

defined mixtures, which possess very doubtful claims to rank as good mineral species.

THE ZEOLITIDS.

THE ZEOLITES PROPER.

These, as remarked above, are all aluminiferous Silicates, which may be regarded as corresponding in composition to hydrated Felspars. They readily part with more or less of their water of crystallisation.

438. HEULANDITE. Pseudo-monosymmetric aggregates of anorthic* crystals, often mimicking in its habit crystals of the orthorhombic system. Silica 59·2, alumina 16·8, lime 9·2, water 14·8.

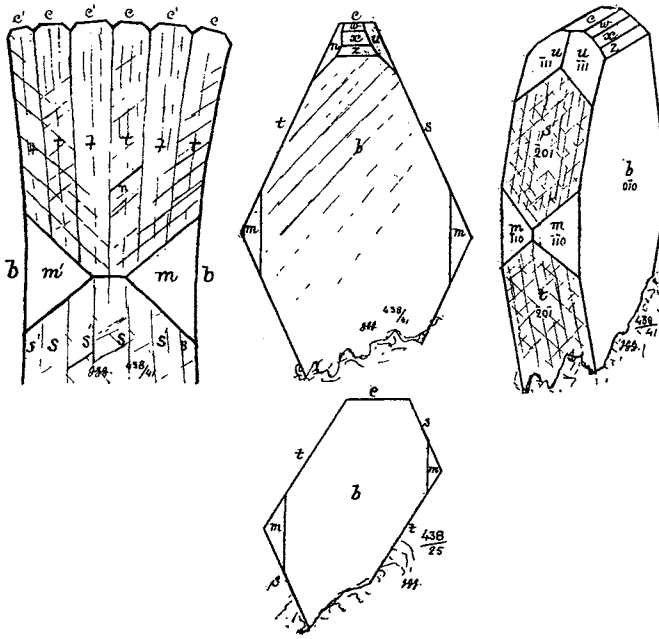
The forms represented on Scottish crystals include some, here marked with an asterisk, that have not hitherto been described. Treated as monosymmetric, they are as follows:—*a*, (100); *b*, (010); *c*, (001); *m*, (110); *t*, (201); *s*, ($\bar{2}$ 01); **d*, (101); **w*, (032); *x*, (021); *z*, (052); **n*, (111); *u*, (111); *v*, ($\bar{2}$ 21). To these may have to be added others, amongst which is a low ("vicinal") face near *m* in the zone [*m t*], seen on (438/25), and another in the zone [*a u*] which may be (213).

An examination of a large number of specimens leaves no doubt upon my mind that Heulandite really consists of an aggregate of anorthic sub-individuals, in which the angles denoted by α , β , γ , differ but little from 90°. These consist of thin plates, polysynthetically twinned on *b*, in the same manner as in the case of Albite. Alternate salient and re-entering angles arc as perfectly clear upon the faces of *s*, *t*, *c*, in Heulandite, as they are in analogous positions in the case of the anorthic Felspars. Hence, no further evidence is required to prove that what has been regarded as a monosymmetric crystal is really an aggregate of anorthic crystals polysynthetically twinned upon the *b* axis.

There is often more or less doubt as to whether a given specimen belongs to Heulandite or to Stilbite. Both have nearly the same pearly lustre upon the *b* face, and both are striated parallel to *a c*. Both tend to occur as more or less sheaf-like aggregates, and, lastly, both species take on almost exactly the

*Breithaupt seems to have been the first to regard Heulandite as trichinite (anorthic), see "Min.," iii. p. 449 (1847).

same colours. When the crystalline form is clearly shown there cannot be much doubt; for Heulandite shows a very characteristic outline, which resembles that of a coffin-lid, while the fourlings which make up Stilbite unite to form a much more decidedly orthorhombic outline. But the chief point of difference lies in the fact that, when viewed perpendicularly to *c*, Heulandite crystals appear to be (as they really are) simple individuals, while those of Stilbite, viewed in the same direction, are evidently of a much more complex character. The most common habit of Stilbite, as noted below, is that of complex aggregates of sheaves, narrowed in the middle, and spreading out at the ends.



Heulandite.

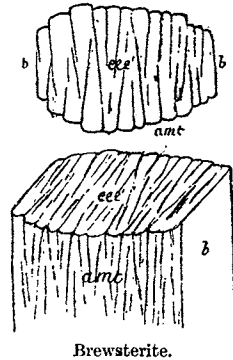
Heulandite occurs in Scotland in the vapour cavities and other vacuities of eruptive rocks of various ages, ranging back in time from those of the Tertiary volcanic series of the Western Islands to the Andesitic lavas of the Caledonian Old Red Sandstone. But, undoubtedly, the finest and most striking-looking crystals come from the Lower Carboniferous lavas of the Clyde Basin. The

finest of all are stated by Heddle to have come from Cochno, Dumbartonshire. Another locality given is Campsie, which, though vague, is probably correct, seeing that the mineral may occur anywhere within the lavas of the type prevalent there. Earlsburn Reservoir, Touch Hills, is, again, one locality within a large area where the mineral is known to occur. The vapour cavities in the Old Red Andesitic lavas of Forfarshire and Kincardineshire are also well known as repositories of Heulandite. So are those in the Tertiary volcanic rocks of Skye and the Western Isles. As for specifying any particular locality, this is needless, as the mineral may be expected to be met with anywhere there. Thin veins traversing the volcanic agglomerate on the shore west of Kincairg, Elie, afford small but excellent crystals of the mineral under notice. Lastly, it may be remarked that a white, opaque, mineral occurring along with Epidote in a vapour cavity of a highly-altered lava on Ben More, Mull, which has lately been referred to this species, looks so much like Albite that, until its crystalline form, or its chemical composition, has proved it to be Heulandite, I propose to omit it from the list. Some Heulandites, reputed to be Scottish, may have come from Iceland or the Farøes.

On the preceding page are figures showing the characteristic habit of Heulandite as it occurs in Scotland, together with other figures which show new or rare forms. They are all taken from specimens in the Scottish Mineral Collection, and are each accompanied by their respective registration marks, by which means the specimens figured may readily be found. (See p. 29.)

439. BREWSTERITE. Silica 54·3, alumina 15·4, baryta 6·6, lime 1·2, water 13·6. Pseudo-monosymmetric; but really an aggregate of anorthic sub-individuals. This is shown by the numerous re-entrant angles on the *a m* side and on the distal termination. The form referred to, *e*, (016), is probably nothing more than aggregate faces due to oscillations of upper and lower *c*. In like manner the numerous striations on the *a m* sides of the crystals are due partly to the asymmetric character of the forms referred to, the unit prism as well as those regarded as brachy-prism (120), each analogue of which forms re-entrant angles with its neighbour. The polysynthetic twinning, indeed, seems to be carried to such

an extent that it is difficult, or almost impossible, to figure a typical crystal which may be regarded as representing the simple habit of the species. The figures of this species given in text-books certainly do not correctly represent the usual habit of Brewsterite. The specimens in the Scottish Mineral Collection show the distal face made up of a series of wedges with their thick and thin ends placed alternately, and with the exposed parts of each wedge rounded from side to side, smooth, and with a vitreous lustre. The face referred to, *b*, (010), is also smooth, but it is even, and it shows a well-marked pearly lustre. The side above referred to as *amt* is a rounded aggregate formed by the series of wedges whose thinner ends as displayed on *c* point towards the middle of each crystal. Much more careful study of this species will have to be carried out before its true crystalline nature can be known.



Brewsterite.

Like Harmotome, this mineral is one of the latest deposited in the contents of the vein where it occurs. In general it coats fragments of the fault breccia of the lead veins, and it does not appear to have been recognised in Scotland anywhere else than at Strontian in Argyllshire.

For the reason just given it is not possible to give a list of the forms; but the general character of the crystals can be seen from the sketches annexed.

440. EPISTILBITE. Silica 57·1, alumina 17·6, lime 9·7, water 15·6.

This mineral has generally been included in the Scottish list, as it has been stated to occur "in small flesh-coloured crystals at Skye." But I do not feel satisfied with the evidence, and therefore make no further reference to it here.

441. PHILLIPSITE. Silica 48·8, alumina 20·7, lime 7·6, potash 6·4, water 16·5.

The remarks in the latter sentence under the foregoing species apply equally to this.

442. HARMOTOME. Silica 47.1, alumina 16.0, baryta 20.6, potash 2.1, water 14.1.

Anorthic, in aggregates whose simpler forms mimic monosymmetric crystals, and whose more complex aggregates assume almost a tetragonal habit.

a , (100); b , (010); c , (001); m , (110); m' , ($\bar{1}\bar{1}0$); v , (410); v' , ($4\bar{1}0$); w , (520); w' , ($5\bar{2}0$); t , (101); ϵ , (702) (e and f not seen).

The Ba O varies from 20.6 per cent. to 20.86. Many analyses have been published, but none call for repetition here.

The mineral appears in all cases to be of secondary origin, and due to epigenic action upon eruptive rocks. The parent rock is commonly one of the more basic kinds which contains Labradorite. Decomposing Barytes may have furnished the Barium.

Harmotome occurs at several localities in Scotland, chiefly in the West, that best known being Strontian, Morven, Argyllshire, where it is found in a series of metalliferous veins yielding Galena and other ores, with Barytes. Specimens from this place have found their way into most collections, and the habit of the Strontian crystals may therefore be regarded as more or less typical of the species.

