

AUSTRALIAN MUSEUM SCIENTIFIC PUBLICATIONS

Anderson, C., 1920. Mineralogical notes no. x. Beryl. Torrington, N. S. Wales.
Records of the Australian Museum 13(1): 1–32. [16 March 1920].

doi:10.3853/j.0067-1975.13.1920.853

ISSN 0067-1975

Published by the Australian Museum, Sydney

nature culture **discover**

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MINERALOGICAL NOTES: No. X.

BY

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(Plates i.-viii.).

BERYL.

Torrington, N.S.Wales.

(Pls. i., ii.)

Beryl is a fairly common mineral in the granite area of New England, occurring both *in situ* and, more frequently, as rolled crystals and fragments in alluvial deposits. Fine crystals, some of considerable size, have been found in the Torrington district, and in a previous paper¹ crystals from Heffernan's Mine in this locality have been described and figured. The crystals measured up to 6×5 cm. and were very simple consisting merely of the prism m (10 $\bar{1}0$) and the base (0001); recently choice crystals of greater complexity have been obtained from this mine and others in the vicinity, and are here described. An interesting feature of some of the crystals is the curious markings they exhibit, particularly on the basal plane. The zonal and parallel growth shown by many of them is also instructive and may afford a clue to the conditions under which they were formed.

Occurrence and Associates:—According to Mr. J. E. Carne², Government Geologist, the beryl at Heffernan's Mine is found in a soft, decomposed, micaceous rock where it occupies vugs containing also quartz, felspar and mica. A specimen in the Australian Museum collection, coming however from another mine in the neighbourhood, consists of a mass of fractured and opaque beryl embedded in black mica. Many of the larger crystals from Heffernan's contain dark inclusions, the nature of which could not be determined, and in one a fragment of smoky quartz is embedded, indicating that quartz probably preceded beryl; some of the beryls are invested, particularly on the base, by a closely adhering skin of silvery mica.

¹ Anderson—Rec. Austr. Mus., vii., 1908, pp. 62-63.

² Carne—Dept. Mines N.S.Wales: Min. Resources, No. 15, 1912, pp. 58, 93.

Mr. Charles Bogenrieder, Mining Engineer, who visited Heffernan's Mine at the time when the beryl crystals were being obtained (the mine is now closed), and was, I believe, the first to correctly identify the mineral, has favoured me with the following account of its mode of occurrence:—"While inspecting Heffernan's mine in 1908 for the purpose of seeing whether the then owners of the property would be able to produce a steady supply of wolfram, the writer was shown a small heap of green crystals of beryl, which the miners thought to be either fluorspar or some variety of quartz, the latter opinion being suggested by the fact that some of the crystals were intergrown with quartz matrix and white or smoky crystals of quartz. In a trench about a hundred feet long and four to eight feet deep the writer was able to secure a number of loose crystals of beryl of beautiful colour and transparency. These crystals were found embedded in a clayey stratum not more than two or three feet from the surface, and were accompanied by a number of druses of smoky quartz, which showed decided zonal growth, the outer layers being progressively darker than the kernel. A foot or two deeper, still in the clayey stratum, were found nodules of wolfram ore, occurring in rich patches and bunches and constituting a friable mass, with here and there well defined crystals of wolframite. Some of these lumps weighed twenty to thirty pounds carrying sixty to seventy per cent. of wolframite. On returning to Sydney the writer presented some of the beryls to the Australian Museum and others to Mr. Percy Marks, Jeweller, who later obtained a considerable quantity of these fine crystals and exhibited them at the Paris Exposition of 1910."

Elements.—Nine crystals were measured on a two-circle goniometer; of these four gave excellent signals and the angles obtained from them were utilised to determine the axial ratio. The data and results are tabulated below.

Form.	ρ	Limits.	No. of Obs.	c
p 10 $\bar{1}1$	29 58 $\frac{1}{2}$	29 57—30 7	15	.49949
u 2021	49 5 $\frac{1}{3}$	49 3—49 6	9	.49968
s 11 $\bar{2}1$	44 57 $\frac{1}{3}$	44 56—44 58	9	.49924

Weighting these results according to number of observations we obtain for c the value .49947, as compared with Koksharov's ratio .49885.

