pufahl, Centralbl. Min., 1920, p. 295. [M.A. 1-150.]

associated with other lead minerals, and from Brandy Gill as thin coatings also associated with lead minerals, great care was called for in sampling, and only very small quantities of satisfactorily pure material were obtained. Using samples ranging from 0·8 to 4·7 mg. Dr. M. H. Hey kindly made microchemical determinations by the dithizone method[1] with the following results:

	PbO.
Duftite, Tsumeb (B.M. 1939,225)	51 %
,, Mapimi (B.M. 1948,267)	42
,, Brandy Gill (B.M. 1950,444)	39
Conichalcite, Carissa mine, Mammoth, Utah (B.M. 81763) ...	0
Theoretical for duftite ($CuPbAsO_4OH$)	52·3

It is estimated that the accuracy of the determinations is $\pm 5\ \%$.

Descriptions of the specimens.

Ojuela mine, Mapimi, Durango, Mexico (B.M. 1948,267).—A friable aggregate of colourless to pale brown wulfenite crystals up to 8 mm. in maximum dimension loosely cemented by mimetite as white fibrous aggregations and duftite as bright yellowish-green minute crystals and crystal complexes. The largest duftite crystals are small prisms about 0·2 mm. long and many are as short as 0·07 mm. The length to width ratio is usually between 10 to 1 and 4 to 1. All refractive indices are above 1·848, that of the highest available immersion liquid.

Brandy Gill, Caldbeck Fells, Cumberland (B.M. 1950,440–444, and other specimens belonging to Mr. W. F. Davidson).—Thin botryoidal coatings of duftite varying in colour from pale emerald-green to deep moss-green in association with mimetite, pyromorphite, stolzite,[2] cerussite, malachite, ankerite, and linarite on a quartzose matrix containing galena and chalcopyrite. The small spherulites of duftite are commonly about 0·1 mm. in diameter and show under crossed nicols typical spherulitic crosses. Variations in refractive index within single spherules suggest that the interior is usually more lead rich than the outer shells. Frequently there is a sharp change in refractive index between core and outer coatings, although all may be above 1·848. Outer layers are sometimes below 1·848. Very occasionally minute, approximately single crystals have been observed.

[1] E. B. Sandell, Colorimetric determinations of traces of metals. New York, 1944, p. 286.

[2] Stolzite is new to this locality and good specimens were also exhibited at the meeting on November 2, 1950, by A. W. G. Kingsbury and J. Hartley.