Three varieties of Harmotome occur there, and are often to be found in the same specimens. One of these may be described as consisting of spindle-shaped crystals, as these are greatly elongated parallel to b , (010), and they may be said to taper off to each end from the middle. Crystals of this habit used to be regarded as simple, and were long known by the name of Morvenite, from the locality where they occur. They are usually of small size. A second habit is one in which the elongation is parallel to a , (100), and the crystals are rectangular in cross-section transversely to that, and are terminated at the longer ends by what look like low four-faced pyramids. This variety appears to be the commonest. It is really a fourling or quadruple aggregate of the elementary crystal. The third variety is that which is best known through the medium of the figures in text-books. It is cruciform in cross-section, and it is obviously an aggregate of crystals which are really twinned fourlings of the simpler variety last referred to. This variety, with many minor modifications, dependent upon the relative size of each face, is the one most common at Andreasberg, in the Hartz, and we may therefore conveniently distinguish it from the others

by the name of the locality where it occurs. There is no difference in composition between any two of these three varieties, but only in reference to the mode of aggregation of the sub-individuals which make up each crystal upon which the difference of the varieties is founded. The Andreasberg type is represented in the right hand figure of 442/7. (See p. 36.)

Closer observations upon crystals of the Morvenite type show that the four *b* faces which unite to form the ends of a crystal do not lie in the same plane, but form a compound face which, as just now remarked, assumes the aspect of a low four-faced pyramid. This feature, taken in conjunction with a very evident tendency to an unequal development of the faces in the prism zone, may be taken as suggesting that each component of the Morvenite fourling belongs to the anorthic system, the crystals which the four sub-individuals combine to build being, as is usually the case under these circumstances, a mimetic aggregate which assumes a higher grade of symmetry than that proper to the elementary crystal.

In Morvenite the crystals are greatly elongated parallel to *b*, as may be seen by reference to the figures annexed. The *c* faces are usually very narrow in the direction of *a*. They are smooth, and are traversed parallel to *b* by a series of shallow grooves, and the entire surface is gently undulated from front to back. No traces of any striæ parallel to the faces *a* can be made out.

In the older books on mineralogy Morvenite was regarded as the simple crystal whose aggregation gives rise to Harmotome of the Andreasberg type. Increased knowledge of the structure of the mineral has, however, made it quite clear that Morvenite itself consists of fourlings, with *c* as a twin plane; and the view now generally taken regarding these elementary sub-individuals comprising Morvenite is that they belong to the monosymmetric group. If, however, a careful examination be made of these supposed monosymmetric sub-individuals, it will be seen that their habit is much more in accordance with the view that they are really aggregates of units whose crystalline forms are anorthic. This point will be reverted to further on.

Morvenite crystals from Strontian are, as already remarked, much elongated parallel to *b* (010), and they commonly assume a more or less spindle-shape, which is shown by Greg & Lettsom's

figure 3,* and, again (perhaps more correctly), in the figure here, 442/7, left hand. (See p. 36.) The c faces in this variety are usually very narrow parallel to b , (010). They are generally smooth, and are undulated from back to front, with more or less evident traces of re-entrant angles; but there are no striæ in directions at right angles to these lines which might be suggestive of any polysynthetic twinning parallel to b .

The face a rarely occurs, and, when it does do so, it is not in the position where its presence might be looked for; but it may now and then be found as a bilateral component of the aggregate prism face v , (410). This prism face is usually wide, and, indeed, it forms the most prominent feature of the Morvenite crystals. In most cases it oscillates with w , (520), and the oscillations thus produced give rise to re-entrant angles, parallel to $m a$ where a comes in, and to striæ also, parallel to the vertical axis, in other cases. The unit prism m , (110) is generally small, and is often accompanied by w , (520), both occurring as narrow, independent faces, and also, in oscillatory combination with each other.

The four-faced pyramid which takes the place of the simple b face is due to the anorthic character of the units, as b is inclined to c a few seconds more than 90° , so that when the units are thus united into furlings they give rise to an aggregate whose faces do not quite fall into the same plane. The angle a referred to has not yet been accurately determined. But when the crystals are examined in a good light the feature mentioned is perfectly evident.

The place of a is occupied, in many crystals, by the low orthodome (or macrodome) e , (702), which occurs in oscillatory combination with t , (101), the latter face and its negative analogue f being of very rare occurrence. On many specimens this orthodome aggregate-face is repeated bilaterally, and in such a manner as to suggest that the sub-individuals which build up the quarter crystals of Morvenite may themselves consist of a polysynthetic aggregate of more elementary components, in the form of thin plates parallel to b , like those which unite to form such felspars as Albite.†

The whole structure of Morvenite, indeed, suggests that it

* "Mineralogy of Great Britain and Ireland," p. 189.

† See Author's paper in *Proc. Roy. Soc. Edin.*, vol. xxiv., part 3, pp. 321-341.

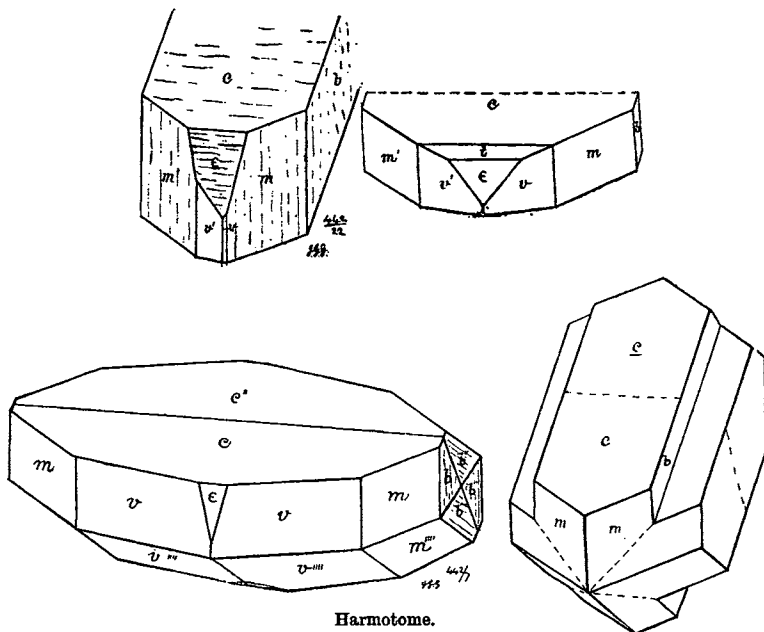
really consists of a mimetic aggregate of anorthic elements, doubly-twinned, and presenting a pseudo-monosymmetric aspect. Harmotome proper is therefore, on this view, at least trebly twinned, if, indeed, its structure does not represent an aggregate of even a higher order than that.

Furthermore, it appears to be probable that even the more elementary components of the crystals may themselves consist of isomorphous mixtures of some allied crystalline compounds, very much as is the case with such Felspars as Oligoclase, Labradorite, &c. These compounds, in the case of the group of minerals to which Harmotome belongs, may be regarded as analogous respectively to a hydrated Albite at one end of the series, and a hydrated Anorthite at the other. The present species, on this view of its composition, may be regarded as a hydrated compound of both of these, in which the place of part of the calcium is taken by barium.

It is a remarkable fact that Harmotome is one of the latest-formed of the minerals in the veins at Strontian, as it is in many other localities. Galena, &c., and Barytes form part of the earlier constituents of the veins. These are followed by Calcite and Pyrites, and the mineral under notice occurs implanted upon the two older generations of Calcite, while it is often surmounted by the third.

As regards the genesis of the Strontian Harmotome, it is not improbable that the rocks where it occurs may have been covered, in quite recent geological times, by the basalt lavas of Tertiary age which cover so large an area in the districts adjacent. These basalts, in their turn, may have been traversed by faults, through which the original contents of the metalliferous veins may have been carried upwards, by means of thermal waters, at a time near the close of the latest manifestations of volcanic action. At a much later period the decomposition of the lavas on the one hand, and of the Barytes on the other, may have furnished the solutions from which the latest ebb-products of these mineral veins have been deposited. Brewsterite occurs in the same veins there, and may well have been formed under similar conditions. I may here remark that I have not yet met with any Scottish crystals of Harmotome which correspond with the published

figures. There are certainly none such in the Scottish Mineral Collection.



443. STILBITE or DESMINE. Silica 57·4, alumina 16·3, lime 7·7, soda 1·4, water 17·2. It loses 1·3 per cent. of its water at 100° C.; 13 per cent. between 100° and 150° C.; at 170° it loses 16·2 per cent. (Damour, quoted by Dana.)

Pseudo-orthorhombic, but really consisting of fourlings of what are usually regarded as monosymmetric sub-individuals, which, however, never occur in their simple state. The components of the fourlings seem, like those in the case of so many other species of the groups here under consideration, to be really anorthic, as they were long ago regarded by Langemann, "Jahb. Min.," ii., p. 132 (1886).

Treated as pseudo-monosymmetric, the forms observed in Scotland may be given as follows:—*a*, (100); *b*, (010); *c*, (001); (210); *m*, (110); *t*, (250); *f*, (101); *e*, (011); (019). The fourlings are thin parallel to the face *b*. Simple fourlings are, however, by no means of common occurrence, as these are usually aggregated into

groups in a manner analogous to that of Prehnite, and, like this mineral, they often tend to give rise to celtiform or axiniform aggregates, in which the bevelled edge of the "axe" is formed by numerous *m* faces grouped together with a certain amount of regularity. Still more commonly these are aggregated into sheaves (as its name Desmine, from *δεσμη*, a bundle, implies), in which the bundle of furlings is constricted in the middle and spread out at both ends. (See fig. 54, page 41.) An excellent photograph showing this characteristic arrangement of Stilbite is given by Miers in his "Introduction to the Scientific Study of Minerals," from which I have already quoted. It may be remarked here that the author of that work has seen the importance of representing minerals as they actually occur, instead of presenting his readers only with ideal crystals, which, although of importance for a correct understanding of the nature of the aggregates, are but seldom met with in nature.*

Stilbite is always a mineral of secondary origin, and is, like all the minerals described with it in the present paper, a product of the decomposition, by epigenic causes, of eruptive rocks containing lime-soda Felspars—the chief agent concerned in the initial stage of the genesis of the mineral being water charged with the humus acids or with carbonic acid. Like its associates it is deposited in the crystalline form usually within the vapour cavities of eruptive rocks. Occasionally, however, unlike most of its allies, it may fill veins or other fissures, and in that case it may occur in tuffs or agglomerates. It rarely occurs (I have not met with it) in rocks of sedimentary origin, even in the cases where these have been covered within recent geological times by eruptive rocks whose decomposition must have furnished the materials for crystals of this mineral. Apophyllite does so occur; but it is by no means clear why this species (and others allied) should not do so.