Forms and Angles.—Eleven forms, of which two, θ (30 $\bar{3}1$) and the new form (90 $\bar{9}2$), are probably prerrosion faces were identified; these are tabulated along with the measured angles and those calculated from the axial ratio as given above.

Form.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>c</i> 0001	—	—	—	—
<i>a</i> 11 $\bar{2}$ 0	30 0	90 1	30 0	90 0
<i>m</i> 10 $\bar{1}$ 0	0 0	90 0	0 0	90 0
<i>p</i> 10 $\bar{1}$ 1	0 0	29 58	0 0	29 58
<i>u</i> 20 $\bar{2}$ 1	0 0	49 5	0 0	49 5
θ 30 $\bar{3}$ 1	(0 0)	59 55	0 0	59 58
9092*	(0 0)	68 51	0 0	68 56
<i>s</i> 11 $\bar{2}$ 1	30 0	44 57	30 0	44 58
<i>v</i> 21 $\bar{3}$ 1	19 5	56 45	19 6	56 46
<i>z</i> 42 $\bar{6}$ 3	19 6	45 30	19 6	45 29
<i>n</i> 31 $\bar{4}$ 1	14 8	64 36	13 54	64 19

Combinations.—The subjoined table shows the distribution of the forms on the nine crystals; it will be noticed that the most common forms are *c* (0001), *m* (10 $\bar{1}$ 0), *p* (10 $\bar{1}$ 1), *u* (20 $\bar{2}$ 1), *s* 11 $\bar{2}$ 1).

Cryst.	<i>c</i>	<i>a</i>	<i>m</i>	<i>p</i>	<i>u</i>	θ	new.	<i>s</i>	<i>v</i>	<i>z</i>	<i>n</i>
	0001	11 $\bar{2}$ 0	10 $\bar{1}$ 0	10 $\bar{1}$ 1	20 $\bar{2}$ 1	30 $\bar{3}$ 1	9092	11 $\bar{2}$ 1	24 $\bar{3}$ 1	42 $\bar{6}$ 3	31 $\bar{4}$ 1
I.	×	×	×	×	×		×	×	×		
II.	×		×	×	×		×	×			
III.	×	×	×	×	×	×		×			
IV.	×		×	×	×			×			
V.	×		×	×	×			×			
VI.	×	×	×	×	×			×			×
VII.	×	×	×	×	×			×		×	
VIII.	×	×	×	×	×			×	×	×	
X.	×	×	×	×							

Description of Crystals.—The crystals have the usual beryl habit, long prismatic with well developed base and *m* prism, narrow planes of *a* and small pyramidal faces.

Crystal i. (Pl. i., figs. 1, 2) measures 3×1.5 cm. In colour it is an aquamarine of good quality but much flawed internally. The prisms are strongly striated vertically but the base is perfectly smooth and devoid of markings. The principal faces are c (0001), a ($11\bar{2}0$), m ($10\bar{1}0$), p ($10\bar{1}1$), and u ($20\bar{2}1$); two small faces of v ($21\bar{3}1$) are present. Between the prisms and pyramids there is a narrow etched band shown in the figure as a stippled area; reflections were obtained from this band, the angle ρ varying from $68^\circ 15'$ to $69^\circ 26'$ with a mean of $68^\circ 55'$. This indicates a form (9092), hitherto undescribed, for which the calculated value of ρ is $68^\circ 56'$. As this is clearly a prerosion face, I have not assigned a letter to it.

Crystal ii. is essentially similar to No. i. but it is much smaller, measuring $1.4 \times .6$ cm., and almost colourless. It shows nearly the same combination with the absence, however, of a and v ; u is relatively narrow. There is the same etched zone between the prisms and pyramids and the average reading for the reflection obtained gave an angle ρ of $68^\circ 47'$ which agrees well enough with that obtained in crystal i. and the calculated angle for (9092).

Crystal iii. resembles Nos. i. and ii. but here the prerosion form seems to be θ ($30\bar{3}1$) for the average value for ρ is $59^\circ 53'$ (calculated $59^\circ 59'$).

Crystal iv. measures $1.1 \times .5$ cm. It has the usual etched zone between pyramids and prisms and the pyramids themselves are slightly attacked.

