ON ROSENBUSCHITE

BY

M. A. PEACOCK

WITH 3 FIGURES

Rosenbuschite is one of the numerous mineral species named by Brøgger (1887) and described in full detail in his great work on the minerals of the syenite-pegmatites of southern Norway (1890). This rare mineral occurs in sparse pale-orange patches of close-packed parallel to divergent fibres and needles embedded in coarsely crystallized pegmatite at Langesundsfjord. From the straight extinction of the fibres and such meagre goniometric measurements as were possible on this unfavourable material, Brøgger concluded that rosenbuschite is monoclinic, elongated with the symmetry axis. Taking the plane of cleavage parallel to the needle-axis as the base, and naming the observed forms $c\{001\}$, $a\{100\}$, $s\{\overline{2}01\}$, $h\{540\}$, Brøgger obtained geometrical elements somewhat similar to the accepted monoclinic elements of pectolite and wollastonite. Analyses on limited material revealed a complex composition which Brøgger interpreted as essentially a fluo-silicate, zirconate and titanate of lime and soda, of metasilicate type. These crystallographic and chemical findings appeared to form a firm basis for accepting rosenbuschite as a zircon-pectolite and appending it to the wollastonite group, which was regarded as a part of the wider group of the pyroxenes. Since the appearance of Brøgger's work no direct observations on rosenbuschite have been recorded.

Recent studies on unusually well-developed crystals of wollastonite (author, 1935 A) and pectolite (author, 1935 B) led in both cases to triclinic elements directly comparable to the elements of the structure lattices of these minerals previously determined by Warren and Biscoe (1931). The absolute lattice elements of the two minerals are nearly alike; and in both cases the classical monoclinic lattices are related to the proper triclinic lattices in such a manner that the important vertical planes with the improbable symbols (140) and (540)

in the monoclinic lattices receive the natural symbols (010) and (110), respectively, in the triclinic lattices, while the symbols in the common main zone [010] remain unchanged. Since schizolite and vogtite were already known to be triclinic with lattice elements similar to the newly determined elements of wollastonite and pectolite, the wollastonite group proved to be a group of homeomorphous triclinic minerals to which rosenbuschite presumable also belonged.

In view of the analogy which Brøgger had established between rosenbuschite and pectolite, the writer considered it probable that the only known plane cutting the needle-axis of rosenbuschite, namely h (540) in the monoclinic lattice, was in reality m (110) in a triclinic lattice, as had proved to be the case in wollastonite and pectolite. On this assumption he computed triclinic elements for rosenbuschite which seemed more probable than the original monoclinic axial ratio. These triclinic elements, which compare roughly with those of wollastonite, were given in both the studies mentioned, in which rosenbuschite is tentatively retained in the wollastonite group pending further investigation.

The symmetry of rosenbuschite was first directly determined at the Geophysical Laboratory in Washington, by Professor T. F. W. Barth and Mr. C. J. Ksanda who kindly undertook to make X-ray measurements on a minute needle from a specimen from Langesundsfjord. In a private communication Dr. Barth reported that rosenbuschite is triclinic with elements which proved to be roughly proportional to those computed by the present writer; but that the presence of two unaccounted spots on the weak equator Weissenberg photograph indicated a true unit cell larger than that defined by these parameters.

Further X-ray study with a larger crystal was clearly necessary to obtain a satisfactory determination of the structural lattice of rosenbuschite; and since the available material failed to yield a suitable crystal, Dr. Barth requested Dr. I. W. Oftedal of the Mineralogical and Geological Museum of the University in Oslo to supply a suitable specimen. Dr. Oftedal promptly responded with a handsome specimen from Skutesundskjær, Langesundsfjord, Norway, from which Dr. Berman skillfully detached a single needle of sufficient thickness to give X-ray photographs of the desired intensity. On this crystal the writer determined the structural lattice of rosenbuschite during a recent visit to the Geophysical Laboratory in Washington. He is·

grateful to Dr. Oftedal for supplying suitable material, to Mr. Ksanda for preparing the X-ray photographs, to Dr. Barth and Dr. Tunell for assistance in discussing the results, to Dr. Day for permission to work in the Laboratory, to Professor Palache for facilitating the visit to Washington, and to Dr. Berman for advice on the classification of rosenbuschite.

