On Kaolinite.

By Allan Dick.

(Communicated by J. J. H. Teall, M.A.)

I PROPOSE to add one more account to those which have already been published of this mineral. It is described as a rhombic mineral in Dana's Mineralogy and other standard works. Latterly it has been described by Reusch as an anorthic mineral, from National Belle Mine, Red Mountain, Colorado, in the *Jahrbuch für Mineralogie*, 1887, Bd. II. Now I describe it as monoclinic, principally from a study of that variety of it which occurs in Anglesey, of which an account was published by Dr. Percy in 1875 in his Metallurgy, Vol. "Fuel." The mineral had been analysed in his laboratory by Mr. Tookey, who found it to have the following composition :—

Silica		46·53
Alumina		88·98
Water		14·54
		100·00

Corresponding to the formula $Al_2O_3, 2 SiO_2, 2 H_2O$. As the water had been estimated by difference, I recently determined the actual loss on ignition. Dried at 100° Cent. the loss amounted to 0·21 per cent., and it suffered no further loss of weight in an air bath heated to 275° Cent. At a red heat the dried mineral lost 18·87 per cent., and nothing further at a heat approaching whiteness.

Dr. Percy says, at page 96, Vol. "Fuel," "I have received (May 27, 1871) from my friend, Mr. Thomas F. Evans of Amlwch, the following precise information concerning the locality and mode of occurrence of the kaolinite from the Isle of Anglesey. Between Bull Bay and Small Bay further west, in the vicinity of Amlwch, is a place called Porth-yr-hwch, very near which a level was driven many years ago from the sea-level with a view of proving a lode of quartz-rock containing small specks and strings of copper pyrites which show on the land above. It has been driven as nearly as he could measure in the water—for the work has been abandoned for years—about 88 fathoms. There are near the end two or

three short bits of level driven east and west, and in one of those going west occurs the mineral in question. The fore breast in this level is a bluish and rather hard slate, having veins of quartz running through it, and there are several small cavities which occur in the line of the quartz veins, and appear to be parts of those veins : some of the cavities are lined with a rather hard crystalline substance, and others contain the crystallised kaolinite. This level is driven through clay slate, but there is a band of hard rock of an Elvan character between the lode and the sea shore. (The word *Elvan* is Cornish, and is applied to particular rocks, more or less porphyritic, occurring in Cornwall.) "

The bulk of the mineral consists of hexagonal plates, amongst which are a few rhomboidal ones. Until it is examined under the microscope it might be mistaken for powdered starch. It is a white glistening powder. It remains suspended in Sonstadt's solution of the density 2·62, as I found by careful trials made at the temperature of 60° Fahr. That, therefore, is its density. The mineral, washed from small, generally doubly terminated crystals of quartz and rhombs of calcite or dolomite, which are sparsely distributed through it, scratches selenite with ease, and muscovite with difficulty. It does not scratch calcite, so that its hardness is about 2·7. It is scarcely attacked by boiling hydrochloric or sulphuric acid unless previously finely ground, and even then only very slowly. The crystals dissolve slowly but completely in hydrofluoric acid, diluted with its own bulk of water, and the powder in weaker acid.

Its refractive index is about equal to that of Canada balsam, and its double refraction rather less than that of quartz. I have not been able to determine the character of its dispersion in convergent polarised light, owing to the small size of the crystals. The largest I have met with produced a retardation of only a half wave length between the two rays into which a ray of polarised light is divided after passing through the crystal at 45° to the plane of polarisation, so that no rings could be seen, only the parabolic curves. These passed out of the field of view during the rotation of the section alike when the positive and negative bisectrices were being examined, so that I could not determine which is the acute bisectrix. This observation was made with a ¼-inch objective of the highest possible angle, immersed in oil.

EXPLANATION OF THE FIGURES ON PLATE III.

Fig. 1.—Five compound tabular crystals to illustrate the appearance of kaolinite from Anglesey, when seen through a microscope, magnifying about 130 diameters : the drawings were made by the help of a camera lucida. The crystals consist of hexagonal and rhomboidal plates, often excessively thin, arranged one upon another so that the compound crystal becomes thicker by steps. Each successive plate is smaller in certain directions, and sometimes in all directions, than the plate immediately beneath it, but the top plate is frequently much thicker than the others. The plates are represented as lying on their basal planes in the position of extinction between crossed nicols, the diagonals of which are supposed to be parallel with the edges of the sheet of paper.

