

*Okenite and nekoite (a new mineral).*

(With Plate I.)

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*Summary.*—The unit cell of okenite ( $\text{CaO} \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ ) has been determined for a specimen from Bombay, India, using a combination of X-ray, electron-microscope, and electron-diffraction methods. It is anorthic with<sup>1</sup>  $a$  9.84,  $b$  7.20,  $c$  21.33 Å.,  $\alpha$  90.0°,  $\beta$  103.9°,  $\gamma$  111.5°, elongation  $b$ ,  $Z = 9$ . These data are compatible with the goniometric results of Bøggild (1922) and allow the latter to be interpreted.

A specimen from Crestmore, California, which Eakle (1917) had described as okenite, was also examined. It was found to be a new species, having the same composition as okenite but distinguishable from it by its optical properties, X-ray powder data, and unit cell. The latter is anorthic with<sup>1</sup>  $a$  7.60,  $b$  7.32,  $c$  9.86 Å.,  $\alpha$  111° 48',  $\beta$  86° 12',  $\gamma$  103° 54', elongation  $b$ ,  $Z = 3$ . Because of the relation to okenite, the name *nekoite* is suggested.

## PART I. OKENITE.

**O**KENITE ( $\text{CaO} \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ ) was discovered on Disko Island, Greenland. It was first analysed by von Kobell<sup>2</sup> and described by Breithaupt.<sup>3</sup> It has since been found in other localities, usually associated with basalt. Satisfactory optical and goniometric data were first obtained by Bøggild;<sup>4</sup> the former are given in table I and the latter in table IV. These data showed that okenite was anorthic, but the axial ratios could not be obtained. The optical data were confirmed by Tilley and Alderman.<sup>5</sup> X-ray powder data have been reported (table II), and X-ray photographs of fibrous aggregates have shown that okenite belongs to the group of fibrous hydrated calcium silicates having a repeat distance of about 7.3 Å. in the fibre direction.<sup>6</sup> No single-crystal data have been reported and the unit cell has not previously been determined.

<sup>1</sup> This cell is not in conventional orientation: see pp. 13 and 16, footnotes.

<sup>2</sup> F. von Kobell, Arch. gesammte Naturlehre (Kastner), 1828, vol. 14, p. 333.

<sup>3</sup> A. Breithaupt, Ann. Phys. Chem. (Poggendorff), 1845, vol. 64, p. 170.

<sup>4</sup> O. B. Bøggild, Kgl. Danske Vidensk. Selsk., Math.-fys. Medd., 1922, vol. 4, no. 8 [M.A. 2-59].

<sup>5</sup> C. E. Tilley and A. R. Alderman, Min. Mag., 1934, vol. 23, p. 513.

<sup>6</sup> H. F. W. Taylor, Proc. Int. Symp. Reactivity of Solids, Gothenburg, 1952 p. 677.

*Optical and X-ray investigation.*

A specimen from the Syhadree Mountains, Bombay, India (B.M. 27989), was employed. It consisted of fibrous aggregates showing parallel extinction, positive elongation, low birefringence, and mean

TABLE I. Optical and unit-cell data for okenite and nekoite.