Morphology.

On the newly acquired specimen from Langesundsfjord rosenbuschite presents the described appearance. The longitudinal cleavage planes of the needles are easily distinguished from vitreous random lengthwise fractures. Groups of divergent needles are also traversed by subparallel fractures cutting the needle axes obliquely. It was thought that these fractures might represent a cleavage after a rational plane; but later optical study showed that the fractures are not constant in their inclination to the needle-axes although their surfaces are tolerably plane. Ferruginous films in the transverse fractures, and to some extent between adjacent needles, seem to account for most of the pale orange colour of the aggregates. A true body colour is barely perceptible in single needles; fragments suitable for optical study are almost colourless and perfectly transparent.

The fragment detached for crystallographic study was part of a single crystal; it was about 1.0 mm long and 0.3 mm in greatest width with five measurable faces representing three forms, including the cleavage, in the zone of the needle-axis. Both ends of the fragment were formed by broken surfaces. On the reflecting goniometer the parallel opposite cleavage surfaces gave fair reflections; the remaining faces gave only feeble and blurred images. Table 1 gives the measured angles and the corresponding angles calculated from the later determined elements of the structural lattice; Brøgger's measured angles, suitably reduced, are added for comparison.

Table 1.

Rosenbuschite: Interfacial Angles.

Peacock Measured	Calculated	Brøgger Measured
a (100) : b (010) $= 68°$ 33$'$	67° 30$'$	c (001) : s ($\bar{2}$01) $= 67°$ 39$'$
68 07		67 32
		67 02
		70 26
a (100) : n ($1\bar{2}$0) $= 76$ 11	78 30$^{1/2}$	c (001) : a (100) $= 78$ 13
76 06		78 04

The calculated values agree sufficiently well with the measurements of Brøgger, who evidently succeeded in isolating a better developed crystal than the one on which our indifferent goniometric readings were obtained. The agreement between the new measurements and the calculated angles is poor, yet good enough to confirm Brøgger's three forms in the zone of the needle-axis, $a \{100\}$, $c \{001\}$ cleavage, $s \{\overline{2}01\}$, which become $n \{1\overline{2}0\}$, $a \{100\}$ cleavage, $b \{010\}$, respectively, in the adopted setting. The material studied showed no end-planes and therefore there is no prospect of obtaining morphological elements. Brøgger's remaining form, $h \{540\}$, was based on a single face which Brøgger first regarded as a contact face but later accepted as a rational plane since it gave an axial ratio similar to that of pectolite. The position of $h \{540\}$, as defined by Brøgger's elements, proves, however, to be highly complex in the reciprocal structural lattice; this shows that the plane on which it was based was, after all, a random surface. From this it follows that Brøgger's axial ratio, and consequently the present writer's previously given triclinic elements, are partly erroneous.

As will appear later, rosenbuschite is less closely related to the wollastonite group than was formerly supposed. I have therefore abandoned the unconventional setting of the species, in which the axis of the main zone was taken as [010], and have adopted the "normal triclinic setting", as recently defined (1937). In this setting the morphological elements correspond to the simple cell whose edges are the three shortest non-coplanar identity periods in the structural lattice; and the orientation of this cell is the one out of twenty-four positions in which the axis of morphological elongation is [001], the basal plane (001) slopes to the front and to the right (α and β both obtuse), and b [010] is greater than a [100]. In this setting the cleavage becomes $\{100\}$ and Brøgger's forms in the main zone receive the symbols already given.

Structural Latice.

The X-ray measurements were made on a Weissenberg X-ray goniometer, with certain improvements described by Dr. Tunell in a paper by the present writer (1937). The method used was one which gives a rigorous determination of the six lattice elements even when only one zone axis is recognizable on the crystal. A rotation photograph about the needle-axis gave c_0, the identity period in that axis;

a zero-layer Weissenberg photograph gave d_{100} and d_{010}, the spacings of the two sets of planes with the greatest spacings in the zone [001], and γ^*, the reciprocal axial angle included by their normals; and a first-layer Weissenberg photograph gave the horizontal off-set of the first layer of the reciprocal lattice with respect to the zero layer, measured by rectangular co-ordinates, x, y, which are functions of the reciprocal axial angles, α^*, β^*. The lengths x, y, were measured in millimeters on a projection in which the radius of the sphere of reflection is 100 mm, with reference to rectangular axes, the positive Y-axis being directed normal to (100), with the positive X-axis directed to the right (Fig. 1).[1]