In this kaolinite there does not seem to be any cleavage parallel to the lines bounding the superimposed plates. When an attempt is made to develope a cleavage by thrusting a needle through the compound crystal, it bends and breaks with ragged edges, as shown in the upper right-hand corner of the largest crystal. The sides of the superposed plates are true facets. Beneath the five figures are two diagrams intended to show crystals like those above, cut parallel to the clinopinacoid, extinguishing about 20° on one or other side of the cross wires of the eye-piece. The diagram on the left hand, where the plates are seen diminishing above and below the largest plate, is very rarely met with: the common form is seen on the right hand. They seem to point to the building up of crystals, such as fig. 14 and fig. 4. The plates are too thin to be drawn to scale, and are therefore shown as a diagram.

Fig. 2.—Cleavage plates of kaolinite produced by pressing the crystal shown in fig. 8 between the glass slip and cover till the crystal broke up with a crack. Some of the bottom plates have detached themselves. I counted between 70 and 80 plates, but many of them were compound. The bottom plate, for instance, consisted of 11 plates, but so little shifted in position as to appear like one plate, as here drawn. These cleaved plates differ from the immense majority of the natural plates in being each of uniform thickness. They are often so thin as to exert no appreciable effect on polarised light. The thinnest plates I reckon do not exceed the 40,000th of an inch.

The drawing, although made by the means of the camera lucida, is not quite correct where the detached plates meet the pack of almost unshifted plates. There the lines seen through the plates are with difficulty distinguished from those above, and have been left out so that the drawing

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may be simplified. The drawing is magnified about 130 diameters, and it will be seen that the crystal has about doubled in length by being broken up. It is a beautiful example of cleavage, and may be repeated on any crystal lying on its side.

Fig. 3.—The crystal from which fig. 2 was produced. It was water-clear and free from visible cleavage planes : magnified by about 130 diameters, drawn by the aid of the camera lucida as it lay on its side, *b*. The forms of the top and bottom were got by turning the crystal over in water under the microscope, and adding the shapes to give solidity to the camera tracing. The angle in the lower left-hand corner was about 80°: that in right-hand corner about 76°. These angles in perfect crystals are nearly constant, the limits which I have found being from 80° and 76° to about 83° and 79°. They do not quite agree with the angles found by reflections on a goniometer by Mr. Miers. I suppose this may be due to the tendency of the mineral to build itself up in steps, as shown in subsequent figures. The edges and faces seen under high powers are never quite perfect. The edges waver a little, and here and there steps are seen, which, if frequent enough, though ultra-microscopical, would produce the result, but would not affect reflections. When such a crystal is mounted, so that it can be rotated in oil round an axis at right angles to the basal plane, it is found to give the maximum angle of extinction about 20° from the vertical, on one or other side the upright cross wire, according to which side of the clinopinacoid the observer looks through. It then shows the emergence of a well-marked positive bisectrix in convergent polarised light. There does not appear to be much difference in the apparent angle of this bisectrix and that of the negative one emergent from the basal pinacoid, so that the angle must approach a right angle. As the crystal is rotated between crossed nicols, the angle of extinction diminishes till straight extinction is reached, when the observer is looking along the direction of the clinopinacoid, which, therefore, must be the plane of symmetry.

Fig. 4.—A crystal somewhat similar to figure 8, but showing a few cleavage planes and internal markings: magnified about 75 times. It is the largest crystal I have met with, being a little more than the hundredth of an inch in height. I have figured it as seen looking through the clinopinacoid in the reverse position to that of figure 3, so as to show the direction of extinction reversed. The more acute angle formed by the basal plane and the pyramidal-looking sides is now at the left-hand lower corner, and from its position the extinction in any crystal can always be foretold. Finding the angles 80° and 76°, or thereabouts, very uniform, I thought

the sides might be the $\pm$ P of a half monoclinic octahedron; but Mr. Miers informs me, as the results of his measurements, that the crystal can be better defined if the left-hand sides of fig. 3 are regarded as composed of two prism faces and the right-hand side of two pyramid faces, which is reversed in fig. 4. It will be seen in fig. 4 that one prism and one pyramid face is reduced to very small dimensions, with the result that when the crystal is broken up into plates, as in fig. 2, there will be produced top plates, having the optic axial plane along the greatest length of the plate (fig. 5), and bottom plates in which the same plane is at right angles thereto.