<i>Optical data.</i>	Okenite.	Nekoite.
Locality:	Disko Island and Faeroe Islands	Crestmore, California
Investigator:	Bøggild	This investigation
Habit:	Usually fibrous. Single crystals are prisms with one good cleavage	Needles with one good cleavage
Twinning:	On the cleavage face, very common. On the prism axis, rare	Needles show repeated twinning with lamellae parallel to the cleavage
Indices:	$\alpha'$ 1.530, $\gamma'$ 1.541	Mean 1.535 $\pm$ 0.002 (Na)
Birefringence:	0.011	Very low
Extinction:	Crystals lying on the cleavage have parallel extinction, + elongation. In other orientations, extinction is oblique; for laths lying on edge it makes $32 \pm 2^\circ$ , and for laths standing on end, $25^\circ$ with the cleavage trace	Always inclined. Individual lamellae lying on the cleavage have - elongation, extinction angle $26^\circ$ . Lamellae standing on edge have - elongation, extinction of adjacent twin lamellae symmetrical at $5^\circ$ to the twin boundaries
Interference figure:	?	Individual lamellae lying on the cleavage give a poor biaxial + acute bisectrix figure
2V:	Probably large	$70^\circ$ approx.
Optic sign:	Negative*	Positive
Optic orientation:	?	X makes about $26^\circ$ with the needle axis, and Z is roughly perpendicular to the cleavage
<i>Unit-cell data.</i>		
System:	Anorthic	Anorthic
Parameters:	$a$ 9.84 Å. $b$ 7.20 $c$ 21.33 ( $3 \times 7.11$ ) $\alpha$ $90^\circ$ $\beta$ $103.9^\circ$ $\gamma$ $111.5^\circ$	$c$ 9.86 Å. $b$ 7.32 $a$ 7.60 $\gamma$ $103^\circ 54'$ $\beta$ $86^\circ 12'$ $\alpha$ $111^\circ 48'$
Cell contents:	9[CaO.2SiO <sub>2</sub> .2H <sub>2</sub> O]	3 [CaO.2SiO <sub>2</sub> .2H <sub>2</sub> O]
Fibre direction:	$b$	$b$
Cleavage:	(001)	(100)

\* C. E. Tilley and A. R. Alderman, loc. cit., for a specimen from Scawt Hill (Northern Ireland).

refractive index,  $1.540 \pm 0.003$ . Similar data were obtained by Christie<sup>1</sup> for a specimen of a comparable degree of crystallinity, also from Bombay. The data are compatible with those obtained by Bøggild for single crystals from the type locality and elsewhere although, because they relate to fibrous aggregates, they are necessarily less detailed.

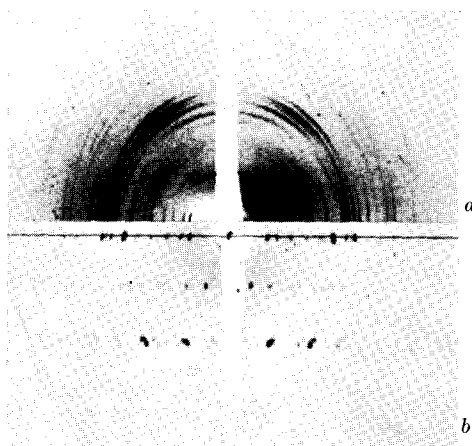


FIG. 1. X-ray rotation photographs about the needle or fibre axis. Cu- $K\alpha$  radiation. *a*, okenite, Bombay; *b*, nekoite, Crestmore.

X-ray powder data, obtained using 6-cm. and 19-cm. diameter cameras with Cu- $K\alpha$  radiation, are included in table II. They are in substantial agreement with the various sets of data obtained by previous workers, including those of McMurdie and Flint, which probably relate to material from the type locality. Minor differences exist between all the sets of data, but they can probably be attributed to the presence of impurities in some or all of the specimens, and the data indicate that all consist of substantially the same mineral.

The X-ray fibre rotation patterns previously reported, and reproduced in fig. 1*a*, showed that the repeat distance along the fibre axis (later shown to be *b*) was  $7.20 \text{ \AA}$ . They also enabled the *k*-indices of the powder reflections to be determined, and these indices are also included in table II.

Attempts to isolate single crystals of sufficient size for X-ray work were unsuccessful, even the thinnest fibres giving rotation photographs. Complete indexing of the data by X-ray means was therefore not possible, and electron diffraction was employed.

<sup>1</sup> W. A. K. Christie, Rec. Geol. Survey India, 1925, vol. 56, p. 199 [M.A. 3-287].

TABLE II. X-ray powder data for okenite and nekoite. Spacings in Å.