Excellent photographs were obtained with copper radiation which gave four serviceable layer lines in the rotation photograph and up to eleven orders of diffraction from the widest-spaced planes in the Weissenberg photographs. The zero and second layer-lines are strong; the first, third, and fourth layer-lines are weak. Before finally fixing the lattice parameters further Weissenberg photographs were taken of the second and fourth layers, to make sure that all the spots could be taken into account.[2]

Table 2.

Rosenbuschite: Lattice constants.

c_0	7.27 ± 0.05 Å	$a^* = 0.1669$	$a_0 = 10.12$ Å
$d_{100} =$	9.22 ± 0.02 Å	$b^* = 0.1463$	$b_0 = 11.39$ Å
$d_{010} =$	10.52 ± 0.03 Å	$c^* = 0.2157$	$c_0 = 7.27$ Å
$\gamma^* = 67°30' \pm 10'$		$\alpha^* = 84°36'$	$\alpha = 91°21'$
$x =$	0.5 ± 0.3 mm	$\beta^* = 79°02\frac{1}{2}'$	$\beta = 99°38\frac{1}{2}'$
$y =$	4.1 ± 0.3 mm	$\gamma^*\ 67°30'$	$\gamma = 111°54\frac{1}{2}'$

The constants in Table 2 define the structural lattice of rosen-buschite in the normal setting. The first column gives the values obtained from the X-ray photographs; the second and third columns

[1] This unusual choice of reference axes is due to the fact that the projections were treated as "second permutation" (as defined by the writer, 1936) projections of a triclinic crystal elongated with [010]. Normally the positive Y-axis is directed to the right, normal to (010), the positive X-axis to the front.

[2] The Weissenberg photographs showed systematically weak spots which had almost all failed to appear on the pictures previously taken by Barth and Ksanda. The present study thus proves, as surmised by Barth and Ksanda, that their provisional lattice cell was a submultiple (half) of the real unit cell.

give the corresponding calculated elements of the reciprocal and direct lattices. These have been calculated exactly, for the sake of internal consistency[1]; they are of course subject to a probable error dependent on the probable errors of the experimental values. None of the elements is subject to considerable error except the angles α^*, β^*, and α, β, which are mainly dependent on the small quantities x, y, and may, therefore, be in error up to one degree.

The above absolute lattice constants give the following geometrical elements of the reciprocal and direct lattices:

$p_0 : q_0 : r_0 = 0.7739 : 0.6783 : 1$; λ $84°36'$, $\mu = 79°02^{1/2}'$, $\nu = 67°30'$
$a : b : c$ $0.8887 : 1 : 0.6383$; α $91°21'$, β $99°38^{1/2}'$, γ $111°54^{1/2}'$

Since one of the axial angles of the direct lattice, namely α, is nearly a right-angle, rosenbuschite belongs to the diclinic syngony of Fedorov, which comprises a considerable number of anorthic species (axinite, kyanite, wollastonite, pectolite, and others). Although diclinic lattices cannot be systematically separated from triclinic lattices on the basis of symmetry, the frequent occurrence of lattices with only two oblique axial angles remains an interesting fact which calls for a structural explanation.

The lattice of rosenbuschite possesses a further peculiarity which is expressed in the reciprocal lattice projection (Fig. 1) by the fact that the point (001) is horizontally displaced from the center, nearly in the direction of the a^*-axis by an amount which is nearly one-fourth of the a^*-period. This means, in effect, that one-fourth of the direct lattice points lie on a quadruple lattice which has two axial angles of nearly $90°$ and is therefore pseudo-monoclinic in character. The relations in the direct lattice are shown in Fig. 2 which represents four cells of the triclinic lattice, in full lines, and one cell of the quadruple pseudo-monoclinic lattice, in broken lines. The two lattices have the rows [010] and [001] and the planes (100) and (010) in common. In the pseudo-monoclinic cell the axial angles α, β, are nearly right-angles and [001] is the axis of two-fold pseudo-symmetry. The lattices of all the members of the wollastonite group possess this same peculiarity, which gains significance in the fact that the axis of monoclinic pseudo-symmetry, which is [010] in the

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[1] The writer is obliged to Dr. George Tunell for verifying a part of these calculations.

members of the wollastonite group, in each case nearly coincides with a principal optical direction.