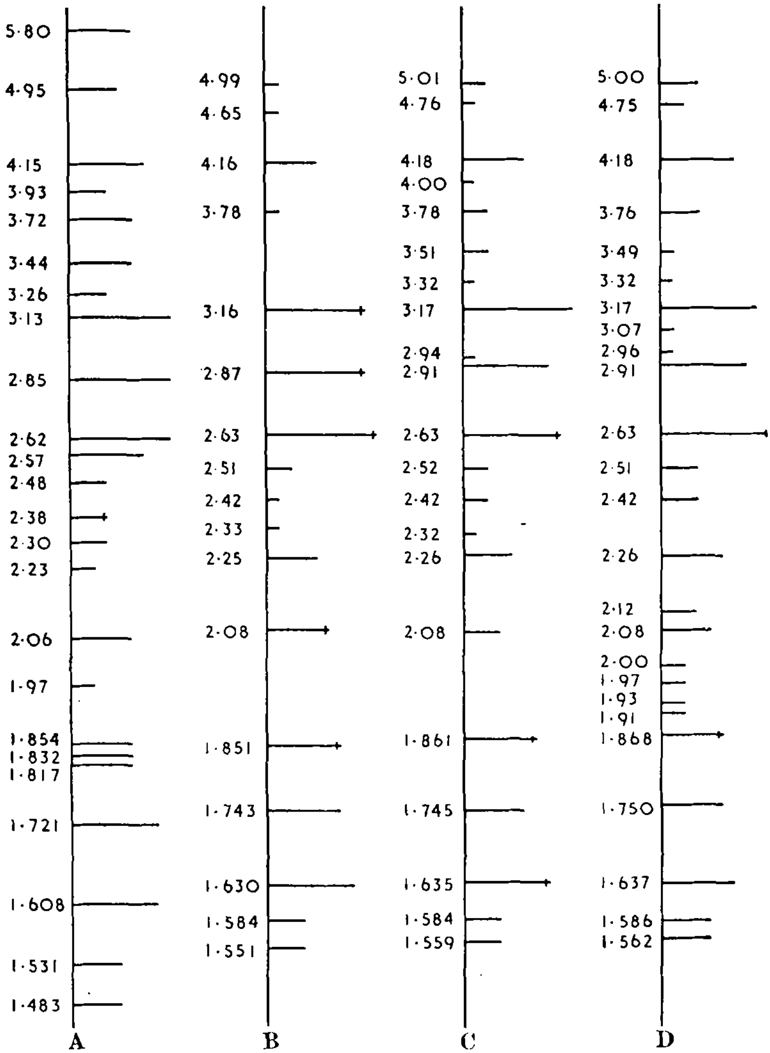


FIG. 1. Spacing-intensity plots of X-ray powder photographs of: (A) conichalcite Bisbee, Arizona (B.M. 1924,696). (B) duftite, Brandy Gill (W. F. Davidson). (C) duftite, Mapimi (B.M. 1948,267). (D) duftite, Tsumeb (B.M. 1939,225).

The *d*-spacings are plotted as reciprocals and their approximate values in Ångström units are given against each line, the length of which is an indication of intensity. A cross-bar indicates a broad and possibly composite line on the photograph. Data derived from table I.

TABLE I. X-ray powder data for conichalcite and duftite in Å.

		Duftite.		Tsumeb.		Mapimi.		Brandy Gill.		Conichalcite, Higgins mine.			
hkl.		$d_{calc.}$		*I.*	$d_{obs.}$	*I.*	$d_{obs.}$	*I.*	$d_{obs.}$	$d_{calc.}$		*I.*	$d_{obs.}$
001		—		—	—	—	—	—	—	5·81		m	5·80
011		4·95		w	5·00	vw	5·01	vvw	4·99	4·94		mw	4·95
101		4·64		vw	4·75	vvw	4·76	vvw	4·65	—		—	—
111		4·13		ms	4·18	m	4·18	mw	4·16	4·11		ms	4·16
—		—		—	—	vvw	4·00	—	—	—		—	—
120		—		—	—	—	—	—	—	3·93		w	3·93
200		3·75		w	3·76	vw	3·78	vvw	3·78	3·71		m	3·72
210		3·47		vvw	3·49	vw	3·51	—	—	3·45		m	3·44
121		3·25		vvw	3·32	vvw	3·32 }	vvsb	3·16	{ 3·25		w	3·26
201		3·16		vvs	3·17	vvs	3·17 }			{ 3·13		vs	3·13
030		3·05		vvw	3·07	—	—	—	—	—		—	—
002		2·95		vvw	2·96	vvw	2·94	—	—	—		—	—
130	(012 ?)	2·82	(2·81)	s	2·91	s	2·91	vsb	2·87	2·92	(2·79)	vs	2·85
131		2·61 }		vsb	2·63	vsb	2·63	vsb	2·63	{ 2·62		vs	2·62
221		2·60 }								{ 2·59		ms	2.57
022		2·48		w	2·51	vw	2·52	vw	2·51	2·47		w	2·48
310	(230 ?)	2·41	(2·42)	w	2·42	vw	2·42	vvw	2·42	2·38	(2·42)	wb	2·38
202		2·32		—	—	vvw	2·32	vvw	2·33	2·30		w	2·30
212		2·25		m	2·26	mw	2·26	mw	2·25	2·23		vw	2·23
222		2·11		w	2·12 }	w	2·08	mb	2·08	{ 2·06 }		m	2·06
321		2·05		mw	2·08 }					{ 2·12 }			
132 ?		2·04		vw	2·00	—	—	—	—	—		—	—
240		1·96		vw	1·97	—	—	—	—	1·98		vw	1·97
330		1·931		vw	1·93	—	—	—	—	—		—	—
400		1·911		vw	1·91	—	—	—	—	—		—	—
312		1·867		mb	1·868	msb	1·861	msb	1·851	1·850		m	1·854
232		—		—	—	—	—	—	—	1·839		m	1·832
123		—		—	—	—	—	—	—	1·821 }		m	1·817
410		—		—	—	—	—	—	—	1·819 }			
203		1·741		m	1·750	m	1·745	ms	1·743	1·726		s	1·721
332 ?		1·616		ms	1·637	sb	1·635	s	1·630	1·608		s	1·608
402		1·582		mw	1·586	w	1·584	w	1·584	1·566		mw	1·564
				mw	1·562	w	1·559	w	1·551			mw	1·531
				w	1·483							vw	1·483
				vvw	1·464							w	1·463
				w	1·413							vw	1·441
				w	1·394							vvw	1·419
				vvw	1·359							w	1·386
				mw	1·343							vw	1·372
				mwb	1·322							vvw	1·345
												vvw	1·321
												ms	1·301