1.		2.			3.		4.		5.	
<i>d.</i>	<i>I.</i>	<i>d.</i>	<i>I.</i>	<i>k.</i>	<i>hkl.</i>	<i>d.</i>	<i>d.</i>	<i>I.</i>	<i>hkl.</i>	<i>d.</i>
10.61	30	21	vvvs	0	001	20.6				
		10.3	vw	0	002	10.3				
8.87	100	8.8	vs	0	200	8.84	9.25	vs	001	9.15
7.65	70	7.4	mw	0	201	7.46	7.45	w	100	7.39
6.72	70	6.8	vw	1	110	6.67	6.61	w	{ 01 $\bar{1}$	6.63
		6.19	w	0	20 $\bar{3}$	6.26			{ 010	6.61
5.72	30	5.79	vvw	1	11 $\bar{2}$	5.86			{ (10 $\bar{1}$	5.82
							5.64	w(b)	{ 101	5.67
5.35	10	5.22	w	0	004	5.25			{ $\bar{1}$ 1 $\bar{1}$	5.55
									{ 002	4.57
4.57	90	4.42	w	0	400	4.42	4.55	vw	{ (110	4.44
4.23	70	4.27	vvw(b)	1	311	4.28				
4.08	70	4.08	vw	0	401	4.11	4.14	vw	$\bar{1}$ 1 $\bar{2}$	4.20
3.90	70	3.90	vw	1	114	3.90				
3.56	90	3.56	vs	0 &	{ 405	3.56				
					{ 021	3.55				
					{ 22 $\bar{1}$	3.34				
3.35	60	3.34	vvw	2	{ 220	3.33	3.36	vs(b)	{ 201	3.39
					{ 510	3.18			{ (020	3.30
		3.22	vvw	1	{ 51 $\bar{3}$	3.18				
					{ 116	3.18				
					{ 60 $\bar{2}$	3.05				
		3.07	s	0 &	{ 207	3.04				
					{ 222	3.08	3.04	w	003	3.05
3.09	90	3.05	s	0	{ 60 $\bar{1}$	3.03				
					{ 60 $\bar{3}$	3.00				
(2.99 m)*		2.98	ms	0 &	{ 404	2.99				
					{ 22 $\bar{4}$	3.01				
					{ 024	2.95				
					{ 600	2.95				
2.92	90	2.93	vs	0 &	{ 206	2.95	2.92	w	{ 12 $\bar{1}$	2.94
					{ 007	2.94			{ 20 $\bar{2}$	2.91
					{ 223	2.89			{ 202	2.84
		2.80	w	0	{ 40 $\bar{7}$	2.81			{ 12 $\bar{2}$	2.81
2.78	70	2.77	ms	2	420	2.79	2.82	vs	{ (02 $\bar{3}$	2.81
2.69	30	2.68	vw	0	602	2.66			{ 103	2.79
2.53	40	2.53	w	0	40 $\bar{8}$	2.53			{ 120	2.78
		2.44	vvw	2	423	2.45	2.47	ms	{ 121	2.45
2.39	60	2.38	vw	0	20 $\bar{9}$	2.37	2.36	vw	301	2.36
					{ 22 $\bar{7}$	2.32				
2.30	40	2.30	vw	2	{ 62 $\bar{1}$	2.32	2.28	vw		
					{ 424	2.30				
					{ 226	2.28				
2.22	40	2.24	w	0	{ 60 $\bar{8}$	2.25				
		2.20	w	2	{ 407	2.24				
(2.16 w)*		2.15	mw	0	{ 427	2.21	2.20	w		
					{ 605	2.15	2.15	vvw		
1.98	60	1.98	vw	0	{ 209	2.15				
		1.91	vw(b)	0	803	1.96	2.09	vvw		
					0.11.0	1.87				
1.88	60	1.89	w	2	{ 62 $\bar{8}$	1.91	1.90	mw		
					{ 820	1.88				
					{ 427	1.88				
		1.84	vw	2	{ 625	1.84				
					{ 821	1.82				

TABLE II (cont.)