In regard to the relations of the proportions of the structural lattice to morphological development, it will be seen that the shortest lattice period is the direction of morphological elongation, as is commonly the case. On the other hand, the cleavage {100} follows the second greatest lattice spacing, whereas the lattice planes with the greatest spacing are usually the planes of weakest cohesion.

Optics.

Brøgger (1890, p. 380) obtained the following optical data on rosenbuschite; the orientation referring to the monoclinic axes: X b [010] (needle-axis), $Z : c$ [001] about 12° to 14° in the acute angle β; birefringence strong; $2V$ large; sign uncertain, probably negative; body colour, light orange-gray; pleochroism very weak; absorption $Z > X > Y$. Observations on the universal stage partly confirm Brøgger's findings and partly correct and amplify them.

As Brøgger stated, one of the principal axes of the optical ellipsoid, namely X, is sensibly coincident with the needle-axis, c [001] in our notation; the direction of least optical retardation is thus the direction of the shortest lattice period. Z is inclined to the normal to the cleavage, a (100), at 28½′ nearly in the acute axial angle γ. This orientation agrees fairly well with Brøgger's data, when transformed to the new lattice; it is pseudo-monoclinic in nature since one ellipsoid axis lies in a crystallographic axis which is the axis of two-fold pseudo-symmetry of the pseudo-monoclinic quadruple lattice cell. Geometrical and optical pseudo-symmetry are often associated; here we have the interesting case, also exemplified in the wollastonite group, of optical orientation apparently controlled by the pseudo-symmetry of a quadruple cell.

Directly measured in sodium light $2V$ is 78° about Z as the acute bisectrix; the optic sign is thus positive, contrary to Brøgger's conjecture. The dispersion of the optic axes is weak, $r > v$. A body colour is barely perceptible; and since Brøgger's absorption formula does not agree with the effects described in his text the pleochroism of rosenbuschite may be neglected as insensible.

The new optical observations on rosenbuschite are summarized below, the co-ordinate angles φ, ρ, of the ellipsoid axes, X, Y, Z,

referring to [001] as pole and the vertical great circle through (010) as prime meridian. The orientation is shown in stereographic projection in Fig. 3, which also shows the known forms of rosenbuschite and the relations of the axial angles of the reciprocal lattice, α^*, β^*, γ^*, and of the direct lattice, α, β, γ.

	φ	ρ	n (Na)	
X (palest orange gray)	—	$0°$	1.678⎫	Positive
Y » » »	129°	90	1.687⎬ ±0.002	$2V$ 78°
Z » » »	39	90	1.705⎭	$r>v$ weak

Atomic Content of the Unit Cell.

The existing knowledge of the chemistry of rosenbuschite rests on three analyses given by Brøgger (1890, pp. 382 383): the first represents previously published mean values of duplicate analyses by Cleve, reporting a considerable amount of rare earths, an appreciable loss on ignition but no fluorine; the second gives a considerable proportion of fluorine which was determined by Bäckström, but only a small amount of rare earths and no ignition loss in the remainder of the analysis, which was completed by Cleve; the third is a compilation of what Cleve believed to be the best values, which differ but little from those of the second analysis. For the discussion of the cell content it seems best to consider the second analysis rather than the compiled values.

From the determined elements of the structural lattice the volume of the unit cell is $V_0 = 763.2$ cubic Å; the measured density is $d = 3.315$ (Cleve), which is close to 3.30 (Brøgger), and is perhaps the better value since it almost certainly represents the analysed material. The molecular weight of the unit cell is $M_0 = V_0 d/1.65 = 1533$. The analysis then gives the number of each kind of atom in the unit cell, as shown in table 3.

Considering the complexities of the case the numbers of atoms treated as structurally equivalent approach the whole numbers: 8, 4, 12, 36, with surprising closeness. Neglecting the minute amount of doubtful cerium and accepting the number of fluorine atoms as 4,

Table 3.

Rosenbuschite: Atomic Content of Unit Cell.