Stilbite occurs in Scotland in eruptive rocks of various ages, ranging from Carboniferous to Tertiary, but is of much more common occurrence in the former.

Perhaps the simplest plan of treating this mineral will be to notice a few of the leading types and combinations in the order

* See Author's paper in *Proc. Roy. Soc. Edin.*, already quoted, for remarks on this subject, p. 333.

in which the specimens are exhibited in the Scottish Mineral Collection.

(443/3.) From the vapour cavities of the Tertiary basalt lavas of Skye, given as from the Storr Rock. These are aggregates of colourless crystals, many of which are discrete, and which show combinations of bfc , $bfc m$. The crystals are broad and thin parallel to the face b . The f face is well seen, and it appears at first sight to be the a face of an orthorhombic crystal, as the angle it forms with c is $89\cdot30^\circ$, and with b 90° . The f faces form the distal end of the crystals and their proximal end or base of attachment. They are dull, with a peculiar greasy lustre or shimmer like that of the surface of finely-ground glass. This shimmer, on closer examination in a good light, and with a high-power lens, is seen to be due to the fact that the f face itself is an aggregate face formed by the coplanar ends of numerous rod-like components which are parallel to the face b . The lustre of b is, as usual, pearly; and c is striated parallel to $b c$. With a high-power lens and a good light this face, too, is clearly seen to be an aggregate one, which is made up of alternate salient and retiring angles, reminding one of the striations on Oligoclase, though the feature is not quite so pronounced in the case of the Stilbite under consideration. The striation referred to seems to me referable to the fact that the Stilbite consists of polysynthetic twins grouped in accordance with the Albite Law, and that the laminæ themselves are built up of components of a lower order, which are grouped in parallel aggregation, and give rise to the appearance referred to on the f face. They may be c , e , and (014). When the face b is carefully examined in the same manner it is seen to show traces of a feathered striation, which, however, being more pronounced on some other specimens, may be left without further remark here. The unit prisms $m m'$ are usually small in these crystals. They are striated parallel to $m b$, and also to $m e$. The Stilbite is associated with Apophyllite and Calcite, and is based in some cases upon Mesole. Specimen 443/4 shows similar crystals with the addition of the pseudo-clinodome e . 443/7, again, shows the combination $b m e$, in which e is striated parallel to $b c$. Some specimens stated to be from Sgurr an Duine in Skye present very typical examples of the axiniform or celtiform type of aggregates. The component fourlings are combinations of

$m b c e f r$, which are grouped into the bundles whose general shape reminds one of that of an axe or of a bronze palstave. 443/31, said to be from Cochno, Dumbartonshire, is a very fine specimen of a bright red colour. It shows a clino-prism, which appears to be τ , (250); but it may correspond with Heddle's t , (130); so far I have not been able to get reliable measurements of it. Its c face is crossed by striæ parallel to $c\tau$, and it oscillated with e and (014). 443/33, from the same locality, shows the b face of the fourling two sets of striations running approximately parallel to (102) in the one case and (201) in the other. There is also a trace of a clino-pyramid which is near to (251), and an obscure dome not yet made out.

Some Stilbites in the Scottish Mineral Collection are stated to have been obtained from cavities within the Tertiary granite of Arran. The occurrence is a very likely one; but the specimens in question bear so close a resemblance to those found in the corresponding granite of the Mourne Mountains that I cannot help feeling that the occurrence referred to stands in need of confirmation. The same remarks may be made with reference to a specimen of Stilbite which is stated to have come from the corresponding granite of Mull. Probably both of these occurrences will be verified before long.

In the Stilbites from the Tertiary basalt lavas of the Treshnish Isles, 443/61, the dominant forms are $f b c e$. All of these are clearly aggregate faces; and it is not a little remarkable that the f aggregate face should show re-entrant angles, and in some instances should be almost regularly concave round an axis parallel to b , while the c aggregate should be convex around the same direction. In this specimen the Stilbite has grown upon Analcime, and this, in its turn, upon Scolecite. The tendency to assume curved faces occasionally gives rise to curious misleading impressions, as one aggregate of $f b c$ from the Quiraing, specimen 435/7, has taken on a pseudo-tetragonal habit, in which the face corresponding to c is such, and those corresponding to a are convex. Hence, the whole looks like a crystal of Apophyllite with a barrel-shaped habit, which reminds one forcibly of fig. 2, in plate lxxiii. of the "Mineralogy of Scotland."

Specimen 443/59, from the Storr, consist of aggregates of $f b c$ grouped on f around tufts of Aragonite, and in such a manner as

to remind one of a bottle-brush. A specimen from Kildalioig shore, Kintyre, 443/29, is an aggregate of $f b c e$, $b f c m$ (019) r of an amber colour, occurring, as usual, in a vapour cavity of an eruptive rock, and based upon what appears to be Laumontite. The components of the aggregate have their f faces as the distal (and proximal) ends, and show a remarkable resemblance in outline to orthorhombic crystals. They are grouped side by side on the b faces almost like a string of beads, and upon an axis corresponding in direction to that of b . The middle components are largest, and successively smaller components follow each other from the middle outwards in both directions, so that the aggregate assumes a pseudo-convex outline around one axis corresponding to c , and around another corresponding to a . There seems, indeed, hardly a limit to the variation in shape which may arise through the fasciculation of these crystals of Stilbite. One may be permitted to express a regret that the name Desmine, by which this mineral is so generally known on the Continent, and which is so very specially descriptive of its most characteristic habit, has been replaced by a name referring to its lustre, which it shares equally with the allied mineral Heulandite (which, by the way, is usually called Stilbite by our Continental fellow-workers).

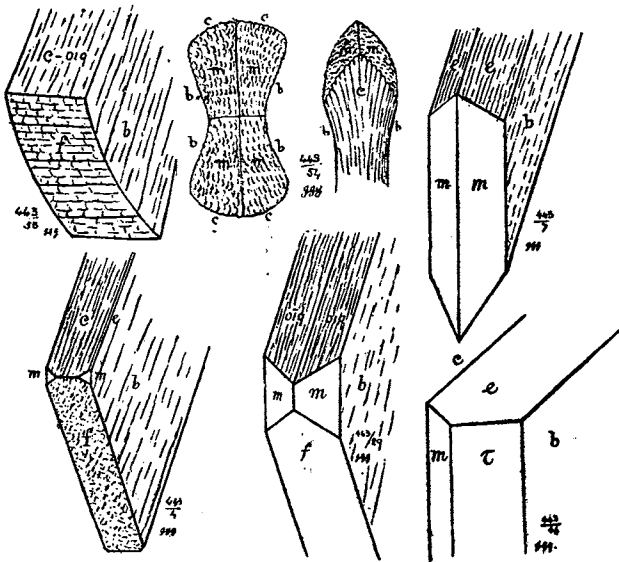
Amongst the crystals hitherto noticed the colour of the Stilbite is usually weak, and is, indeed, more often than not, conspicuous by its absence. Moreover, the almost constant presence, and usually large development of the form f , and the small size of the form m , impart to the Stilbites of the Tertiary volcanic rocks, as a whole, a peculiar facies. In the case, however, of the Stilbites from the Andesitic volcanic rocks of Lower Carboniferous age, as well as those from the Caledonian Old Red Sandstone, the form m is rarely absent, f is small, or often quite cut out by m , and the colour of the specimen tends to be, very commonly, of a lively red. Very few Zeolites, indeed, can rival in lustre and in beauty of colour the fine Stilbites from the basin of the Clyde, and from such districts as Kilpatrick, Kilmalcolm, Campsie, the Touch Hills, and other localities in that part of Scotland. There may be some connection between the colour of the Stilbite and the lithological nature of the rock from which it has been derived.

At all these places Stilbite occurs in connection with eruptive rocks (usually lavas) of Lower Carboniferous age, whose ancient

vapour cavities are lined with this and other Zeolites. It also occurs, though less plentifully, on the eastern side of Scotland, where it may occasionally be found even in the lavas associated with the Caledonian Old Red Sandstone. It appears to affect basalt lavas as commonly as Andesites; but it is usually pale in colour when occurring in the former rocks.

There is comparatively little variety in habit of the crystals referred to in the last two paragraphs. They mostly consist of the usual fourlings of the combination $a b c m e \tau$ (or t) which present the well-known pseudo-orthorhombic habit. The disposition to aggregate into bundles, or sheaves, is equally well marked here.

Indeed, it is chiefly this tendency to take on the sheaf-like habit which serves to distinguish Stilbite or Desmine from its



Stilbite or Desmine.

near ally, Heulandite, which it quite commonly resembles in lustre, colour, and mode of occurrence; and it is very frequently the case that the two minerals occur in the same cavity.

Stilbite or Desmine must have been formed at an early stage in the history of the rocks in which it occurs; and it is therefore

not a little remarkable that it should have survived unchanged as commonly as it has. There are a few pseudomorphs after it here and there ; but they are by no means common.

The figures on page 41, which, as in the case of the others in this paper, have been drawn by myself from specimens in the Scottish Mineral Collection, will serve to convey a fair general idea of the habits and range of shape of the Scottish forms.

