On Datolite from the Lizard district, Cornwall.[1]

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IN the course of his official work in the Lizard district, Dr. J. S. Flett collected various samples of minerals which were handed over to me for examination. Two of these specimens proved to be datolite remarkably well crystallized. As this species, now rare in Britain, had not been recorded before from Cornwall, although pseudomorphs of chalcedony after it—the well-known haytorite—are mentioned by Greg and Lettsom[2] from North Roskear mine, Camborne, the facts of its occurrence seemed well worthy of further investigation. Accordingly, in October of last year, Dr. Flett and myself paid a visit to the locality, where we succeeded in obtaining a large amount of the material.

The spot is situated in the parish of Mullion, about 550 yards SSW. of Predannack Farm in a little cove—Parc Bean Cove—lying at the foot of the cliffs. The rocks carrying the datolite are covered at high water, which renders the work of obtaining specimens somewhat awkward, and possible only at certain states of the tide; but, to compensate for this, the material is plentiful, and beautifully crystallized specimens are by no means rare. The following is Dr. Flett's description of the geology of this locality:—

'On its western margin the serpentine of the Lizard is folded with the hornblende-schist in a remarkable manner first described by Mr. Howard Fox and Dr. J. J. H. Teall.[3] The border of the main serpentine is situated about 400 yards south-east of Parc Bean Cove (at Pol Cornick), but smaller masses of serpentine are brought up among the hornblende-schists by folding at Parc Bean Cove and to the west of it. The datolite occurs at the junction of the serpentine and schist. There is a certain amount of interbanding of the two rocks, and the matrix

[1] Communicated by permission of the Director of H.M. Geological Survey.

[2] R. P. Greg and W. G. Lettsom, 'Manual of the Mineralogy of Great Britain and Ireland,' 1858, p. 231.

[3] Howard Fox and J. J. H. Teall, 'Notes on some coast sections at the Lizard. Quart. Journ. Geol. Soc., 1893, vol. xliv, p. 199.

of the datolite-veins is partly a foliated tremolite-serpentine, partly a tremolite-schist derived from serpentine, and partly a felspar-enstatite-rock which is passing into hornblende-schist by metamorphism. The banding and foliation of the metamorphic series has a north and south strike. These rocks are traversed by crushed dolerite dykes which are posterior to the folding, but are to some extent metamorphic, and run in a west-north-west direction. The datolite-veins are not specially connected with these dykes, and are evidently long subsequent to the metamorphism, because they show no distortion or re-crystallization by pressure.'

The veins vary in size from mere threads up to those measuring 4 cm. across, but this is exceptional, the usual width being 0·5–1 cm. They consist of white, massive, crystalline datolite, and swell out every now and then into geodes lined with large, well-formed crystals. Some of these cavities attain a fair size, one specimen in the Museum of Practical Geology measuring 20 cm. in length and 5 cm. in breadth; it is covered with large crystals of white, brownish, and greenish tinges.

The material of the geodes frequently shows evidence of two stages of crystallization: (*a*) a layer of crystalline or poorly crystallized datolite, sometimes of light-brown colour and measuring 2–3 mm. in thickness; and (*b*) the large crystals mentioned above, which frequently measure 1–2 cm. along their greatest length (the *b*-axis), and which rest on the layer (*a*). They are sometimes white, but often exhibit a brownish and, more rarely, a greenish colour, and are seldom transparent, being flawed and fissured in the interior, besides enclosing little specks of copper-pyrites. At the contact of the crust with the matrix there can often be seen with a lens, and sometimes with the unaided eye, a layer of little spherules showing a fibrous-radiating structure; these consist of the botryoidal form of datolite to which the name 'botryolite' has been applied, although the material mentioned here differs optically from that found at Arendal, Norway, the original locality.

Other geodes show no evidence of two growths of datolite, there being simply a crust of white crystals with or without botryolite resting on the parent-rock. In such cases the crystals are generally smaller than when two growths are present; but there are exceptions to this, and exceedingly small crystals have been noted in the second generation.

Throughout the veins there are also smaller cavities lined with very clear, brilliant crystals, which are usually colourless, but sometimes show a pronounced green; they are associated with botryolite.