$M_0 = 1533.$

1	2	3	4	5
SiO_2 ...... 31.36	0.5263	8.07	Si 8.07	8.07
ZrO_2 ...... 20.10	0.1644	2.52	Zr 2.52	
TiO_2 ...... 6.85	0.0864	1.33	Ti 1.33	4.08
[1]Fe_2O_3 ..... 1.00	0.0063	0.10	Fe''' 0.20	
[2]Ce_2O_3 ..... 0.33	0.0010	0.015	Ce 0.03	
MnO 1.39	0 0198	0.30	Mn 0.30	
CaO 24.87	0.4475	6.86	Ca 6.86	12.04
Na_2O 9.93	0.1589	2.44	Na 4 88	
F 5.83	0.3093	4.74	F 4.74	36.16
O .... −2.45	0.1543	−2.37	O .... −2.37	
			33.79	
99.21				

1. Rosenbuschite, Langesundsfjord, Norway; analysts Cleve and Bäckström (Brøgger, 1890, p. 383). [1] State of oxidation not determined. [2] Reported as „Ceritoxyde (?)".
2. Molecular proportions of the oxides reduced to the sum of 100.
3. Number of molecules in the unit cell = molecular proportion × $M_0/100$.
4. Number of atoms in the unit cell.
5. Number of atoms treated as structurally equivalent.

the cell formula of rosenbuschite is: $(Na, Ca, Mn)_{12}$ $(Fe''', Ti, Zr)_4$ $Si_8O_{32}F_4$ or $4[(Na, Ca, Mn)_8 (Fe''', Ti, Zr) (SiO_4)_2F]$, in which $Na : (Ca+Mn)$ approaches $1 : 2$.

If zirconium and titanium are reckoned with silicon, and fluorine with oxygen, then the formula of rosenbuschite in square brackets becomes $3RSiO_3$, which is that of a typical metasilicate. The formulations of Cleve (in Brøgger, 1890, p. 384), Brøgger (1890, p. 385), and the author (1935 A, p. 526; 1935 B, p. 110), are based on this grouping. If, however, zirconium and titanium are regarded as not equivalent to silicon, which is probable from structural considerations, and fluorine is taken as structurally distinct from oxygen, as it often is, then the formula of rosenbuschite, as already given, has the characteristic form of an orthosilicate, with $Si : O$ $1 : 4$, corresponding to unconnected silica tetrahedra in the structure.

A somewhat similar conclusion was already reached by Zachariasen (1930) who derived the general formula: $R_4Si_2X_9$ or $R_4Si_2O_7$ (O, OH, F)$_2$ for låvenite, wöhlerite, hiortdahlite and rosenbuschite, in which R represents all the cations except silicon, and X all the anions. It should be noted, however, that Zachariasen's second formula indicates Si_2O_7 as the motif of the structure while the present study suggests Si_2O_8 as the fundamental arrangement.

Systematic Relations.

The determined cell dimensions and cell content of rosenbuschite do not support the systematic relation to pectolite indicated by Brøgger. Apparently supporting the supposed relation are the following facts: rosenbuschite is triclinic and therefore comparable in symmetry with the members of the wollastonite group (wollastonite, vogtite, bustamite, pectolite, schizolite), which have triclinic lattices; like the wollastonite lattice, the lattice of rosenbuschite is of a special diclinic type in which may be drawn a pseudo-monoclinic quadruple cell whose axis of two-fold pseudo-symmetry is the direction of morphological elongation, which is the direction of the shortest identity period in the lattice and nearly the direction of a principal optical axis. The shortest identity period in rosenbuschite (c_0 7.27 Å) is equal to the corresponding identity period in wollastonite ($b_0 = 7.27$ Å) and nearly equal to that in pectolite ($b_0 = 7.08$ Å), as determined by Warren and Biscoe (1931). This similarity in the principal lattice periods of the three species points to a similarity in the atomic arrangements in the corresponding directions; but the lack of any further simple inter-relations of the lattice parameters indicates no further structural similarities. Furthermore, the cell formula of rosenbuschite, (Na, Ca, Mn)$_{12}$ (Fe''', Ti, Zr)$_4Si_8O_{32}F_4$, is quite dissimilar from that of pectolite, $Na_2Ca_4Si_6O_{16}(OH)_2$, and wollastonite, $Ca_6Si_6O_{18}$, found by Warren and Biscoe (1931). There is thus no good ground for retaining rosenbuschite in the wollastonite group, as Zachariasen already concluded from general structural considerations.