1.		2.			3.		4.		5.	
<i>d.</i>	<i>I.</i>	<i>d.</i>	<i>I.</i>	<i>k.</i>	<i>hkl.</i>	<i>d.</i>	<i>d.</i>	<i>I.</i>	<i>hkl.</i>	<i>d.</i>
1.80	90	1.80	s	4	040	1.80	1.83	ms		
1.77	30	1.77	vw				1.79	mw		
1.73	20	1.74	vwv							
		1.71	vwv							
1.68	30	1.68	vwv				1.69	w		
1.63	10	1.64	vwv(b)				1.65	vw		
							1.615	vw		
1.58	40	1.59	ms				1.583	vwv		
1.55	30	1.56	mw				1.546	w		
1.51	40	1.52	mw							
1.45	40	1.47	vwv				1.455	vw		
1.43	30	1.45	mw				1.413	vwv		
1.39	30	1.39	vwv				1.392	vwv		
1.36	40	1.36	mw				1.357	vw		
1.33	40	1.33	w							
1.28	20	1.289	w							
1.26	20	1.256	w							
1.21	30	1.207	w							
1.19	30	1.193	vw							
1.14	10	1.146	vw							
1.11	10	1.112	w							
		1.080	w							
		1.064	w							

- Okenite, Bordö, Faeroe Islands. American Society for Testing Materials. Card File of X-Ray Diffraction Data. Cards Nos. 2-0069 and 2-0070, from data supplied by Imperial Chemical Industries Ltd., Northwich, England. Relative intensities on numerical system.†
- Okenite, B.M. 27989, Syhadree Mtns., Bombay. This investigation. Cu- $K\alpha$  radiation. *k*-indices deduced from fibre photographs.
- Okenite. Indices and spacings calculated on the basis of the monoclinic pseudo-cell of the present investigation.
- Nekoite, U.S.N.M. 95637, Crestmore, California. This investigation. Cu- $K\alpha$  radiation.
- Nekoite. Anorthic indices and calculated spacings. Indices and calculated spacings of weak reflections making minor contributions to the powder photograph are enclosed in parentheses; those of very weak reflections making negligible contributions are omitted.

\* Data of McMurdie and Flint (see below); these lines were not recorded in the I.C.I. data.

† Less complete powder data for okenite were given by L. M. Clark and C. W. Bunn (Journ. Soc. Chem. Ind., 1940, vol. 59, p. 155 [M.A. 8-116]), locality and radiation not stated; and by H. F. McMurdie and E. P. Flint (Journ. Res. Nat. Bur. Stand. U.S.A., 1943, vol. 31, p. 225 [M.A. 9-45]; A.S.T.M. Index, Card No. 2-0068), Disko Island, Greenland, Cu- $K\alpha$  radiation.

#### Electron-diffraction investigation.

A Metropolitan-Vickers EM3 electron microscope was used. The operation of this type of instrument has been described elsewhere.<sup>1</sup> It

<sup>1</sup> C. E. Challice, Proc. Physical Soc., ser. B, 1950, vol. 63, p. 59; J. F. Brown and D. Clark, Acta Cryst., 1952, vol. 5, p. 615; T. B. Rymer, Brit. Journ. Appl. Phys., 1953, vol. 4, p. 297.

can be used both as an electron microscope and as a diffraction instrument. In the latter case, the area of the specimen from which the diffraction pattern is obtained can be reduced to a circle about  $2\mu$  in diameter. A pattern can thus be obtained from a very small individual crystal, and its orientation relative to the outline of the crystal can be determined. The diffraction pattern is a practically undistorted picture of the reciprocal lattice in the plane through the origin and normal to the electron beam.

Specimens were prepared by crushing a little material in water and allowing a drop of the dilute suspension to dry on a film-coated specimen grid. An electron micrograph is shown in pl. I, A, B, and C. The crystals were laths of average dimensions  $6 \times 2 \times 0.5 \mu$ . On closer examination these were seen to consist of very thin parallel sheets, with excellent cleavage in planes parallel to the supporting film, i.e. normal to the electron beam. Individual sheets were found by shadow-casting<sup>1</sup> to vary in thickness between about 20 and 250 Å. It will be shown later that these sheets are possibly twin lamellae.

The laths had well-defined edges along a direction later identified with the fibre axis of the X-ray rotation photograph, but no faces other than the one cleavage face could be distinguished.