Figs. 6 and 7.—A very curious crystal, over which I spent much time before I could understand it. I turned it over and over in a drop of water under the microscope, so as to inspect each face and find its positions of extinction, shape, &c. It will be seen that there are two faces, one on the prism, and the other on the pyramid side, which taper to a point, giving rise when the crystal is split, as in fig. 2, to a rhomboidal plate at the bottom, and an hexagonal plate at the top. Fig. 7 is fig. 6 looked down upon in the field of the microscope. I have seen crystals of mica which appear to have the same form, but what the triangular face is I do not know. Possibly it may be a combination of the prism and an obtuse pyramid, the steps not being visible. When I had the crystal I did not know that such small ones could be measured on a reflecting goniometer. I broke the crystal first into 5 plates by pressure, and then into a larger number by increased pressure. I have not found another so perfect, but many with a few steps in the triangular face. If composed of the prism and pyramid I suppose it should give two images on a reflecting goniometer. Drawn by eye. Magnification not known, perhaps 100 times.

Fig. 8.—A portion of a crystal like fig. 3, after being heated to redness to expel all water. The crystal swells much, and becomes opaque. Drawn by means of the camera lucida.

Fig. 9.—A crystal like fig. 3, in which the prism edges are truncated at the top by what appear to be two pyramid faces inclined from 40° to 45° to the horizon when the basal plane is parallel to the horizon. Drawn by eye from a model in wood made from drawings through the camera lucida. The M.m. faces seen in front extinguish about 4° or 5° on alternate sides of the cross wires. When immersed in Canada balsam, so as to allow the light to pass exactly along the clinopinacoid (thus practically abolishing both M.m. and N.n. faces), the crystal gives a straight extinction. Having almost the same refractive index as Canada balsam, the

observer seems to be looking through the faces of the orthopinacoid, though it is not present in the crystal under observation.

In reference to the above-named angle of 40° to 45° (for it seems to vary in different crystals), it must be remembered that angles measured from drawings through the camera lucida of this mineral always differ from the angles measured on a goniometer, owing, I suppose, to minute steps in the building up cf the faces. These steps can often be seen excessively small, even under high power.

Fig. 10.—A crystal in which the M.m. faces seem to have been suppressed, or it may have arisen from the natural cleavage of such a crystal as No. 9, the top part forming No. 10, and the bottom part No. 8. Looking down upon it and through it on the field of the microscope to a scratched surface beneath, the scratches are seen through the basal plane, but not through the sloping sides. The crystal shows three partial cleavage planes and one internal line parallel to the more sloping face.

Fig. 11.—A crystal similar to the preceding, but prolonged upwards into a crystal like fig. 4. One or two partial cleavage planes are visible, and there are one or two steps in the angle where the right-hand faces join. As a rule, such crystals have a curved surface at the point of junction, and generally steps are visible thereon: magnified about 75 diameters, and drawn by the help of the camera lucida.

Fig. 12.—A long flat crystal to illustrate the manner in which one or other of the pyramidal looking sides is sometimes set back in steps. In trying to separate the crystal from others among which it lay on the field of the microscope for the purpose of mounting it, to measure the position of extinction between crossed nicols, and determine which faces are set back here in steps, the crystal was lost, but from other crystals it seems that either M.m. or N.n. faces may be so set back. When such a crystal is mounted on a glass slip with a scratched surface, the scratches can easily be seen through the crystal, even when the steps are very close together. This crystal is the most extreme instance of setting back which I have seen, and it is confined to one side. It will be noticed that the line joining the hexagonal plates on the left-hand is not a straight line as in the more perfectly developed facets on the right-hand, but this is only a matter of degree. The line, so far as I have seen, examined under a high power (say 500 diameters) always wavers a little, so do the edges of the clinopinacoid, and I have noticed the same thing in quartz and other crystals when they looked perfectly true to the unassisted eye. Magnified about 130 times, and drawn by the help of the camera lucida.

Fig. 13.—The same crystal as it would appear seen on its edge, but I have not attempted to represent the steps.

Fig. 14.—Shows the manner in which two crystals, such as Fig. 8, combine. They extinguish between crossed nicols as one crystal. In this case the lower one is one-twentieth part longer than the upper and a trifle thicker. The latter point is much exaggerated in the drawing to make it visible. A distinct cleavage-line always separates the two halves : otherwise they look like a true oblique octahedron modified by the clino- and basal-pinacoids : magnified about 100 times.

Figs. 15, 16 and 17.—Other examples of similar grouping, but in which the relative size of the two halves is very varying. In fig. 17 a crystal like fig. 10 is mounted on a thick plate, to which a crystal, like that of fig. 8 turned round and over, is attached. The fitting at the edges is not quite so perfect as is here drawn, and there are many cleavage planes and a few steps near the points of junction. These have been omitted in order to render the grouping more clear.

