X-ray, optical, and morphological observations on hodgkinsonite from Franklin Furnace.[1]

By W. M. B. Roberts

Bureau of Mineral Resources, Geology, and Geophysics, Canberra, A.C.T., Australia,

and

F. M. Quodling,

Department of Geology and Geophysics, The University of Sydney, Sydney, Australia.

[Taken as read 8 November 1962.]

Summary. Re-examination of hodgkinsonite by optical and X-ray methods has shown the desirability of adopting a setting different from that selected by Palache and Schaller and by Rentzeperis. In the new arrangement the *b* and *c* axes are interchanged and the original negative end of the *b*-axis becomes positive. A table of angles for the common forms is given, also X-ray powder data and a space-group determination.

EARLY studies of the morphology of hodgkinsonite were made by Palache and Schaller (1914); when better crystals became available, Palache (1914) recorded angle measurements and forms and gave the elements: $a:b:c = 1{\cdot}538:1:1{\cdot}1075$, β 95° 25′. In 1935 Palache published a beautifully illustrated note dealing largely with habit variations in hodgkinsonite.

We have made X-ray observations (W. M. B. R.) and optical and morphological studies (F. M. Q.). Both approaches show that the adoption of a new parametral plane and a reorientation of the crystallographic axes are warranted.

X-ray examination. This analysis was carried out in the Department of Mineralogy and Petrology at the University of Cambridge under the guidance of Dr. P. Gay. The hodgkinsonite used was a portion of specimen 1934.75 from the museum of the same Department. The mineral is associated with calcite, and forms a coarsely crystalline vein about 6 mm wide, cutting across a granular aggregate of franklinite and willemite. Because of the large grain-size and the perfect cleavage, a

[1] Published by permission of the Director, Bureau of Mineral Resources.

small fragment for single-crystal study was readily obtained. A series of Laue photographs showed the mineral to belong to Laue group $2/m$.

Taking the perfect cleavage as (001) (Palache, 1935), the values found for the cell dimensions from oscillation photographs are: a 8·12 Å, b 5·30 Å, c 11·71 Å, all ±0·05 Å. From the b-axis Weissenberg photograph, the $h0l$ diffractions had h even, suggesting a glide-plane, which was confirmed by a first-layer-line equi-inclination Weissenberg photograph about the same axis. By convention this was made a c-glide, necessitating a transformation of axes. The new axes are: a 11·71 Å, b 5·30 Å,

TABLE I. Unit-cell contents of hodgkinsonite, calculated from the cell-dimensions a 11·71, b 5·30, c 8·12 Å, β 95° 15′, density 3·99, and three analyses quoted by Palache (1935).

	1.		2.		3.	
Si	4·07		3·902		3·981	
Zn	8·013	8·024	7·831	8·141	7·685	7·976
Fe	nil		nil		0·132	
Mg	0·011		0·310		0·159	
Mn	3·590	3·793	3·796	3·928	3·968	4·099
Ca	0·203		0·132		0·132	
H_2O	3·948		4·118		3·700	
O	19·957		19·423		20·038	

c 8·12 Å, all ±0·05 Å, and giving axial ratios $a:b:c = 2·2094:1:1·532$, β 95° 15′; they are related to Palache's axes by the axial transformation (Palache to X-ray) [001/0$\bar{2}$0/200]. The cleavage now becomes {100}.

The general reflections hkl gave no systematic absences, and the lattice is therefore primitive. An a-axis Weissenberg photograph showed that the reflections $0k0$ all have k even, indicating the presence of a screw-axis normal to the c glide-plane. Consequently the space-group is $P2_1/c$.

The volume of the unit cell is 502·41 Å^3; using the density of 3·91 given by Palache, there are 4 (3·8) formula units per unit cell. The calculated density is 4·12; a fragment of material was measured on the Roller-Smith balance, and the observed density was 3·99. Table I gives the unit-cell contents calculated from the measured density of 3·99, the present cell-dimensions, and the three analyses quoted by Palache (1935). In the Sterling Hill and Franklin Furnace memoir Palache gave the water as 'water at 110°' (1935); Palache and Schaller (1914) stated that no water was given off at 110° C. A specimen was heated at 120° C for 2 hours by Mr. J. H. Scoon of the Dept. of Mineralogy and Petrology, and no loss in weight occurred. The ratios $Mn:Zn:Si:H_2O$ agree with those

given by Palache, i.e. 1:2:1:1, the structural formula being $(Mn,Ca)[(Zn,Mg,Fe)OH]_2SiO_4$.