The crystals all gave substantially identical diffraction patterns, a typical example being shown in fig. 2*a*. If the cleavage plane normal to the beam is taken as (001), two unit-cell dimensions  $a$  and  $b$ , and the angle  $\gamma$ , can be obtained directly from the pattern. The reciprocal lattice direction  $c^*$  coincides with the electron beam, but the  $(0a^*b^*)$  plane coincides with (001) only if  $\alpha$  and  $\beta$  are both  $90^\circ$ . Evidence will be presented to show that this is not the case, and that the pattern is therefore a projection of the  $(0a^*b^*)$  plane in the direction of the beam, the large number of reflections recorded being due to the fact that the reciprocal lattice points are elongated parallel to the thin direction of the crystal.

Measurement of the pattern showed that all the reflections could be fitted geometrically on to a  $c$ -face centred monoclinic reciprocal lattice, and the resulting dimensions for the real and reciprocal cells are given in fig. 3*a*. The relative intensities depend on too many factors to confirm or disprove monoclinic symmetry, but the goniometry and optical data strongly indicate anorthic symmetry. It therefore seemed preferable to express the results in terms of an anorthic unit cell. These are given for the real and reciprocal cells in fig. 3*b*.

<sup>1</sup> R. E. Williams and R. W. G. Wyckoff, Journ. Appl. Phys., 1944, vol. 15, p. 712.

The other three parameters,  $c$ ,  $\alpha$ , and  $\beta$ , were obtained from a comparison of electron-diffraction and X-ray data. The two longest X-ray spacings (21 and 10.3 Å.; table II) have  $(h0l)$  indices, but are too large to correspond to any of the  $(h00)$  reflections, found using electron diffraction. They therefore have  $(00l)$  indices, and were assumed to be respectively (001) and (002), giving  $c^* = 1/(20.6) \text{ \AA.}^{-1}$

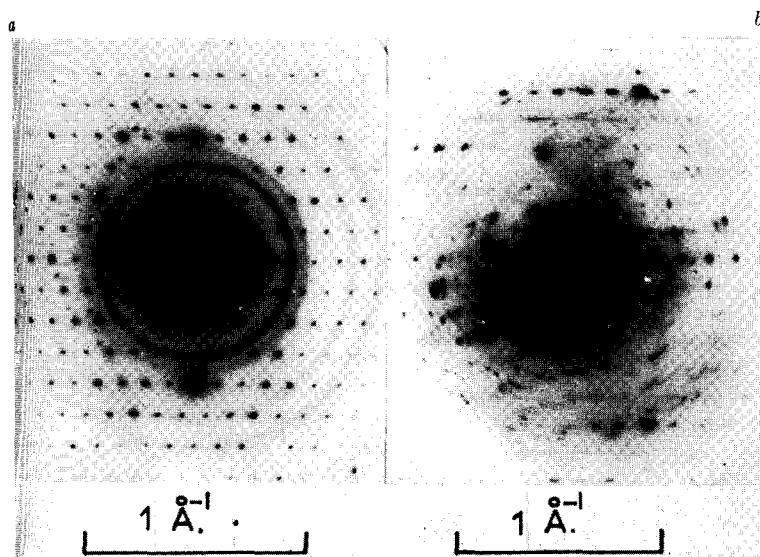


FIG. 2. Electron-diffraction patterns given by single flakes in the electron microscope. *a*, okenite lying on (001); *b*, the same after heating at 1000° C. Fibre direction vertical in each case.

The repeat distance of 7.20 Å. along the fibre direction, found using X-rays, agrees with the value of  $b$  obtained with electron diffraction. The  $(0a^*b^*)$  plane of the reciprocal lattice therefore coincides with (001) along the fibre direction ( $b$ ), making  $\alpha = 90^\circ$ .

The third longest X-ray spacing, of approximately 8.8 Å., also has  $(h0l)$  indices. It was assumed that that of 4.42 Å. was its second order, giving a more precise value of 8.84 Å. This does not agree with any of the apparent  $(h00)$  spacings measured by electron diffraction, but is near enough to the apparent (100) (monoclinic (200)) spacing of 9.09 Å. (fig. 3) to suggest that the two are probably associated with the same elongated reciprocal lattice point. If this assumption is correct, the angle  $(90 - \beta^*)$  which  $a^*$  makes with (001) is equal to  $\cos^{-1}(8.84/9.09)$ ,

or approximately  $13^\circ$  (fig. 4).  $\beta$  is therefore approximately  $(90+13)^\circ$ , or  $103^\circ$ .