In a forthcoming structural classification of the silicates Dr. Berman has formulated and arranged a number of silicates with essential zirconium in a "Wöhlerite Family" which he treats as a division of the "Normal Orthosilicates" having the structural motif (SiO$_4$). The writer has had the privilege of reading Dr. Berman's essay in manuscript, from which the following presentation is abstracted with slight
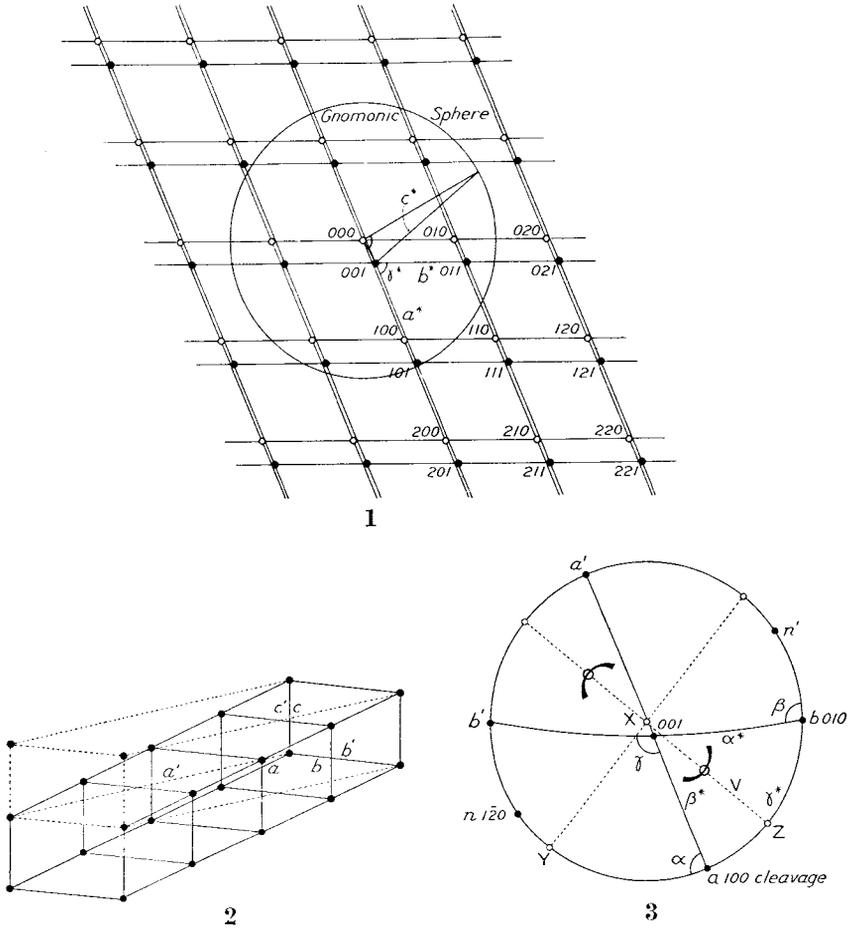
1

2

3

Fig. 1. Rosenbuschite: projection of the zero- and first layers of the reciprocal structural lattice on the plane normal to [001].

Fig. 2. Rosenbuschite: inclined view of the direct structural lattice, showing four unit cells (full lines) and one quadruple cell (broken lines) which is pseudo-monoclinic with [001] as the axis of two-fold pseudo-symmetry.

Fig. 3. Rosenbuschite: stereographic projection showing the relation of the principal optical directions, X, Y, Z, and the optic axes (with brushes) to the axial planes of the crystal lattice; and the relation of the axial angles of the direct lattice α, β, γ, to the axial angles of the reciprocal lattice, α^*, β^*, γ^*.

modifications. The formulas are expressed in terms of $(SiO_4)_2$, which represents one-fourth of the cell content of rosenbuschite. Constituents amounting to less than one-tenth of an atom in the cell containing $(SiO_4)_8$ are neglected.

Table 4.

Wöhlerite Family.