Calcite is exceedingly common on all these specimens, and is usually of

a wine-yellow colour. It occurs as simple acute rhombohedra, $f(02\bar{2}1)$, seated on the datolite, and one such crystal, showing rough, dull faces, measured 3·6 cm. along the principal axis. It is sometimes present as a brownish skin coating the datolite, and is found throughout the veins as brown crystalline masses.

Copper-pyrites is another common associate, occurring as little specks and grains in the larger crystals and in the crystalline layer beneath them.

The most interesting mineral occurring with the datolite, however, is *natrolite*, a species rare in Cornwall, but recorded from the Coverack district of the Lizard by Mr. Harford Lowe.[1] At Parc Bean Cove it is rare, and has been noted on only two of the specimens. One of these belongs to Mr. Reynell,[2] who kindly lent it to me for examination. It shows one crop of white datolite crystals with a thick layer of botryolite; yellow calcite is also present on one or two places. The natrolite occurs as small needles growing on the crystallized datolite.

The other specimen was collected by myself, and shows needles of natrolite growing on small, brilliant crystals of datolite in intimate association with yellow calcite and botryolite.

Owing to the small amount of material available, a chemical analysis was impossible, but examination on the goniometer and under the microscope confirms the view that it is natrolite.

On the goniometer the faces of the needle-like prisms do not yield good reflections, owing to striation and irregularities. It is, however, possible to make out the presence of eight of them in the zone, and they appear to be combinations of $a(100)$, $b(010)$, $m(110)$.

Under the microscope they extinguish straight with axial plane parallel to the zone of elongation, which is positive. By breaking off fragments from the end of a prism one or two were got showing the emergence of an acute bisectrix, which was positive. The refractive index is well below that of balsam.

In the Bunsen-flame the needles fuse readily to a glass, and give a strong yellow coloration.

Crystallography of the Datolite.

The crystallography of this mineral has been the subject of much investigation and discussion, and different sets of axial ratios have been used by various observers. The axes and symbols adopted here are those

[1] H. J. Lowe, Trans. R. Geol. Soc. Cornwall, 1900, vol. xii, p. 336.

[2] This specimen has since been presented to the Museum by Mr. Reynell.

given in Dana's 'System of Mineralogy', sixth edit., 1892, namely, $a:b:c = 0{\cdot}63446:1:1{\cdot}26574$; $\beta = 89° 51\frac{1}{3}'$.

The large crystals have brilliant but irregular faces and rarely yield good reflections. The irregularities on the faces take the form of waviness and striation, features which seem to be rather common in this species. The crystals are usually quite simple in development, being combinations of $c(001)$, $a(100)$, $m(110)$, $m_x(011)$, $g(012)$, $n(111)$, $\epsilon(\bar{1}12)$, $\xi(\bar{1}02)$ (figs. 1 and 2). In some cases a and ξ are suppressed (fig. 1), whilst n is often visible as a mere trace. They measure their greatest length along the b-axis and invariably show $m(110)$ well developed. The c-pinacoid is always present as a large face striated parallel to $\epsilon(\bar{1}12)$, and this striation is often carried so far as to give the face a furrowed appearance; it renders the orientation of the crystal easy. The face ξ in these large crystals is usually corroded and dull, and ϵ often shows the same appearance, though not to the same extent.

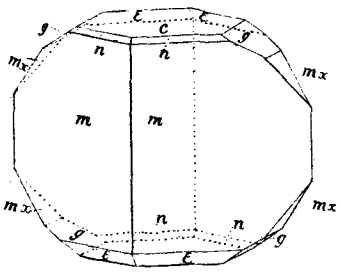

Fig. 1.

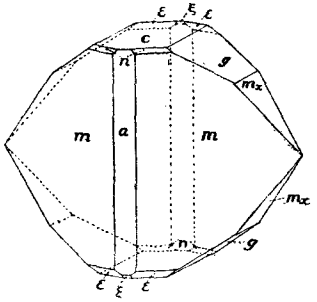

Fig. 2.

Crystals of Datolite from the Lizard district, Cornwall.