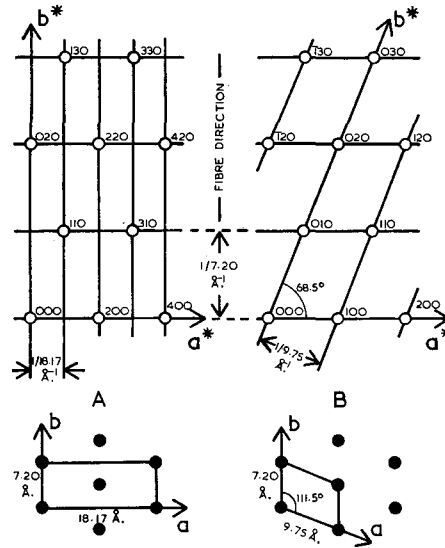


FIG. 3. Interpretation of the electron-diffraction pattern of okenite. A (*left*): observed reflections indexed on the (001) projection of a geometrically monoclinic *c*-face centred reciprocal lattice, with the corresponding real pseudo-cell below. B (*right*): the same reflections indexed on the (001) projection of an orthorhombic reciprocal lattice, with the corresponding real unit cell below.

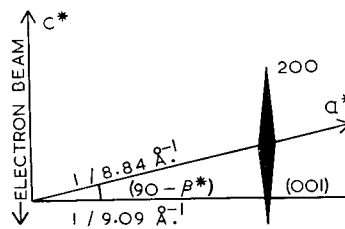


FIG. 4. Determination of the approximate value of pseudo-monoclinic  $(90 - \beta^*)$  for okenite, by comparison of X-ray and electron-diffraction data. Section of the reciprocal lattice passing through the origin and normal to *b*, showing how the apparent *a*-axis of 9.09 Å, derived from electron-diffraction data may be reconciled with the value of 8.84 Å, given by the X-ray data.

*Unit cell, twinning, and goniometric data.*

From the above considerations the monoclinic pseudo-cell was assumed provisionally to have the parameters  $a$  18.18,  $b$  7.20,  $c$  21.2 Å.,  $\beta$  103°. In order to check that these parameters were basically correct, and also to obtain a more accurate value of  $\beta$ , spacings were calculated and compared with the X-ray powder and fibre data. Several values of  $\beta$  were tried, and good agreement between observed and calculated values, as regards both spacings and  $k$ -indices, was obtained for  $\beta = 105^\circ$  (table II). The revised parameters for the monoclinic pseudo-cell were thus found to be<sup>1</sup>  $a$  18.30,  $b$  7.20,  $c$  21.33 Å.,  $\beta$  105°. The corresponding anorthic unit cell has<sup>2</sup>  $a$  9.84,  $b$  7.20,  $c$  21.33 Å.,  $\alpha$  90.0°,  $\beta$  103.9°,  $\gamma$  111.5°.

In the course of the electron-diffraction investigation, attempts were made to determine  $c$  directly by the method of Laue zones.<sup>3</sup> These were unsuccessful, no division of the pattern into zones being observed, even though the specimen stage was tilted at angles up to 35° from the normal position, and diffraction patterns recorded for many crystals with their fibre axes approximately parallel to the axis of tilt. This remarkable absence of zoning is accounted for if the crystals have repeated lamellar twinning across the cleavage plane, so that the continuous row of lattice points along  $c$ , needed for the production of Laue zones, is not present. Twinning according to this law was found by Bøggild to be very common in larger crystals. The present results, including the appearance of the crystals in the electron microscope (pl. I), suggest that repeated twinning of this type may occur in the fibrous material from Bombay on a very small scale in which individual twin lamellae are perhaps sometimes only a few unit cells thick. This might be expected to have some influence on the X-ray pattern; in fact, Heller<sup>4</sup> observed minor variations in the patterns obtained from different fibres taken from this same specimen of okenite, and mentioned complex twinning as one possible explanation.