Wöhlerite group	
Rosenbuschite	(Na, Ca, Mn)₃ (Fe‴, Ti, Zr) (SiO₄)₂F
Wöhlerite	(Na, Ca)₃ (Mn, Fe″, Fe″, Ti, Cb, Zr) (SiO₄)₂ (F, OH)
Hiortdahlite	(Na, Ca)₃ (Mn, Fe″, Ti, Zr) (SiO₄)₂ (F, OH)
Guarinite	(Na, Ca)₃ (Mg, Mn, Fe″, Cb, Zr) (SiO₄)₂ (O, F, OH)
Johnstrupite	(Na, Ca)₃ (Mg, Fe‴, Al, Y, Ce‴, Ti, Zr) (SiO₄)₂ (F, OH)₂
	Additional members
Låvenite	(Na, Ca)₂ (Mn, Fe″, Fe‴, Ta, Cb) (Ti, Zr) (SiO₄)₂ (F, OH) and others.

Berman reluctantly retains rosenbuschite in the wollastonite group, in view of the crystallographic analogy previously indicated by the present writer. Since this analogy has proved to be partly fallacious, it seems proper to transfer rosenbuschite to the Wöhlerite Group, with which it has evident chemical affinities, even though there is as yet no apparent crystallographic similarity between the structural lattice of rosenbuschite and the morphological lattices of the members of the Wöhlerite Group, within which there are evident morphological analogies. As formulated above, the constitutions of rosenbuschite, wöhlerite, hiortdahlite and guarinite are closely similar, the ratio Na:Ca being nearly 1:2 in each case. A general formula for the four species is:

$$Na_4Ca_8 \ (X, \ Zr)_4 \ (SiO_4)_8 \ (F, \ OH)_4$$
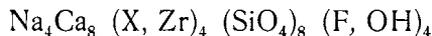
in which X is Mg, Mn, Fe″, Fe‴, Cb, Ti, and slight mutual substitutions are tolerated.

Johnstrupite is slightly removed from the first four species in the above arrangement since the analysis indicates twice the typical proportion of (F, OH). Låvenite is still farther removed as

shown by the replacement of one-third of the (Na, Ca) bracket by other cations.

In spite of its marked chemical relation to the Wöhlerite Group rosenbuschite is placed in this group only tentatively. An X-ray study of the minerals of the Wöhlerite Group will be necessary to show whether the chemical analogy with rosenbuschite is supported by structural similarities.

Summary.

A study of rosenbuschite from Langesundsfjord, Norway, leads to a characterization that differs essentially from the original description of Brøgger (1890). Rosenbuschite is triclinic; $a_0 = 10.12$ Å, $b_0 = 11.39$ Å, $c_0 = 7.27$ Å; $a_0 : b_0 : c_0$ 0.8887 : 1 : 0.6383; $\alpha = 91°21'$, $\beta = 99°38\frac{1}{2}'$, γ $111°54\frac{1}{2}'$. Forms: $a\{100\}$ (cleavage), $b\{010\}$, $n\{1\bar{2}0\}$. $V_0 = 763.2$ cubic Å; d 3.315 (Cleve, 1890); $M = 1533$. Cell content: $(Na, Ca, Mn)_{12}$ $(Fe''', Ti, Zr)_4 Si_8 O_{32} F_4$.

Colour, palest orange-gray; pleochroism negligible. $X = c\,[001]$; Z inclined to the normal to the cleavage $\{100\}$ at $28\frac{1}{2}°$ nearly in the acute angle γ. Indices (Na): $nX = 1.678$, $nY = 1.687$, $nZ = 1.705$, all ± 0.002. Positive; $2V$ $78°$; $r > \nu$ weak.

Except for the equality of the identity periods in the direction of morphological elongation in rosenbuschite and wollastonite, there is no structural or chemical similarity between the two minerals or between rosenbuschite and pectolite. The compositions of rosenbuschite, wöhlerite, hiortdahlite and guarinite may be expressed by the general formula: $(Na, Ca)_{12} (X, Zr)_4 (SiO_4)_8 (F, OH)_4$ in which X is Mg, Mn, Fe″, Fe‴, Cb, Ti; this suggests a relationship which requires to be tested by an X-ray study of the Wöhlerite Group.

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Department of Mineralogy and Petrography
Harvard University.

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