445. LAUMONTITE. Silica 51·1, alumina 21·7, lime 11·9, water 15·3. Generally regarded as monosymmetric. In habit somewhat resembling the Pyroxenes.

The usual habit presented by Laumontite in Scotland is that of a combination of the unit prism *m* with the basal pinacoid *c*, and more often with the negative hemi-orthodome *e*. Occasionally, the clino-pinacoid *b* and the ortho-pinacoid *a* may occur ; and sometimes the hemi-pyramid *r*, with or without its negative analogue. In general aspect the crystals appear like slender, elongated rods, with nearly a square cross-section, as the angle *m m'''* is $93^{\circ} 44'$. It occurs in the manner usual with the group to which it belongs ; but its range is from the lavas associated with the Caledonian Old Red Sandstone, in the vapour cavities of which it is by no means rare, through the Lower Carboniferous lavas, to the volcanic rocks of Tertiary age. In many cases, if not in all, it is found in rocks of Andesitic composition.

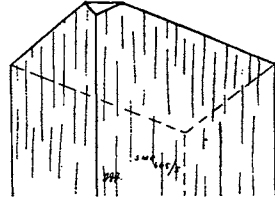
Most Laumontites readily, and at low temperatures, part with some of their water of crystallisation, and, hence, the mineral is very prone to undergo change. The specimens in the Scottish Mineral Collection show this very well. Some of them were left without air-tight covers, and, in the course of a few years, they crumbled down into a mealy powder. Other specimens from the same locality, which have been enclosed within air-tight glasses, have retained their water, and therefore their crystalline form, in its original integrity. In some few other instances the mineral shows little or no tendency to alter in this way. Probably there may be some slight difference in composition between the two specimens which behave so differently. The decay of Laumontite may be arrested by saturating the specimens with boiled linseed oil. This has been done in the case of some of the more friable specimens above referred to, with good results.

The specimens in the Scottish Mineral Collection present very little range of variety in either habit or mode of occurrence. They are all tenants of the vapour cavities or of other vacuities in eruptive rocks; and in most cases these rocks are Andesitic lavas. It is remarkable that the Zeolites in general seem to prefer the cavities of lavas to those found in rocks of intrusive origin—though they are not, of course, entirely absent in these. The proximal end of the crystals is usually *c'*, and the crystals are nearly in all cases very much longer than wide. In most cases there is very little tendency to occur in groups, at any rate of the kind shown by many of their associates; and when they do happen to occur in bundles the association is manifestly more or less the result of accident. But the Laumontites from Skye are exceptional in this respect. Laumontite occurs in the lavas associated with the Caledonian Old Red, in those of the Lower Carboniferous rocks, and in the Tertiary volcanic rocks. It cannot be regarded as a mineral of common occurrence anywhere.

On 445/5, from Bowling, Dumbartonshire, Laumontite occurs in the form of minute white crystals irregularly disposed upon Analcime, and associated with Stilbite. The usual combination, *me, mec*, is observable upon most. On 445/6, from the Caledonian Old Red lavas of Glen Farg, the crystals are of a pale red colour, and are exceedingly friable as a rule. The combination is the usual one of *me*; but it is especially noteworthy that both of these forms are plainly seen to consist of aggregates, and the edge common to the two forms is much notched by the spaces between the sub-individuals. Doubtless the finest and most striking examples of Laumontite are the splendid aggregates of white crystals from the Tertiary volcanic rocks of the Hebrides. These are mostly of a dazzling white colour, and usually consist of the combination shown in the figure annexed. (See p. 44.) They crumble to fragments after a very short exposure to the air. These crystals from Skye show aggregate faces on each part, as is particularly evident upon the rounded face which represents *e*, where a considerable number of sub-individuals are grouped with bundles in such a manner somewhat like that followed by aggregates of the crystals in a bundle of Stilbite or Desmine. The *m* faces are compounded in the like manner, so that it becomes difficult, or almost impossible, to get any accurate

measurements. Occasionally *c* is present, and in a few cases *b* is also present. There is no clear evidence to show whether these sub-individuals possess the same grade of symmetry as the crystal which they help to form.

From the Caledonian Old Red Andesite lavas of Kirriemuir comes Laumontite of the habit shown, which is from a specimen obtained by Mr. Keith O. B. Young of Kingoldrum.



Laumontite.

Another fine specimen typical of its kind was obtained from the rocks of the same age at Glen Farg by Mr. D. Braid of Kirkcaldy.

The three minerals which come in natural order after Laumontite are Chabazite, Gmelinite, and Levyne. Like so many other of the groups treated of in this paper these present many features which are more or less anomalous. They are all aggregates of sub-individuals whose true grade of symmetry is much lower than that of the crystalline combination under which they usually appear. Furthermore, like the Felspars, and also like Natrolite, Scolecite, and Mesolite, they are often regarded as isomorphous mixtures, in varied proportions, of two end compounds. In the case of the present group these are regarded respectively as $m(\text{Ca}_1 \text{Na}_2) \text{Al}_2 \text{Si}_2 \text{O}_8 + 4 \text{H}_2\text{O}$, and $n(\text{Ca}_1 \text{Na}_2) \text{Al}_2 \text{Si}_6 \text{O}_{16} + 8 \text{H}_2\text{O}$. Crystallographically they are pseudo-rhombohedral; but there is more or less good evidence to show that the apparently-simple crystals are really highly-complex aggregates of anorthic sub-individuals, each of which, as we have just seen, is supposed to consist of a mixture of the two other compounds whose formulas have just been given.

Their mode of occurrence does not call for any general remark, beyond what has been already given in connection with the species above mentioned.

447. CHABASIE OR CHABAZITE, which is somewhat variable in composition, may be given as a compound of silica 47·4, alumina 20·2, lime 11·1, water 21·3.

Its usual crystalline habit is that of a pseudo-rhombohedron,

which is the form assumed by the well-known crystals from Kilmalcolm, and also by many from the Tertiary lavas of the Hebrides. At a first glance these look almost like cubes, and, indeed, a beginner may be pardoned if he mistakes some of these crystals for Fluorspar. Yet the following quotation from Dana's "System of Mineralogy," 1892, p. 590, may serve to explain why this apparently very simple crystal is regarded in quite another light by those who have closely investigated its structure:—"The optical characters of Chabazite have led Becke ("Min. Mitth.," ii., 391, 1879) to a hypothesis of a twinning of triclinic individuals. On this view the Chabazite rhombohedron is formed of six or more individuals, each cleavable in three directions, corresponding to the rhombohedral planes, but to be taken as the pinacoids of a triclinic crystal, 100, 010, 001. The angles α , β , γ , formed on each of these faces, respectively, between the diagonal and the extinction-directions, vary for the different localities, but in a typical example from the Farøes were as follows:— $\alpha = 22^\circ 8'$, $\beta = 5^\circ 8'$, $\gamma = 12^\circ 3'$. The following angles were also obtained on the cleavage form:— $100 \wedge 010 = 83^\circ 42'$, $100 \wedge 001 = 85^\circ 31\frac{1}{2}'$, $010 \wedge 001 = 85^\circ 5'$.

"These six or more individuals are regarded as united into double twins, according to two twinning laws, the twin planes, 110 and $\bar{1}\bar{1}0$ (corresponding to faces of the second series) inclined $118^\circ 5'$ to each other. Three types are distinguished, according as to whether the faces taken as 100, 010, or 001 form the exterior of the pseudo-rhombohedral crystal. These three types are recognised by the angle formed by the extinction-directions in the two halves of a rhombohedral face on either side of the diagonal line. In the first type this angle is about 46° ; in the second, small, about 11° ; in the third, about 24° . A basal section shows six sectors with an arrangement of the extinctions in the different parts corresponding to these types, of which, however, the second is rare, and not positively identified."

I have given these two paragraphs in full, because they seem to me to express, in a very definite form, the conclusion that I have been led to independently by a study of the exterior aspect of the crystals of this species.

As in the case of the minerals previously noticed, this one may conveniently be treated in the order in which the specimens in the Scottish Mineral Collection are exhibited. The first twenty

are stated to be from the Tertiary eruptive rocks of Skye. There is more or less sameness in their general aspect, as well as in their mode of occurrence. Nearly all the crystals consist of the primary rhomb r , whose faces are striated through oscillation with $\omega o t t' t^2 e' e$. A few specimens show also s and e , one of which is figured here. Most of the Chabazite is based upon the "priming" formed of numerous hemispherical groups of the variety of Thomsonite which used to be distinguished as Mesole, and which Dr. Heddle afterwards re-named "Faröelite." Some of the Chabazite also lies across crystals of Analcime; and in other cases it is associated with what is said to be Scolecite. In a few instances some small, but pretty, dendritic growths of Limonite decorate the faces of the Chabazite. None of the crystals much exceed half an inch across, and most of them are colourless. Calcites of unusual habit occur with these in a few instances.

Two or three specimens, stated to be from the Quiraing, show a complex interpenetrant growth, with some curious coplanar faces common to all the components of the twin. These require fuller investigation.

Most of the other specimens, stated to come from Skye, consist of more or less complex double sixlings, of which a basal view of a typical example, drawn from 447/35, is given on page 48.

I may remark here upon the extraordinary similarity between these Zeolites from the Tertiary volcanic rocks of the Hebrides and those from Antrim. I have myself collected numerous specimens from both localities, and can answer for the fact. The same remark applies to the specimens from the Faröes. Before leaving the subject of the Chabazite crystals from the Tertiary volcanic rocks of the Hebrides, it may be proper to remark that they usually consist of what is called the primary rhomb r , more or less striated by a series of faces in the zone $[r e]$, or else, if other forms occur, the whole crystal tends at once to become complex, and to take on more or less of the character of double sixlings. It will be seen presently that even the unit, as it may be regarded in this case, is a very complex aggregate of forms belonging to a much lower grade of symmetry.