Table II gives the X-ray powder data for hodgkinsonite, obtained on a diffractometer with Cu-$K\alpha$ radiation, nickel filter, and using a silicon internal standard.

TABLE II. X-ray powder data for hodgkinsonite; Cu-$K\alpha$ radiation.

$\theta°$.	d.	I.	$\theta°$.	d.	I.	$\theta°$.	d.	I.
11·3	3·931	30	18·07	2·483	40	26·48	1·727	30 broad
11·9	3·735	25	18·60	2·407	50	27·15	1·688	30
12·23	3·636	30	19·33	2·327	55	27·75	1·654	50
12·72	3·498	25	19·51	2·306	30	28·90	1·594	60
13·81	3·227	50	19·96	2·256	15	29·85	1·547	85
14·60	3·056	30	20·85	2·164	40	29·90		
14·80	3·015	40	21·36	2·115	60	30·35	1·524	45 broad
15·10	2·957	90	22·26	2·033	30	31·00	1·495	50
15·60	2·864	100	23·28	1·950	50	31·60	1·470	45 broad
16·30	2·744	30	24·00	1·893	40	32·65	1·428	55
16·63	2·691	25	25·00	1·823	55	32·73		
16·87	2·654	30	25·72	1·775	50	33·075	1·412	65
17·35	2·583	50	26·07	1·753	45	33·20		
17·46	2·567	65						

Optical properties. The hodgkinsonite from specimen 1934.75 was pale mauve and distinctly pleochroic. Cleavage sections gave off-centred one-brush interference figures of negative sign, and showed colourless to faint blue-green. Refractive indices were determined by immersion and 2V by universal stage measurement.

The position of α relative to [001] in the (010) plane was established only after studying additional crystals made available from the Franklin Furnace specimens in the Australian Museum, Sydney, through the courtesy of Mr. R. O. Chalmers.

The optical properties may be summarized as follows: α 1·720±0·001, pink-amethyst, β 1·741±0·002, colourless to faint blue-green; γ 1·746±0·002, pale amethyst; $2V_\alpha$ 52°±30′ (measured), 52°26′(calc.); distinct dispersion $r > v$; $\beta \parallel [010]$; α:[001] 44° in the acute angle β.

Morphology. Australian Museum specimens of hodgkinsonite crystals from Franklin Furnace were examined for form development. Their size ranged from 3 mm down to microscopic dimensions. All were doubly terminated and wedge-shaped, a habit that Palache (1935) illustrated (fig. 166) and described as common. He stated that the crystals were 'of acute pyramidal habit, determined by the development of the unit prism and the steep hemipyramid (221)'. X-ray examination has shown that the a and c crystallographic axes of Palache's orientation should be

interchanged (see above), and Palache's $r\{221\}$ becomes the parametral form {111}. The longitude and co-latitude of common forms in the new setting have been calculated from Palache's data and are listed in Table III.

TABLE III. Angle-table for hodgkinsonite, with form indices in Palache's and the new settings.

Palache.	New.	Longitude.	Co-latitude.	Palache.	New.	Longitude.	Co-latitude.
$c\{001\}$	{100}	90° 0′	90° 0′	$w\{\bar{2}01\}$	$\{\bar{1}01\}$	−90° 0′	30° 57′
$o\{021\}$	{110}	24 24	90 0	$v\{\bar{4}03\}$	$\{\bar{3}02\}$	−90 0	43 25
$s\{011\}$	{210}	42 12	90 0	$r\{221\}$	{111}	27 16	59 52
$l\{210\}$	{012}	7 3	37 39	$p\{111\}$	{211}	44 5	64 51
$m\{110\}$	{011}	3 32	56 59	$E\{\bar{4}21\}$	$\{\bar{1}12\}$	−18 20	38 54
$t\{\bar{4}01\}$	$\{\bar{1}02\}$	−90 0	14 10	$P\{\bar{1}11\}$	$\{\bar{2}11\}$	−40 12	63 35

In the new setting the common forms are $r\{111\}$, $m\{011\}$, $s\{210\}$, and $o\{110\}$, the face transformation from Palache's to the new setting being $[002/0\bar{1}0/100]$. Comparison of the face indices in the old and new settings shows that the new leads to simpler indices.

References.

PALACHE (C.) and SCHALLER (W. T.), 1914. Zeits. Kryst. Min., vol. 53, p. 529.
—— 1914. Ibid., p. 675.
—— 1935. U.S. Geol. Survey Prof. Paper 180.
RENTZEPERIS (P. J.), 1958. Acta Cryst., vol. 11, p. 448.