The best material for crystallographic work is found in the small crystals which line little cavities in the veins of massive datolite. They are usually bright and well modified, the faces yielding good reflections, though here again the faults mentioned above are sometimes observable. They are often attached by one end of the c-axis and are prismatic in this direction. All the forms enumerated above are present, in addition to which $x(102)$, $\lambda(\bar{1}13)$, $q(312)$, $\beta(121)$, and $\Phi(211)$ were observed. The last-named of these forms occurs as a small parallelogram yielding fair reflections and lying at the intersections of the zones [100,111] and [110,312]; it has only quite recently been described by H. Ungemach[1] as a new form on crystals of datolite from Markirch,

[1] H. Ungemach, Bull. Soc. franç. Min., 1909, vol. xxxii, p. 402.

Elsass. Single crystals occur on which all the above forms are present, and a drawing of such a combination is given (fig. 3).

On a small broken crystal a low pyramid g_0 was observed lying in the zone $[ng] = [1\bar{2}1]$. It yielded an excellent reflection on the goniometer, but, unfortunately, the other faces, owing to irregularities, yielded poor readings; consequently the calculated symbol (2.15.28), is not beyond doubt. A drawing of this crystal is given (fig. 4).

On some of the smaller crystals the face m (110) is strongly striated, and on one or two individuals there appears to be another face present in this prism-zone. In such cases, however, a continuous band of images is obtained from these faces, thus rendering it impossible to determine the symbol accurately.

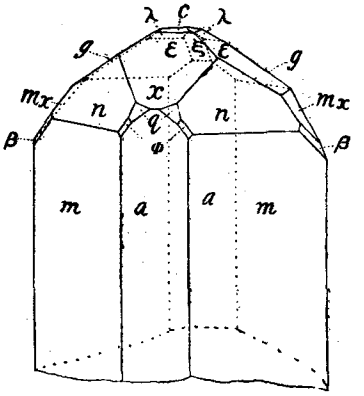

Fig. 3.

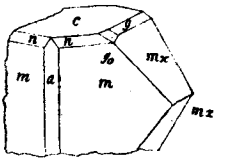

Fig. 4.

Crystals of Datolite from the Lizard district, Cornwall.

Measured and Calculated Angles.

		Measured.	Calculated.			Measured.	Calculated.
ca	$=(001):(100)$	89° 55½′	89° 51⅓′	an	$=(100):(111)$	38 50	38 55
ax	$=(100):(102)$	44 58	45 0	aq	$=(100):(312)$	21 35	21 34
xc	$=(102):(001)$	44 57	44 51	qq'	$=(312):(3\bar{1}2)$	22 40	22 40
$c\xi$	$=(001):(\bar{1}02)$	44 57	45 0	$m\beta$	$=(110):(121)$	25 36	25 44
mm'	$=(110):(\bar{1}10)$	115 18	115 18	$c\Phi$	$=(001):(211)$	76 36	76 18
gg'	$=(012):(0\bar{1}2)$	64 44	64 39	$a\Phi$	$=(100):(211)$	22 3½	22 2
$m_xm'_x$	$=(011):(0\bar{1}1)$	103 12	103 23	$\Phi\Phi'$	$=(211):(2\bar{1}1)$	34 7	34 14
cn	$=(001):(111)$	67 0	66 57	$m\Phi$	$=(110):(211)$	19 36	19 53
$c\lambda$	$=(001):(\bar{1}13)$	38 15½	38 16	cg_0	$=(001):(2.15.28)$	34 19	34 43
$c\epsilon$	$=(001):(\bar{1}12)$	49 45	49 49	ng_0	$=(111):(2.15.28)$	46 36 47 17	46 45
nn'	$=(111):(1\bar{1}1)$	59 4	59 4				
$\lambda\lambda'$	$=(\bar{1}13):(1\bar{1}3)$	38 32	38 45	mg_0	$=(110):(2.15.28)$	66 26 66 52	66 40
$\epsilon\epsilon'$	$=(\bar{1}12):(1\bar{1}2)$	48 10	48 19				

Optical Properties.

The plane of the optic axes lies parallel to $b(010)$, and the acute and obtuse bisectrices are almost perpendicular to $a(100)$ and $c(001)$ respectively; the mineral is optically negative.