Fig. 18.—A crystal which is the only one of its kind I have yet seen. The right-hand side is formed by the clinopinacoid. In front the M.m. faces are replaced by three faces, of which the central one rises at a small angle from the basal plate. If the M.m. faces are regarded as prism faces it is the orthopinacoid. I have not seen it developed in any other crystal. The lateral faces are slightly curved and much more inclined to the horizon than the faces M.m., as are the faces beneath on the basal plate. Since the drawing was made the crystal has been measured by Mr. Miers. The results are given at the end of the paper.

Fig. 19.—I have seen only one example of this manner of two crystals growing together. It is water-clear and free from cleavage cracks. A fine line is seen where the crystals join, but it is not more marked than is seen in many twin crystals. Such a combination would be formed by the simultaneous growth of two crystals exactly alike, one turned 180° around its axis of symmetry. One face on each crystal has not been developed, or is so small that it cannot be seen. If present it must be less than the 20,000th of an inch. I do not know what face it is which appears on the lower right-hand corner. Magnified about 130 times : drawn by the help of the camera lucida.

Figs. 20 and 21.—These represent a common form of grouping. The curved faces are generally due to the setting back of plates, but in many cases, especially in parts of fig. 21, the surface looks like a polished curve. The individuals are nearly always separated by a longer plate,

which is often also broader, and, as a rule, all have differently shaped basal sections.

Fig. 22.—A crystal like fig. 9, to which a crystal resembling that of fig. 8 is adherent, with a plate between them.

Fig. 23.—A crystal, the bottom part of which is irregularly developed, the sides are in part step-like and show here and there partially developed cleavage planes running into the crystal from a step. Many polished curves exist on each side.

Fig. 24.—A water-clear crystal, except that near the base where it is regularly developed there are two cleavage-planes. All the lines are gently curved, reminding one of the appearance of many crystals of gypsum. A few steps are to be seen on the upper part of the side faces. The last five figures are magnified about 130 times.

Fig. 25.—An illustration of the unsymmetrical manner in which many crystals are developed, so far as the M.m. and N.n. faces are concerned. It is of uniform thickness, and symmetrically developed at the top. It is adherent to a step-like base. It shows only one partial cleavage-plane. The right-hand shows a curved surface made up of steps so close together that they are here only roughly represented. It would be possible to focus through them and see scratches on the glass slip. This would not be possible on the opposite side, which therefore I think are true planes, more inclined than the ordinary M.m. faces. Magnified about 150 times. Drawn by eye as the crystal did not lie flat.

It will be seen that all the preceding crystals are of pyramidal form, so far as their sides are concerned, whilst the front and back faces are parallel. I spent much time in trying to find out what the crystal would do if the tapering growth continued till the clinopinacoid ran out to a point. I have found only five crystals continued so far upwards, and in four of these cases the crystal stopped exactly at the point of the clinopinacoid. In only one instance have I seen the M.m. and N.n. faces developed beyond the clinopinacoid, and they did not extend to the apex, but were terminated by a small basal plane. In two cases the basal plane appeared, on which was placed a miniature crystal resembling the larger lower crystal. The other two crystals are illustrated in the following figures.

Figs. 26 and 27.—Two views of the same crystal drawn by eye. It will be seen that the M.m. faces are cut off by what look like two pyramid faces, as in fig. 9, a small basal plane terminating the crystal.

Fig. 28.—This crystal puzzled me for long. The apex is a fine line. It would be formed by the continuation upwards of a crystal somewhat

like fig. 4, if it were so proportioned that the basal plane seen on the top should be narrowed to a line when the edges of the clinopinacoid meet in a point. For long I thought that two faces had been suppressed, or were represented only by lines too small to see, but I have since been able so to illuminate the crystal as to see a line of light on the front edge and another on the back edge, which must come from very minute faces. The N.n. faces are very irregular, being in parts made up of steps indicated in the drawing by a few lines and of curves. The crystal shows only a few partial cleavage-planes, represented by dotted lines on the further clino-pinacoid. It is drawn by the help of the camera lucida as seen lying on the field of the microscope with its base resting on another crystal, and therefore slightly inclined towards the observer. Magnified about 130 times.