In the Scottish Mineral Collection there is one remarkable specimen of Chabazite, 447/44, of quite the normal character, so far as the crystals are concerned, which is from what appears to

have been an inclusion of some calcareous rock, which occurs in the granite of Alford, Aberdeenshire. It occurs in small primary rhombs upon Idocrase and is associated with green Apatite. It may even in this case be, as it usually is in others, simply a decomposition-product of some of the rock-forming Silicates. The occurrence is, perhaps, unique.

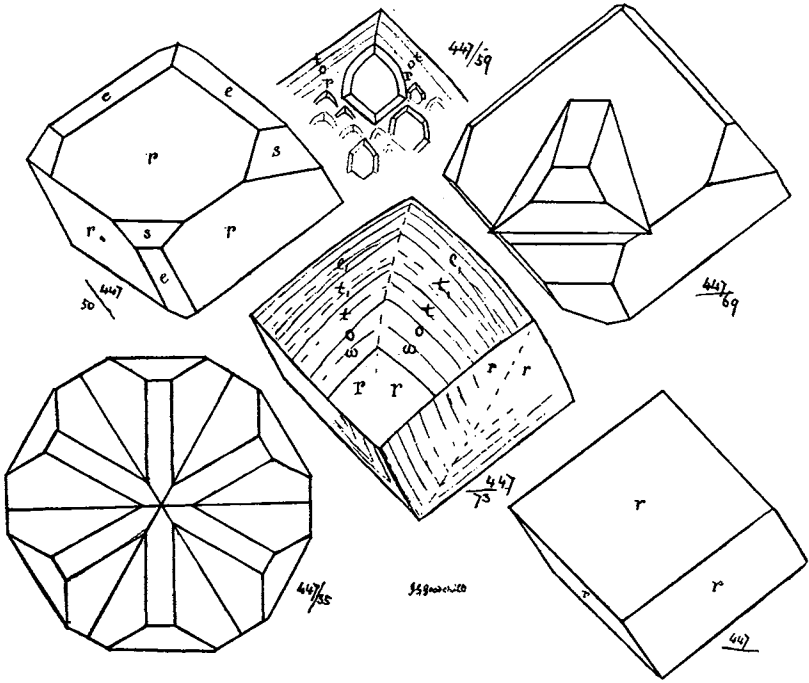
The Collection, which is rich in Zeolites, includes a specimen of Chabazite from the Tertiary volcanic rocks of Sanda, in the island of Canna, 447/46, looking at first sight to be like a roughly mammillated crust, but on closer examination it is seen to be built up of nearly spheroidal aggregations of crystals of Chabazite. The crystals composing this are very small, and they need a much more careful study than I have yet been able to give to them; but their general facies is not unlike that shown in fig. 3 of Chabazite in Dana's "System." On the other hand, it may prove that these rounded faces are built up by tessellations of the kind to which further reference is about to be made.

Some of the very finest Scottish specimens of Chabazite occur (or *did* do so) near Kilmalcolm. The locality given by Greg is "Grainger's Quarry, half a mile north of Alton House, two and a half miles south-west of Kilmalcolm." The crystals there are, in many cases, of large size, and a few measure quite an inch across. They are usually some pale shade of "middle chrome," or I should be inclined to liken their colour to that of sugar-candy, and, in other cases, to that of the inside of an apricot. In many cases they are based upon Mesolite, and they are somewhat older than some sheaves of pale-coloured Stilbite or Desmine, and some small, but pretty, groups of Heulandite. But the Chabazite stands out prominently before all the rest. Specimens 26, 27, 40, 58, 59, 60, are all remarkably fine, and worthy of study. They mostly consist simply of the so-called primary rhomb, r , which, however, is clearly an aggregate form in this case, and shows, as is usually the case elsewhere, a series of oscillatory combinations of r with ω , o , t , z , and e , the forms ω , o , nearer to r , predominating as a rule.

Perhaps the most instructive example of the whole is 447/39,*

* This has been erroneously numbered 59 on the figure given under this heading on page 48.

which is stated to be from "Gryffe Tunnel, Renfrewshire." Calcite crystals have been formed first, then follows what has been called Sphæromesolite, then the amber-coloured Chabazite, and finally Mesolite or, perhaps, Scolecite. The feature of special interest about this specimen is that although at a first glance it appears to consist of the primary rhomb *r* somewhat rougher on the surface than usual, it is seen on a closer scrutiny to be a tessellated compound of small crystals whose general habit is quite unlike



Chabazite.

that of any of the aggregates. These are *not* solution figures, for they stand up in good relief; they are all alike so far as their boundaries and their orientation is concerned, and they are clearly terminated by plane faces. Their general aspect can be best understood by a reference to figure 59 on this page, drawn under the microscope with the aid of the *camera lucida*. That these units (if such they are) are anorthic, hardly, I think,

admits of a doubt. But for the present I must be content to call attention to their occurrence, and to await an opportunity of measuring their angles carefully with a good reflecting goniometer, which it ought not to be difficult to do.

A study of these remarkable units raises the question whether in looking even at these we see before us the true units of structure of Chabazite. The rule in all these cases of complex aggregates appears to be that the aggregates assume a higher grade of symmetry than any of their components; there being, apparently, no case in which it can be shown that the structural unit of a crystal belongs to a higher grade than its aggregate. It would further seem as if when a certain grade of symmetry is reached the higher aggregates tend to assume curved boundaries. The fact is observable in so many cases that one is led to think it must be an expression of a general law. In that case the lowest grades of organic structure may, so far as their shape is concerned, be regarded as standing only just beyond the limits which are attained by many crystalline aggregates. But the subject is too extensive to be discussed at length here. The figures on p. 48 may be regarded as fairly representing the chief varieties of crystalline habit shown by the Scottish examples of the species.

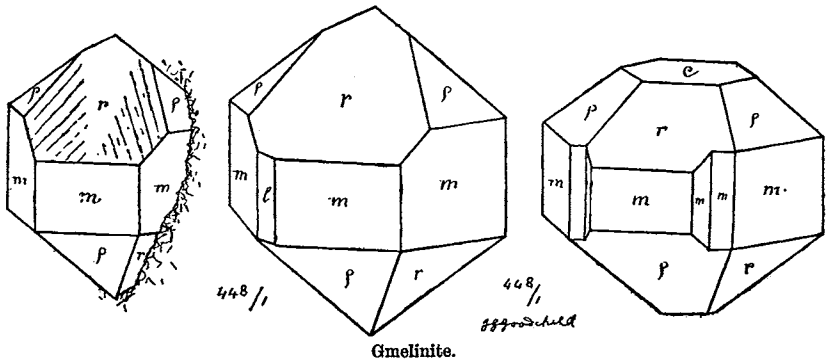
The forms observed and their symbols and indices are as follows:— r , (10 $\bar{1}$ 1); o , (21 $\bar{3}$ 4); t , (11 $\bar{2}$ 3); e , (01 $\bar{1}$ 2); s , (02 $\bar{2}$ 1). In addition to these well-marked faces, which are of common occurrence, there is certainly a series of planes lying in the zone [re] and which give rise both to the striations and to some of the apparent rounding seen upon the crystals in a few instances. These may be taken in the following order:— r , ω , (31 $\bar{4}$ 5); o , t , t_1 , (23 $\bar{5}$ 8); e_1 , (12 $\bar{3}$ 5); in which ω , t_1 , and e_1 are introduced as the new forms referred to.

448. GMELINITE. Silica 46·9, alumina 19·9, soda 12·1, water 21·1. Pseudo-rhombohedral; but really an aggregate of anorthic sub-individuals.

There are two specimens in the Scottish Mineral Collection which are stated to have come from the Tertiary volcanic rocks of Skye. The occurrence is a very likely one, but it would be more satisfactory if it were independently confirmed. They look very much like specimens from Antrim.

Assuming, however, that there is no proof that the crystals in question are not Scottish, I have sketched three of them, and give the figures here. One of the specimens is stated to be the one figured by Greg, (*op. cit.*, fig. 5,) but I cannot see much resemblance between the specimen and the figure, so, perhaps, even he did not always draw exactly what he saw. Or, it may be that the diagram referred to was sent to him ready made.

I may remark here that it does not appear to be always quite clear whether a specimen shall be called Chabazite or Gmelinite. When the *m* faces are developed, the distinction is clear enough; but this cannot always be made out. Furthermore, it is not always possible to make use of the test afforded by the cleavage



which follows *r* in Chabazite, and *m* in Gmelinite. Nor is the pseudo-rhombohedral habit of the former, and the pseudo-hexagonal habit of the latter, always quite clearly exhibited. I do not mean to question the distinctness of each from the other; but simply to remark that it is not always an easy matter to distinguish between them. Probably there may be something still to be said for the old view that Chabazite and Gmelinite are dimorphous forms of the same compound.

The forms observed on the specimens above referred to are *m*, $(10\bar{1}0)$; *l*, $(52\bar{7}0)$; *r*, $(10\bar{1}1)$; *p*, $(01\bar{1}1)$; *c*, (0001) ; *a*, $[11\bar{2}0]$.

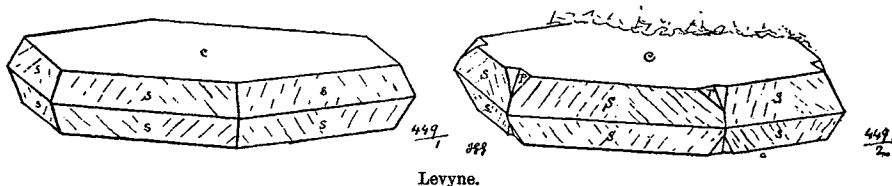
449. LEVYNE* of Brewster (1825), but still earlier called

* Why change the termination so as to make the name Levynite? Absolute uniformity of nomenclature is neither possible nor desirable; and it is only putting a greater burden upon one's memory to change a name already long in use.