Order of decreasing intensity: vvs, vs, s, ms, m, mw, w, vw, vvw; b broad.
6 cm. diameter camera. Cu-$K\alpha$ radiation ($\lambda = 1·542$ Å.).

TABLE II. X-ray powder data in Å. for bayldonite from Cornwall.

I.	*d.*	*I.*	*d.*	*I.*	*d.*	*I.*	*d.*
m	4·92	vw	2·30	vw	1·652	vw	1·260
mb	4·54	m	2·26	mwb	1·613	vw	1·249
vw	3·36	vw	2·17	ms	1·576	vw	1·231
s	3·21	vvw	2·12	vvw	1·508	w	1·221
vvs	3·14	m	1·900	ms	1·467	vvw	1·197
ms	2·93	wb	1·872	vvw	1·449	vvw	1·178
ms	2·71	m	1·816	vvwb	1·402	vw	1·164
mw	2·65	m	1·760	vvw	1·374	wb	1·130
m	2·54	vw	1·737	wb	1·342	w	1·114
m	2·47	vw	1·716	vw	1·316	mwb	1·092
vvw	2·44	m	1·690	vw	1·272		

Order of decreasing intensities: vvs, vs, s, ms, m, mw, w, vw, vvw; b broad.
6 cm. diameter camera, Cu-$K\alpha$ radiation (λ=1·542 Å.).

X-ray investigation.

Comparative powder data for the three duftites are given in table I where they are also compared with a conichalcite from Higgins mine, Bisbee, Cochise Co., Arizona (B.M. 1924,696) (for corresponding photographs see pl. XVI, 2, 3, 4, and 6). These data are plotted on the basis of $1/d$ in text-fig. 1. The indexing of the duftite and conichalcite patterns is based on the single crystal measurements of W. E. Richmond[1] with due regard to the obviously equivalent character of a number of the stronger lines on the two patterns. The restrictions imposed by the somewhat doubtful space-group determination for duftite have not been applied. In a few cases the assignations are uncertain. The Mapimi and Brandy Gill duftite patterns are less well resolved at higher orders than the other two.

Conichalcites from Carissa mine, Mammoth, Utah (B.M. 81763), Calavada mine, Mineral Co., Nevada (B.M. 1948,172), Tintic district, Utah (B.M. 56453 and B.M. 55627), and Congress, Yavapai Co., Arizona (B.M. 1947,267) have also been photographed and are in good agreement with the data for Higgins mine material.

In table II X-ray powder data for bayldonite (pl. XVI, fig. 1) is provided, as this does not appear to have been previously published. Bayldonites from the following localities also gave comparable patterns: St. Day United mines (B.M. 39961, 40632, 42091), Penberthy Croft mine, St. Hilary (B.M. 1905,132, and specimens belonging to Sir Arthur Russell), Wheal Carpenter (Sir Arthur Russell's specimens), and B.M. 1907,885, all from Cornwall; Tsumeb, South-West Africa (B.M. 1912,352, 1912,355,

[1] W. E. Richmond, Amer. Min., 1940, vol. 25, pp. 441–479. [M.A. **8**–11.]

and 1921,432); Sandbeds, Caldbeck Fells, Cumberland (B.M. 1950,445). It is hoped to publish at a later date single-crystal X-ray data for this mineral.

Explanation of Plate XVI.