The crystals from which the preceding 28 figures were drawn represent the larger crystals of kaolinite from Anglesey. They were separated from the bulk, consisting of thin scales, by placing some of it in a tube full of water. The tube was about 3 feet long. When all had settled to the bottom of the tube it was inverted in a saucer of water, in which were several watch-glasses so arranged that the tube could be moved from one to the other. The largest crystals of course arrived first, and were received in a watch-glass. They were accompanied by a few small doubly terminated crystals of quartz and small groups of rhombs of calcite or dolomite. By moving the tube to watch-glass after watch-glass a rough separation was thus effected. The smallest crystals and thinnest flakes, all quite perfect, were received in the last watch-glass. Many of the flakes were bent, but did not seem to cleave in any parti-cular direction. The small solid crystals visible under a magnifica-tion of 250 diameters, were found, under higher powers, to resemble exactly the preceding drawings; but it was noticed that the clinopina-coids in the small crystals are frequently set back in steps and clino-domes sometimes developed. This seems more general in the variety of kaolinite recently described by Reusch, from the National Belle Mine, one or two slides of which I have seen, and from which I have made the four following drawings.

Fig. 29.—A crystal in Canada balsam lying on its base looked down upon from above, extinguishing between crossed nicols when the edges of the clinopinacoid are parallel to either cross wire accurately set. The crystal is the converse of fig. 6. It has the base hexagonal and the top rhom-boidal. Magnified about 130 times, and drawn by means of the camera lucida.

Fig. 30.—The same crystal further magnified, drawn by eye to show

the triangular faces. The inclination of the M.m. and N.n. faces is not intended to represent the true inclination, which cannot be got owing to the crystal being mounted in Canada balsam and lying on its basal plane.

Fig. 31.—A crystal in air. From this it appears that one face of the clinopinacoid is gathered in upwards by steps.

Fig. 32.—Another crystal in air, showing both faces of the clinopinacoid gathered in upwards by steps, looking like clinodomes till a high power is used.

In the kaolinite from the National Belle Mine, Colorado, many of the smaller crystals show faces which appear to be, and I think are, true clinodomes; and this is also the case in the Anglesey kaolinite. In the latter I found one of the larger crystals, showing what seemed to be true clinodomes, but I lost the crystal in trying to mount it for measurement.

Fig. 33.—When the preceding drawings were made I thought such small crystals could not be measured by the reflecting goniometer, but as Mr. Miers thought it might be possible to do so, I gave him one or two mounted crystals, and have received from him the following measurements from one of them :—

$$cb = 90° \; 0$$
$$bm = 60° \; 16'$$
$$bn = 60° \; 46'$$
$$cm = 84° \; 16'$$
$$cn = 78° \; 10'$$

Fig. 34.—Mr. Miers was able to remount another crystal in five different positions, from which he obtained the following measurements :—

Measured.	Limits.
$cb = 90° \; 0'$	$89° \; 52' - 90° \; 5'$
$bm = 60° \; 17'$	$60° \; 16' - 60° \; 19'$
$bn = 60° \; 44'$	$60° \; 42' - 60° \; 47'$
$cm = 84° \; 5'$	
$cn = 78° \; 8'$	
$c\mu = 75° \; 53'$	
$c\phi = 60° \; 24'$	$62° \; 23'$
$c\theta = 70° \; 19'$	$78° \; 28'$

Mr. Miers says " cM as measured is from 75° 20' to 82° 57', so that " it is not equal to cm: this I imagine is due to its step-like structure, " since in another crystal cm = 84° 48' or 83° 53' } c a bent face, giving
            " cM = 85° 3' or 83° 59' }   two images,
" showing that the two angles are really equal. In the present crystal " cn = cN = 78° 8'."

Giving the faces the following symbols :—

$$b = \infty \, \mathbb{P} \, \infty = 010$$
$$mM = \quad \infty \, P \quad = 110$$
$$nN = \quad +P \quad = 111$$
$$c = \quad OP \quad = 001$$

The axial angle is $\beta = 83°\ 11'$
$$a : b : c = 0{\cdot}5748 : 1 : 4{\cdot}7267.$$

These measurements establish the crystalline form of kaolinite with considerable accuracy, since the faces are very perfect.

As I had not seen the planes $\phi\ \theta$ in a microscope very well adapted to show such planes, though not to measure their angles, I asked Mr. Miers whether his goniometer enabled him to locate the planes, as has been done in the diagrams (figs. 33 and 34), or whether the planes, if present, might not be spread over the whole surfaces on the edges of minute step-like plates or otherwise. Mr. Miers replied to this effect :—" I got fair images corres-" ponding to such planes, but the magnifying power of my goniometer " does not enable me to see from what part of the crystal they come. " The important thing is that if there are genuine faces below nN they " are certainly not parallel to mM." It must therefore be borne in mind that the faces $\phi\theta$ shown in fig. 34 are intended only to indicate such reflections. Had these faces had anything like the relative size of those shown in the diagram, they would easily have been seen in the microscope I employed. They must be regarded as doubtful.