Mesoline. Silica 49·2, alumina 10·9, lime 11·5, water 18·4. Pseudo-hexagonal ; but really an anorthic aggregate.

Whatever may be the case with regard to Gmelinite, there cannot be any doubt about this species occurring in Skye. Amongst others who have found it may be mentioned Mr. James Currie, whose knowledge of the mineral localities of the Hebrides is probably unrivalled. In regard to its mode of occurrence, the only feature calling for special remark is that it is frequently the sole occupant of the vapour cavity in which it occurs. Mr. Currie tells me, however, that it is by no means the case that it is found always alone. It may be remarked here that closely-adjacent vapour cavities in eruptive rocks quite commonly differ in their mineral contents. As I write, there lies before me a rock, said to come from "Scroggie, Fife," which contains an Agate in one cavity, one of the Green Earths in another, Quartz in a third, Calcite in a fourth—all within an area which can be covered by a penny. And similar cases are well known to occur quite commonly. *Why* this should be so is another matter. Indeed, one may go further than that. I have just now been examining a specimen of one of the basalt lavas of Skye in which Chabazite occurs solely in unit rhombs, *r* ; while, in another vapour cavity within an inch of it, on the same specimen of rock, the Chabazite occurs in complex twins of *r t o e s*. Of course, in other cases both habits are represented.

The crystalline habit of the Skye Levyne is peculiar. It occurs



in the form of very small discoid crystals, which are really double sixlings. The figures will show what these are like.

The forms observed, and their indices, are as follows:—*c*, (0001); *s*, $02\bar{2}1$ (showing feathered striations parallel to *s r*); *r*, (10 $\bar{1}$ 1).

450. ANALCIME. Silica 54·5, alumina 23·2, soda 14·1, water 8·2. Pseudo-isometric. I do not propose to dwell here at any length

upon the vexed subject of the true crystalline form of this species, beyond expressing my own belief both that it had better be described under the ambiguous heading just given, and that the evidence yet advanced that it is really isometric is by no means satisfactory.

Treating it, for convenience, as isometric, the forms observed upon Scottish crystals, which I have myself examined, are as follows:— a , (100); n , (211); e , (201); z , (332); and some oscillatory combinations of (411) with what may be (944).^{*} Here, Analcime appears to be, invariably, a mineral of secondary origin, which occurs, usually, in the same manner as the other species noticed here. I have never seen any Analcime which, on satisfactory grounds, can be shown to be pseudomorphous after Leucite. It certainly looks as if it might so occur; but proof that it does do so has yet to be forthcoming. The only case in which it occurs within the body of a rock (as distinguished from its vapour cavities) which I have yet seen, is in one of the basic intrusive masses which crosses the Firth of Forth, and which forms Carcraig and the eastern end of Inchcolm. But, even in these, there is no sign of the mineral having replaced Leucite.

Having referred to Analcime at some length in my paper mentioned previously,^{*} there does not remain much to be stated here. Analcime is singularly uniform in its crystalline habit, as in the great majority of cases it occurs simply in the icositetrahedron, n , (211). For the information of those who do not happen to be familiar with the mineral it may be stated that this form is a solid formed by twenty-four faces, each one of which has the shape of the mainsail of a sloop. The lustre of Analcime is very peculiar, and its granular fracture is very characteristic.

I may remark I have not been able to learn anything regarding the whereabouts of the crystals of Analcime figured by Dr. Heddle in the *Trans. Edin. Geol. Soc.*, vii., pp. 241-2 (1898). The crystals are described as "from Boylestone quarry, near Barrhead, in Renfrewshire." The Boylestone specimen, 450/122, in the Scottish Mineral Collection, however, shows distinctly the e and z of the list of forms above, as well as a and n and the, supposed, [944].

^{*} See Author's paper in *Proc. Roy. Soc. Edin.*, xxiv., part 3, p. 334.

(See figs. 6 to 9 of my paper referred to in the footnote on last page, and see also further remarks on this species, *infra*.)

Analcime almost never occurs with the symmetrical development of its faces such as are shown in text-books, and hence, as might be expected, it is sometimes not recognised by those unfamiliar with its habits. I have figured two or three of these malformations already, and reproduce them here by permission of the Council of the Royal Society of Edinburgh, in whose *Proceedings* they were published. I remember seeing in a book dealing with Analcime some figures of malformed Fluorspars, which were taken from Naumann, and reproduced on p. 115 of the 4th edition of Dana's "System," and which were made to do duty by the author of the book referred to, as original drawings of Scottish crystals of Analcime. Perhaps this is only another way of stating the fact that the malformation of Analcime does in some cases go to an unusual length.

In the Scottish Mineral Collection there are some very remarkable examples of malformed Analcimes, far more striking than those to which reference has just been made. Amongst the most striking of these are two specimens, 450/101 & 102, from a vapour cavity in a lava of Lower Carboniferous age, stated to be from Bowling, Dumbartonshire. On this some small crystals showing n faces are elongated in one direction to such an extent that they are from four times to ten times as long as wide. Their general aspect, as they branch outward from their points of attachment, reminds one very much of the outspread fingers of a hand, and the resemblance is increased by the fact that the distal faces of the crystal bear about the same proportion to the length of the crystal, on the whole, as a finger nail does to the finger which supports it. They are based upon what appears to be Scolecite, the distal ends of whose tufts of slender prisms actually extend far within the substance of the Analcime, and, apparently, are the cause of many curious anomalies of growth presented by the faces of the Analcime where these occur. It may be further remarked, in passing, that extremely curious groups of crystals of pale-green Prehnite, resembling short dumb-bells, are, in turn, grown upon some of the Analcimes.

There are several specimens of these Analcimes malformed by excessive growth in one direction; but I need only refer to one of

them, 450/86, which is from a vapour cavity within one of the Andesite lavas of the Caledonian Old Red Sandstone, stated to be from Long Gallery, Kincardineshire.

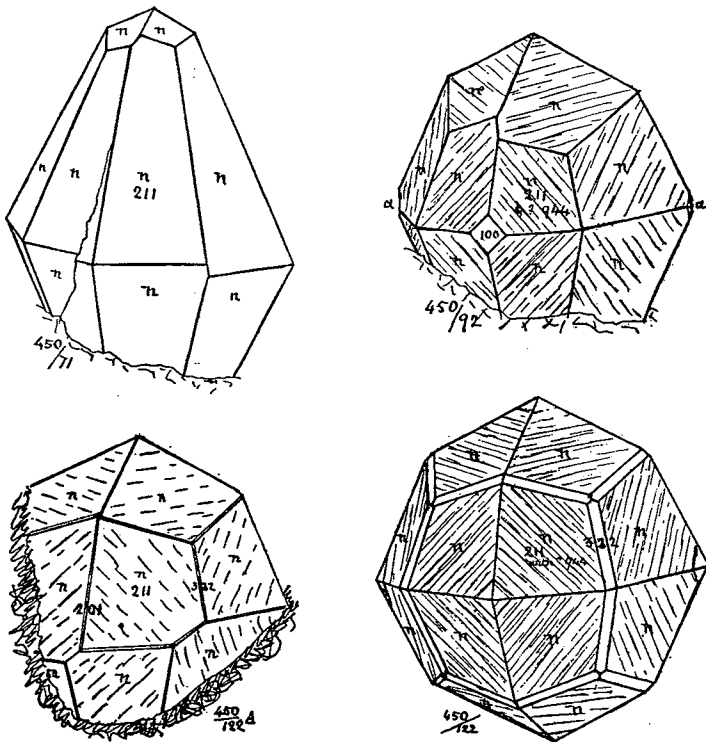
Analcime is usually white or colourless; but crystals of a delicate sapphire blue occur among the lavas of the Hebrides. Crystals coloured red, either wholly or in part, are by no means uncommon. One very interesting group of small crystals from Bowling Quarry, 450/41, seems to graduate into Prehnite, and is associated with native Copper and Malachite. Another, from Boylestone, Barrhead, 450/76, consists of botryoidal groups of minute crystals, n , which are of a decided green colour. These are associated with minute globules of what looks like Chrysocolla. Native Copper and Malachite both occur in association with the Prehnite, so it is possible that the Analcime may be coloured more or less right through. It is not a little remarkable that part of this should, in turn, be coated by a very thin film of Rubinglimmer (which I regard as a scaly form of Turgite, bearing the same relationship to that hydrous oxide of iron that Specular Iron does to Hæmatite).

There are two examples of Analcime graduating into Prehnite, the other one, also from Bowling, being specimen 450/98.

Analcime does not always occur in the single form n . Specimens 450/115 & 116, from the Tertiary volcanic rocks of Kellie Law in Fife, are almost cubes, each solid angle being represented by small trihedral n . 450/115 shows, in addition, traces of two other forms which oscillate with n . Their indices have not yet been made out. Some Analcimes from rocks of the same age at Ruddons Point, west of Elie, in Fife, show three such forms. These seem to be important in affording a hint regarding the true nature of the crystals.

The most complex combinations I have yet seen on Analcime occur upon some small brilliant crystals on pale green Prehnite. The Analcimes are colourless and perfectly pellucid, about a sixteenth of an inch across. The predominant form is n , (211); but the crystals carry in addition the faces of the cube a , (100) always irregularly developed, the faces of the trigonal trisoctahedron (332) truncating those edges of the leucitoid, and an exceedingly narrow face (201). In addition to these there must be another form present which gives rise to striations across the n

face, and which are due to oscillation of n with a face near o in the zone $[a\ o]$. It appears to be (944); but the unsatisfactory nature of the evidence renders this little more than a guess. It is evident that these Boylestone specimens which show the combination (211, 100, 332, 201, and ? 944) are amongst the most complicated yet observed of this usually excessively simple mineral, and it is certainly remarkable that while nowhere else in Scotland are crystals found showing more than two forms, those at Boylestone exhibit no less than four, and perhaps five. The specimens just referred to are in the Scottish Mineral Collection, and their registration number is 450/122. The drawings are placed close to the specimens to which they refer, and mineralogists may have the specimens out at any time for the purpose of closer



Analcime,

examination on the spot if need be. I may add that a long and very careful examination of the crystals referred to failed to lead to the discovery of any other forms than those mentioned.