X-ray powder photographs on 6-cm. diameter camera, Cu-$K\alpha$ radiation ($\lambda = 1{\cdot}542$Å.).

Fig. 1. Bayldonite, Cornwall (B.M. 1907,885).

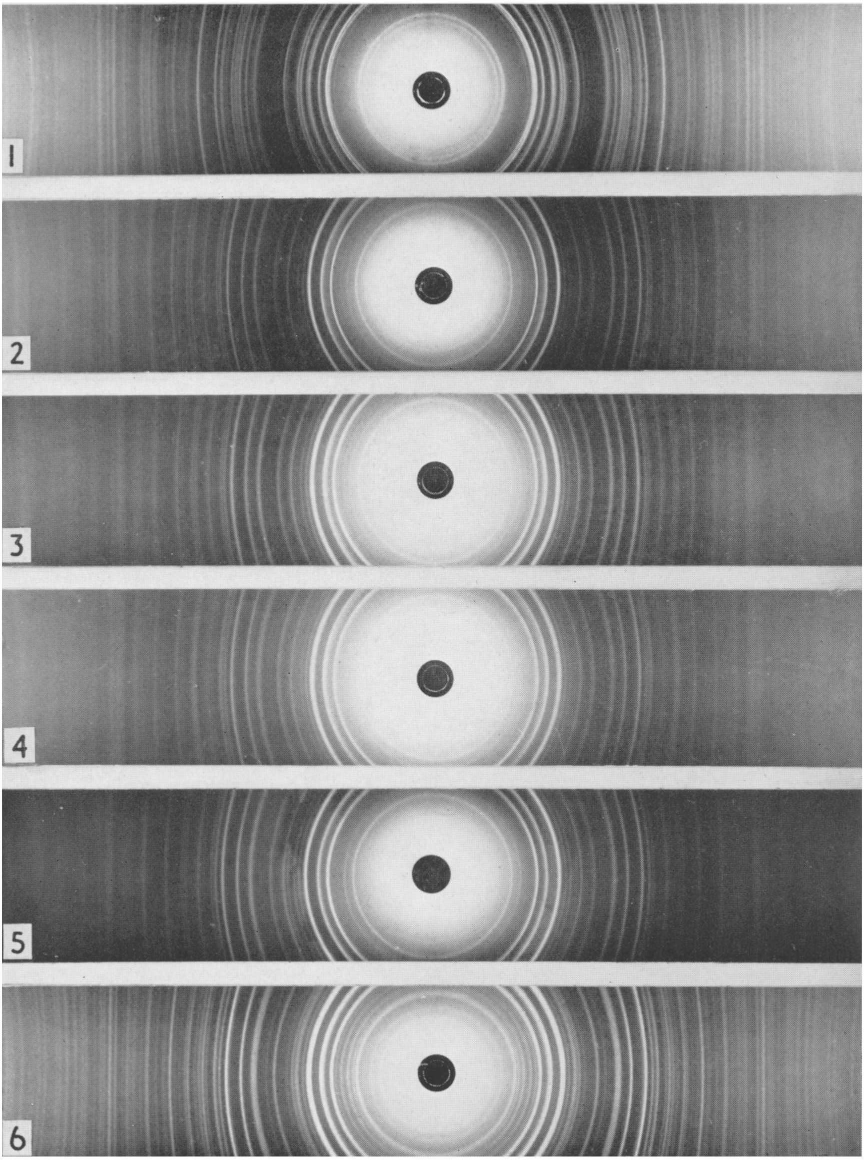
Fig. 2. Duftite, Tsumeb, South-West Africa (B.M. 1939,225).

Fig. 3. Duftite, Ojuela mine, Mapimi, Durango, Mexico (B.M. 1948,267).

Fig. 4. Duftite, Brandy Gill, Caldbeck Fells, Cumberland (W. F. Davidson's specimen).

Fig. 5. Duftite, Brandy Gill, Caldbeck Fells, Cumberland (B.M. 1950,443). Nearer to conichalcite than fig. 4.

Fig. 6. Conichalcite, Higgins mine, Bisbee, Arizona (B.M. 1924,696).



G. F. CLARINGBULL: X-RAY PHOTOGRAPHS OF DUFTITE