Calculation from the unit-cell data obtained in the present investiga-

<sup>1</sup> This cell, having  $c > a$ , is not in the conventional orientation. Application of the transformation matrix  $\|001/0\bar{1}0/100\|$  gives:  $a$  21.33,  $b$  7.20,  $c$  18.30 Å.,  $\beta$  105°; fibres parallel to  $b$ , cleavage (100).

<sup>2</sup> This cell is not in the conventional orientation. Application of the transformation matrix  $\|100/00\bar{1}/010\|$  gives:  $a$  9.84,  $b$  21.33,  $c$  7.20 Å.,  $\alpha$  90.0°,  $\beta$  111.5°,  $\gamma$  86.1°; fibres parallel to  $c$ , cleavage (010).

<sup>3</sup> J. F. Brown and D. Clark, loc. cit.

<sup>4</sup> L. Heller, Proc. Third Internat. Symposium Chemistry of Cement, London, 1952; Cement and Concrete Association, London, 1954, p. 237.

tion and the chemical analysis and specific gravity (2.302) determined by Christie, gave the cell contents listed in table III. They indicate the ideal formula  $9[\text{CaO} \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}]$  or  $\text{Ca}_9\text{Si}_{18}\text{O}_{63}\text{H}_{36}$  per (anorthic) unit cell.

Bøggild obtained approximate goniometric data for very small single crystals from Disko Island and the Faeroe Isles. He described them as laths with cleavage (010) and length  $c$ . His results, obtained using a

TABLE III. Chemical analyses and unit-cell contents of okenite and nekoite.

				1.	2.			1a.	2a.
SiO <sub>2</sub>	...	...	...	53.88	56.17	Si	...	16.86	6.21
Al <sub>2</sub> O <sub>3</sub>	...	...	...	0.08	—	Al	...	0.04	—
Fe <sub>2</sub> O <sub>3</sub>	...	...	...	0.01	—	Fe	...	—	—
CaO	...	...	...	27.61	26.10	Ca	...	9.00	3.09
SrO	...	...	...	0.27	—	Sr	...	0.04	—
Na <sub>2</sub> O	...	...	...	0.12	—	Na	...	0.06	—
K <sub>2</sub> O	...	...	...	0.06	—	K	...	0.02	—
H <sub>2</sub> O	...	...	...	18.02	16.83	H	...	37.8	12.4
				100.05	99.10	O	...	61.6	21.7
Sp. gr.	...	...	...	2.302	2.206				

1. Okenite, Bombay. W. A. K. Christie (analysis no. 2).

2. Nekoite, Crestmore. A. S. Eakle (analyst, W. F. Foshag).

1a. Atomic cell-contents calculated from analysis 1 (anorthic cell).

2a. Atomic cell-contents calculated from analysis 2 (anorthic cell).

two-circle goniometer, are given in table IV, which shows also that each of the faces which he measured can be satisfactorily explained on the basis of the anorthic cell found in the present investigation. Bøggild's choice of axes was not retained, because it obscures the relation between

TABLE IV. Comparison of observed and calculated goniometric data for okenite.

Indices.		Bøggild.		Calculated.	
New		$\phi$ .	$\rho$ .	$\phi$ .	$\rho$ .
Bøggild. (anorthic).	(001)	0°	90°	0°	90°
(010)	(102)	56 ± 2°	90°	58°	90°
(hk0)	(100)	76(68-82)°	90°	75°	90°
(001)	(011)	141 ± 5°	33 ± 2°	139°	31°
(hkl)	(111)	118°	54°	119°	53°
(hko)*	(102)	39°	90°	41°	90°
(010)†	(001)	0°	90°	0°	90°

For the interaxial angle  $\beta$  in his orientation ( $\gamma$  in the new anorthic orientation), Bøggild found 67-68°; we calculate 68.5°.

\* Composition plane of twins about Bøggild's  $c$  [001] (new anorthic  $b$  [010]).

† Composition plane of twins across Bøggild's (010) (new anorthic (001)).