Referring again to fig. 18, Mr. Miers says his measurements are as follows :—

" From upper basal plane (c in other drawings) to the front central " triangular face (orthopinacoid), 82° 5'.

" From upper basal plane to nearest triangular side face, 52° 1' " approximately.

" From upper basal plane to back N face, 78° 9'.

" Other faces did not give good reflections.

" The measured angle, 82° 5', is about one degree different from the " calculated angle β, 83° 11', but the face was striated and the reading " not very reliable. When the crystal was cleaned and remounted, the " angle obtained was 82° 15'."

I have to thank the Director-General of the Geological Survey for the use of the Petrological Laboratory in this investigation, which sprang from one on the composition of the sands and clays of the London basin. During the progress of the same I examined a number of substances containing kaolinite, or supposed to do so. One sample which I received from a

friend was supposed to contain the mineral in definite crystals. It came originally from Tremadoc in North Wales, and consisted partly of small six-sided plates, somewhat resembling kaolinite, and partly of ram's-horn-looking aggregations. When seen in bulk it had a pale leek-green colour. Under the microscope it was found to be uniaxial or nearly so. Thinking it might be a small-angled mineral related to kaolinite as biotite is to muscovite, I analysed it. Under the microscope it seemed a nearly pure mineral. Its composition was found to be as follows:—

Silica	...	...	...	26·03
Alumina	...	...	...	17·87
Iron protoxide		...	...	34·84
Magnesia	...	...	...	8·58
Water[1]	...	...	...	12·90
				100·22

It contained traces of manganese and lime. I reported it as ripidolite, with an unusually high percentage of iron and low percentage of magnesia. My friend said he had been induced to think it contained kaolinite from the residue it left after being boiled in hydrochloric acid. I accordingly boiled it for many hours in that acid and obtained about 17 per cent. of insoluble residue, exactly resembling the original mineral in form, but white when seen in bulk.

The plates no longer showed the uniaxial figure in convergent light, but the ram's-horn-looking aggregations whilst moist showed faint depolarising effects as they were turned on the field of the microscope, being dark when the longer axis of the aggregations were parallel to the cross wires. This residue was found to consist of pure silica. It retained even the markings on the original crystals. It was more opaque in air, but in Canada balsam it could not be distinguished from the ripidolite from which it arose except by its action on convergent polarised light. Formed under favourable circumstances in nature where the residue could harden, it would, I think, form tridymite, the untwinned varieties of which, so far as I can see, it exactly resembles in form, composition, and optical properties, differing only in its lesser cohesion. It is not altered by heating to redness.

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[1] The water was estimated by heating a weighed portion of the mineral to redness in the air, and continuing the calcination till the weight was unchanged. During this the iron was converted into peroxide, and the increased weight arising therefrom was deducted from that of the residue and added to the loss. This method of determining the water is not quite correct, but I had only a small amount of mineral to work upon.

I examined specimens of ripidolite from New Rosewarne Mine, Cornwall, and found it left the silica in like manner of snow-like whiteness, and in flakes of brilliant lustre, but less transparent than the original mineral. I have on previous occasions observed silica, and also titanic acid, remain as pseudo-morphic residues after the action of acids on several minerals.

The silica left by the action of hydrochloric acid on the ripidolite (ogcoite) from the Val Maggia, Switzerland, is, when thin flakes of the mineral have been employed, so coherent and transparent in parts, that it is difficult to believe about three-fourths of the constituents of the mineral have been removed. That it really is pure silica is shown by the fact that it is unaltered by heating to redness in air, the mineral under such conditions becoming deep brown; that it dissolves in a hot solution of carbonate of potash and volatilises when evaporated with hydrofluoric acid. The decomposed scales of the mineral are generally striated by lines indicating, I suppose, planes of easiest solution, or it may be of shrinkage, but in many parts the residue looks like muscovite, the step-shaped edges of the original mineral being perfectly retained by the transparent pseudomorphic residue, which is more lustrous than the original mineral.

That minerals of the ripidolite class thus leave their silica, in part at least, when decomposed, seems worth notice, as such residues may enter into the composition of many clays.