As already mentioned under Pectolite Analcime is in most cases older than the former mineral. In a few cases there seems to be a definite successional order in which this mineral occurs. In some cases it both overlies and is succeeded by Mesolite. In some of these examples the Analcime has grown around and enveloped the ends of the crystals of Mesolite. In other cases it overlies Laumontite.

Some of the finest crystals of Analcime I have yet obtained *in situ* were got in the vapour cavities of the Lower Carboniferous lavas on the Touch Hills, near Stirling. They are often associated with red Stilbite or Desmine. Another locality where large and well-developed crystals occur is at the foot of the cliff about a hundred yards east of the new Canty Bay Hotel, near North Berwick. They are also seen in several cases below Tantallon Castle. Strangely enough, Analcime seems never to occur in either tuff or agglomerate, even when the materials of which these pyroclastic rocks are composed consist of little else than fragments of scoriaceous lava.

Analcime is abundant in the vapour cavities of the Tertiary basalt lavas of Mull and Skye. It occurs in lavas of all ages from those associated with the Caledonian Old Red Sandstone, through the lavas of Lower Carboniferous age to the Tertiary basalts.

452. EDINGTONITE. Silica 36·8, alumina 20·9, baryta 31·3, water 11. ? Tetragonal, with sphenoidal hemihedrism.

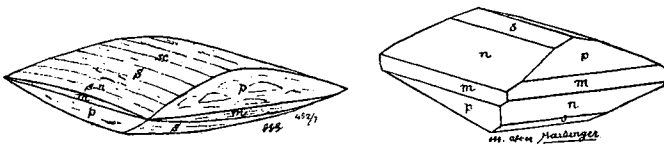
This is a very rare mineral in collections, perhaps on account of its small size and generally inconspicuous character, but still more likely because it appears to be limited to a small area in the Kilpatrick Hills, near Glasgow, and to have occurred there only in quarries which are no longer worked. It is said to have been found, according to Greg, at the following places:—"A quarry half a mile north-east of Old Kilpatrick; with Prehnite at Bell's quarry near Bowling quarry, and also at a quarry five miles north of Old Kilpatrick." (*Op. cit.*, p. 193.)

The general habit of this species is very peculiar, so that no other mineral could very well be mistaken for it.

Hedde reproduces Greg's figure, and Dana reproduces

Haidinger's, which I have re-drawn and inserted here. Miller's figure is different again. My own figures, drawn from registered specimens in the Scottish Mineral Collection, are unlike any of the others.

The majority of the specimens in the Scottish Mineral Collection have the form of small phacoids, with two doubly-curved surfaces, which bend in directions at right angles to each other on opposite sides of the crystals, and which are bounded by four narrow plane surfaces, representing the unit prism m , (110); and by four other hemipyramidal planes or sphenoids, p , (111), in pairs, alternately above and below. The curved faces appear to be aggregates of n , (112); s , (113); and c , (001). The habit is very remarkable, and quite unlike that of any other mineral.



Edingtonite.

I hope to return to the study of this mineral on some occasion in the near future.

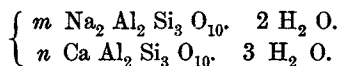
A group of minerals having certain external characters in common follows next. They are sometimes referred to collectively as the Needle Zeolites, because they are all characterised by a more or less acicular type of crystallisation. Tufts of slender, needle-like, crystals start from some small roughness on the walls of a vapour cavity, and, from this, a comparatively rapid outward growth takes place, each "needle" holding on in the same course as that on which it started, and growing lengthways very much faster than it thickens at the side. So it is quite commonly the case that a crystal of one of these Needle Zeolites may be forty or fifty times as long as it is thick, and its diameter throughout may not vary except to a small, and sometimes imperceptible, extent. Not uncommonly, younger needles start up in the interspaces between the older ones, and, as this process is continued, the open order which the tuft of needles was at first inclined to take gradually gives place to a closer aggregate, and the growth of the

mass may eventually fill up the whole, and convert the tufts into a more or less compact mass, in which further growth is impossible except at the outer surface. As the needles quite commonly grow outward at nearly or quite the same rate, the result very commonly is the building up of a hemi-spheroidal mass. This, with further enlargement, may come into contact with a neighbour, or further growth may be rendered impossible by the ends of the needles touching the ceiling of the cavity from whose floor the start was made.

This general description is applicable to the whole of these Needle Zeolites, each of which may now be considered in a little more detail.

Some reference has already been made in this paper to the importance of taking into account the possibility of several apparently different minerals being simply isomorphous mixtures of two end compounds in various proportions. One of the difficulties which arises in connection with this is connected with the fact that minerals which crystallise in different systems appear to be unlikely to form one crystalline compound. I have already discussed this question in my paper, "Contributions to Scottish Mineralogy," previously quoted, read before the Royal Society of Edinburgh, and Professor Miers has also considered the question, and the general conclusion to which he has been led is that one of the component minerals must be dimorphous, and its second form must belong to the same system as that of the other. The suggestion is valuable, and seems on the face of it to be the true one.

In the group of minerals that now comes for consideration, it is assumed that the three species, Natrolite, Scolecite, and Mesolite, are isomorphous mixtures of compounds having the following general formula :—



But the minerals which arise by the mixture are usually regarded as orthorhombic in the case of Natrolite, monosymmetric in the case of Scolecite, and ambiguous in the case of Mesolite. If they are all treated as really anorthic aggregates, which is what they appear to me to actually be, the difficulty would be considerably lessened. Pseudo-monosymmetric would be the

best general name for the crystalline system of the Natrolite group as a whole.

453. NATROLITE or MESOTYPE. Silica 47·4, alumina 26·8, soda 16·3, water 9·5. Pseudo-orthorhombic; but probably pseudo-monosymmetric twins.

As the mode of occurrence of this species does not differ in any essential feature from that of its allies, the subject may be dismissed without further remark beyond the one that it very commonly occurs as the third deposit in an Agate; the first being the priming of Green Earth, the second the clear Chalcedony layer, and the third a more or less sporadic deposit of the present species, in the form of isolated tufts, which in some cases are so small as to be scarcely visible (or may be absent entirely from the Agate), while in others the growth of the mineral may end by filling the whole cavity. It is usually around these tufts of Natrolite that the later deposits of Chalcedony in an Agate tend to accumulate in the form of spheroidal masses. The tendency to form "eyes" and mammillations around tufts of this mineral is one of the chief causes of the diversity in pattern of some of the finest specimens of Agates.

Natrolite generally occurs as elongated rods or prisms whose square cross-section is constituted by the faces of the unit prism, $m m''$, which form an angle of $88^{\circ}45'$. This, at a first glance, does not appear to differ much from a right angle. It grows outward from c , and the length of the crystals may be fifty or more times the width of the cross section. Usually several crystals start from the same point, and hence as they grow outward they give rise to divergent groups or tufts, the individuals of which, however, commonly enlarge at such a rate as to keep in contact, and hence they eventually interfere with the growth of each other's prism faces. Not uncommonly they interlace. Terminated crystals, in Scotland at least, are of rare occurrence, and crystals doubly terminated do not appear to have been observed there. In some cases the crystals diverge from the initial point so widely as to form almost radial groups.

Natrolite affects the eruptive rocks which contain lime-soda Felspars, in whose vapour cavities it is that the mineral chiefly occurs. It is not at all an uncommon mineral in the Andesitic

lavas associated with the Caledonian Old Red Sandstone of Fife-, Perth-, Forfar-, and Kincardine-shires. In these rocks its colour is frequently a pale brick-red. One of its many varieties occurring in the lavas at Glen Farg has been distinguished as Fargite; but the composition of Natrolite is subject to some range, and, hence, such names as Crocalite, Fargite, Galactite, and others that have been given to varieties of Natrolite, are unnecessary, and their use should be discouraged, if for no other reason than that it is a burden upon one's memory, and that it very commonly leads to confusion.

Natrolite is common also in many of the more basic lavas of Lower Carboniferous age; and especially in the belt of volcanic rocks of that age which nearly encircles Glasgow. It is not at all an uncommon associate of Analcime in the vapour cavities of the dykes, sills, and other eruptive rocks exposed on the south shores of the Firth of Forth, between North Berwick and a mile or two to the east of Cauty Bay. At this latter locality there occurs a curious association of Natrolite and Celestine—the one being rarely found without some trace of the other. I have obtained it also in the Lower Carboniferous basalt lavas which extend from the Binn of Burntisland to near Kirkcaldy on the coast of Fife.

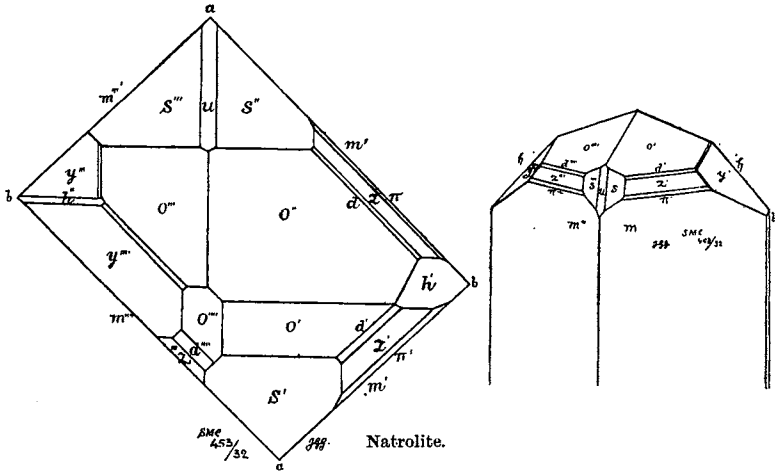
It occurs also in a few cases in the basalt lavas of the Hebrides, and Mr. Currie has recorded it, based upon Mesole, in the basalt lavas at Bloody Bay, near Tobermory, Mull.