Two plates were cut, one parallel to a, the other to c, and the following values obtained on the refractometer with yellow light:—

$$\alpha = 1{\cdot}626(0),\ \beta = 1{\cdot}653(2),\ \gamma = 1{\cdot}670(2),$$

Using the faces $m(110)$ $m'(\bar{1}10)$ as a prism the following values were obtained by minimum deviation with yellow light:—

$$\beta = 1{\cdot}6530,\ \gamma = 1{\cdot}6706$$

In oil of refractive index 1·6038 the values obtained with yellow light for the axial angles were:—

$$2H_a = 76°\,58' \qquad 2H_o = 110°\,36'$$
$$\text{Hence}\quad 2V_a = 74°\,16' \qquad 2V_o = 105°\,30'.$$

Chemical Composition.

A quantitative analysis of the material yielded the following results:—

	Found.	Calculated for formula $HCaBSiO_5$.
SiO_2	37·45	37·6
CaO	34·67	35·0
$(Fe, Al)_2O_3$	0·57	—
B_2O_3	21·87	21·8
H_2O	5·67	5·6
Total	100·23	100·0

The powdered mineral (1·0028 gram) was evaporated repeatedly to dryness with hydrochloric acid and methyl alcohol, and the silica filtered off and determined in the usual way. From the filtrate the iron and alumina were precipitated by ammonia, filtered, ignited, and weighed together. The lime was precipitated as oxalate, ignited, and weighed as oxide, then converted into sulphate and estimated as such. The boron and water were each estimated on separated portions.

The powdered mineral (1·0085 gram) was fused with sodium carbonate and the melt treated with water and filtered. The filtrate was distilled with acetic acid and methyl alcohol into a weighed quantity of lime, and

the boron estimated from the gain in weight. The water was estimated by Penfield's method.

Specific Gravity. A determination on 0·8666 gram of the powder used in the above analysis gave, with the pycnometer, the value 3·001 at 14° C.

Botryolite.

This variety occurs as a layer between the matrix and the crystallized crusts. It sometimes forms fairly large masses intermingled with the crystalline material of the veins; occasionally it is stained a pronounced green on the surface.

The botryolite found here differs from that described by Lacroix[1] from Arendal, Norway. The material from that locality shows, under the microscope, fibres which extinguish straight, and yield sometimes a positive, obtuse bisectrix, sometimes a negative, acute bisectrix, the axial plane being perpendicular to the zone of elongation. Consequently these fibres are elongated parallel to the edge [100,001], i. e. the *b*-axis.

When the Cornish botryolite is crushed and examined under the microscope certain of the fibres extinguish straight, and, with convergent light, the axial plane is seen to be parallel to the zone of elongation and the bisectrix obtuse and positive. They are therefore elongated parallel to the *a*-axis.

A large number of the fibres, however, do not extinguish straight but at from 30° to 40° to the zone of elongation. They frequently show the emergence of an obtuse, positive bisectrix, and appear to be elongated in some direction lying in the plane *c*(001).

On one or two specimens there occurs in small quantity a brownish, amorphous mineral filling up the interstices between the small crystals. Owing to lack of material I was unable to identify it, but it may possibly be a variety of datolite similar to that from Lake Superior.

Until the discovery of the locality described above, datolite has been a mineral of rare occurrence in England, and indeed in the British Islands. The best known localities, hitherto, have been in Scotland, but specimens of late have become very scarce. The crystals on the Scottish specimens are usually small, although Heddle[2] records some from Salisbury Crags, Edinburgh, which measured $\frac{3}{4}$ inch in length.

[1] A. Lacroix, Bull. Soc. Min. de France, 1885, vol. viii, p. 433.

[2] M. F. Heddle, 'Mineralogy of Scotland,' 1901, vol. ii, p. 63.

In England Busz[1] has recorded datolite with garnet in the limestone of South Brent, Devonshire, but only in small quantity.

It is thus satisfactory that a good locality for this mineral has been found, and that another name should be added to the long list of minerals found in Cornwall.

In conclusion, I wish to express my thanks to Dr. J. S. Flett for the interest he has taken in the investigation, and to Dr. W. Pollard for much valuable help given in the chemical part of the work.

[1] K. Busz, Neues Jahrb. Min., 1899, Beilage-Band xiii, p. 127.