The specimens of Natrolite in the Scottish Mineral Collection do not vary much, and, hence, a comparatively brief notice will suffice. It usually happens that the growth of the tufts of Natrolite crystals goes on until they touch each other sideways (and, hence, further growth in the prism zone is rendered impossible), and then it is continued at the outer surface of the mass until the process of growth is arrested by the opposite wall of the cavity. Hence, it is only in those somewhat rare cases in which the growth has been stopped before the space was filled up that crystal terminations are to be found.

On a specimen from Glen Farg, 453/15, with the latter history, good terminations are seen, and they are (one might almost say, "as usual") simple combinations of very long prisms, m , with the unit pyramid o , (111). The so-called "vicinal" plane x may occur, too; but I cannot be quite sure that it is there. The o faces

show the peculiar lustre that is seen on a finely-ground sheet of glass ; and the prisms are striated parallel to their edges.

Another specimen, 453/32, is said to have been obtained near Tantallon Castle, east of North Berwick. The crystals are very complex, with well-defined faces. I have figured one of the crystals as a basal plan, and another, somewhat generalised, as a clinographic projection.



Specimen 453/35, from Boylestone, which is placed among the Natrolites, may, possibly, represent this mineral in a somewhat aberrant habit. It does not appear to have been analysed. But if one may judge by the numerous sharply re-entering angles in the prism zone, and by the peculiar flat and dull terminal plane, this mineral may be Thomsonite. This, again, is only another way of stating the fact that it is by no means always an easy matter to determine by the eye to which of these Needle Zeolites any given specimen belongs.

But on another specimen, 453/46, from the same locality, the characteristic habit of Natrolite is particularly well seen. The crystals in this specimen branch outward from their point of attachment in very open order, and the ends of a large proportion of the crystals are left quite free.

On 453/49 the crystals are also well terminated. The specimen is said to be from Glen Farg ; but the crystals are coated with

Rubinglimmer and associated with Thomsonite, whence one may suspect that it has come from Boylestone, or from somewhere in the neighbourhood of that place.

454. **SCOLECITE.** Silica 45·9, alumina 26·0, lime 14·3, water 13·8. Pseudo-monosymmetric; but really an aggregate of anorthic crystals. The name of the species is from $\sigma\kappa\acute{\omega}\lambda\eta\zeta$, a worm, in allusion to its common tendency to curl up in a worm-like fashion when it is heated before the blow-pipe.

It appears to be confined to the basaltic eruptive rocks—chiefly to lavas of Tertiary age in Skye, Rum, Mull; and it is said to occur also in the basalt of Kincaig, west of Elie. It is far from being a common mineral anywhere in Scotland.

It occurs in much the same manner as Natrolite, and, indeed, it is not always easy to distinguish between them, partly because the two minerals appear to graduate in composition, the one into the other; partly, also, on account of the small size of the crystals. Where terminations can be seen there is no difficulty in making out the species; and where the prism faces are large enough to admit of the test Scolecite can be recognised by the fact that in Natrolite the m faces are striated in the direction of the length of the crystal, *i.e.*, $\parallel m b$, whereas in Scolecite the m faces are striated transversely. Furthermore, Scolecite is manifestly twinned, with a as a twin plane, and on the face b is always to be seen a feathered striation due to this twinning, in which the striæ diverge from the middle of the base upward and outward at angles which are generally near twenty degrees.

I have not yet seen any terminated crystals from any specimen of undoubtedly Scottish origin. Some of the specimens referred to this species are more likely to be either Thomsonite or Natrolite.

455. **MESOLITE.** Silica 46·4, alumina 26·3, lime 9·6, soda 5·3, water 12·4. Probably anorthic. Said to resemble Scolecite in form, angles, and mode of twinning. But the Scottish crystals do not afford much information by which this species can be distinguished from either of the two just referred to.

The chief home of this species in Scotland is in the Tertiary volcanic rocks, in the vapour cavities of which it is not of uncommon occurrence; it also occurs, but more rarely, in some of the eruptive rocks of Lower Carboniferous age.

Its usual aspect is that of groups of very slender crystals which very commonly tend to group into spheroidal masses. These, though usually small, may range up to nearly an inch in diameter. In colour Mesolite is generally whitish or light-coloured. It is probable that most, if not all, of the delicate "cotton stone" of the Hebrides belongs to this species. As a rule, the mineral is one of comparatively late formation, as it occurs over most of the other Zeolites. It overlies even Apophyllite, in some cases. On the other hand, it is sometimes found beneath, or enveloped within, some of these same minerals.

The Mesolite from Kilmalcolm occurs as tufts of very delicate crystals, which look like swan's down, or, perhaps, they resemble still more closely some of the delicate filaments assumed by some of the fungoid moulds. In making the "Gryffe Tunnel" in Renfrewshire, groups of well-formed crystals of Thomsonite were met with, some of which bore hemispherical milk-white aggregates of the mineral under notice. A good example is 455/11.

Crystalline terminations are rarely found, and I cannot feel sure that I have met with a single example from Scotland.

456. THOMSONITE. Composition various:—Silica from 36·8 to 37, alumina 31·3 to 31·4, lime 8·6 to 12·9, soda 4·8 to 9·5, water 13·8 to 13·9. Pseudo-orthorhombic; but really an anorthic aggregate.

The mode of occurrence is the same as that of its associates. It usually consists of groups of very slender lath-shaped crystals, radiating from the initial point, and attached by *c*. The mineral is very brittle, so that terminated crystals are not commonly met with; but a small number of good specimens are preserved in the Scottish Mineral Collection, mostly from the Lower Carboniferous eruptive rocks near Bowling, in Dumbartonshire. I have devoted considerable attention to these Scottish Thomsonites, with the result that I have satisfied myself that the mineral is really an anorthic aggregate, as mentioned above. Regarded in cross-sections, the apparently simple crystals of Thomsonite present an almost infinite variety of form, as they really consist of an aggregate of parallel growths of a large number of sub-individuals ranged parallel to *a*, whose prism faces give rise to many re-entering angles where *m* should be. This is usually expressed by saying that the prism faces are vertically striated.

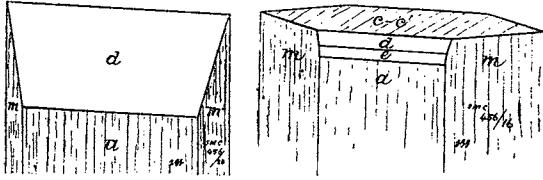
Very commonly the crystals show terminations which at first sight appear to represent a simple basal plane. However, when examined more closely, the face in question is seen to be of a much more complex nature than it appears to be at first sight, and to consist really of alternate salient and retiring angles parallel to the edge *cf*. I have not yet seen any specimen like Greg's figures 2 and 3 (Dana's fig. 1). The termination referred to has in all cases resolved itself into an aggregate of low domes, identical, so far as I have been able to make out, with *x*, (0.1.48). This *x* I am inclined to regard as the true basal pinacoid repeated by twinning. According to this view, therefore, Thomsonite may be regarded as a doubly anorthic aggregate.

Nevertheless, a certain amount of uniformity can be made out after examining a large number of crystals. The general habit of the crystals may be described as lath-shaped, as they are usually very long in proportion to their width, and the front and back *a* faces are generally somewhat large. These are bounded by the aggregate which represents the unit prism, *m*. The ends of the crystals generally look flat and at right angles to *a* and *m*; but, as already remarked, this appearance is deceptive, and the face in question resolves itself on closer inspection into alternate salient and retiring angles due to the polysynthetic twinning on the Albite type of a *c* face inclined a small amount (? 25 minutes) less than 90° to (010). I have not, as yet, seen the face *b* just referred to, as its place is taken by the edge formed by the front and back prisms. There are very few crystals of Thomsonite which do not show a macrodome, and often two such, lying at small angles to *a*. In most cases these are clearly *d*, (401), and *e*, (801). There may be a third macrodome *r*, (101); but when it occurs it forms very little more than a mere line. I have seen no other faces than these on any Scottish specimen amongst a large number that I have examined.

Another type of Thomsonite, the variety that was originally called Mesole and was afterwards renamed Faröelite, is of common occurrence amongst the Tertiary basalt lavas of the Hebrides. It usually occurs in small closely-set aggregations, which commonly take a hemispherical form. It is this variety which so usually forms the basement mineral of the other Zeolites there. Occasionally it shows a crystalline surface; but in all cases

where these crystal terminations were large enough to permit of examination their habit accords with that of the normal Thomsonite.

The following figures of Thomsonite which have been drawn by the Author from registered specimens in the Scottish Mineral



Thomsonite.

Collection, may be accepted as correctly representing the general habit of the species as it occurs in Scotland.

CONCLUSION.

In conclusion I have only to remark that the present paper on the Scottish Zeolites, the expansion of one originally read at an evening meeting of the Geological Society of Glasgow, is not intended to do more than call attention to the broader features that have been made out by a direct study of actual specimens which may be referred to in the Edinburgh Museum of Science and Art. Very much remains to be added before we can be sure that we know even the outlines of the history of these interesting forms of Scottish minerals. I can only express the hope that I may yet be able to make a larger number of goniometric measurements of the crystals than has hitherto been possible while the important work of revising the Collection is still unfinished.