In Crystal v., which measures $1.4 \times .7$ cm., the etching has almost obliterated the small faces of p , u , and s , replacing them by a rough surface from which no distinct reflections could be obtained. The base is slightly attacked and shows a number of lines and roughly hexagonal markings, mainly depressions, the lines and boundaries running parallel to the edge c/p . The prism faces show markings which are oblong or irregular elevations and depressions, the long directions of which are parallel to the vertical axis.

Crystal vi. (Pl. i., fig. 4) from Heffernan's mine, measures 3×1.9 cm.; only the termination is shown in the figure. The etching is here in the early stages and consists of a band between the prisms and pyramids which is pitted and rough but exhibits no definite figures and yields no satisfactory reflections. The base is large and diversified by a number of lines and hexagonal markings as indicated in the figure, the directions of the lines and the boundaries of the markings being that of the edge between c and p . Under the microscope the markings reveal themselves as slightly raised portions of the base bounded by narrow planes of p . The crystal is composed of two or possibly three portions not quite in parallel position and shows a number of growth zones consisting of successive hexagonal shells, the outer shells being partly stripped off. Three small planes of n ($31\bar{4}1$) were identified on this crystal, this being the only instance of their occurrence on the Torrington beryl.

Crystal vii. (Pl. i., fig. 6), also from Heffernan's Mine, is similar to the preceding but the markings on the base are more pronounced and the pyramid faces are almost obliterated. The narrow p faces bounding the elevations on the base are seen in the goniometer telescope as a series of bright, parallel lines.

Crystal viii. (Pl. i., figs. 7, 8, Pl. ii., fig. 7) is the property of Mr. George Smith, Inspector of Mines, who kindly lent it for description. It is believed to be the finest crystal obtained from Heffernan's Mine. It measures $4.5 \times 4.8 \times 3.5$ cm. and is bluish green in colour with numerous internal flaws. In the line drawings the faces are shown without markings, the photograph (Pl. ii., fig. 7) gives a good idea of the basal plane as it really is. To obtain this photograph the crystal was blackened underneath and on the sides and the base coloured a slaty tint with a mixture of lamp black and Chinese white; the result surpassed anticipation. The faces of the prisms are striated vertically and the pyramids are much corroded. The base is traversed by a series of "gullies" which zigzag across the face; the general direction of these gullies seems quite arbitrary in cases, but closer inspection shows that they are made up of short lengths which run parallel to the intersections c/p ; they are flanked by planes of p . In addition to the gullies there are a number of hexagonal elevations, especially in the central depressed portion of the base. These elevations are bounded by faces of the base and the pyramids p and, less frequently, u and s in addition. The main basal surface is covered with thin plates, some regularly hexagonal in outline, others irregular in shape, but all with straight boundaries parallel to the edge c/p , and having edges formed by narrow faces of p . These plates are perhaps the result of oscillatory combination between c and p . If one imagines the gullies filled in, the base of the crystal would then resemble that of crystal vii.

Crystal ix. (Pl. ii., fig. 6), which comes from Heffernan's, presents a striking and puzzling appearance. The photograph represents the termination of a crystal measuring 4.5 cm. in greatest diameter. Round the edges of the base we find a succession of terraces which would seem to indicate that the basal surface has been progressively stripped off, and the whole base is intersected by a series of broad "valleys" separating numerous hillocks. It is difficult to avoid using the language of physiography in describing this crystal for it strongly resembles an island of horizontally bedded rocks which is being terraced by the sea, and the surface of which has been carved into a network of gorges and flat bottomed valleys, trending roughly parallel to the prism faces which form the coast line, and separated by numerous residuals and mesas and occasional sharp pinnacles. The mesas are margined by faces of p ($10\bar{1}1$) and more rarely u ($20\bar{2}1$), which are sometimes pitted and partly eaten into by flutings which run parallel to the vertical axis and deeply score the bounding prism faces of the crystal.

Apart from the large scale features the basal surfaces are in places covered with small pits, some distinctly hexagonal, others apparently circular. On the faces of the unit pyramid bounding residuals a few etch

figures can be observed; these are very small but seem to be isosceles triangles with the obtuse angle, which is not much greater than 90° , directed upwards, and the base parallel to the edge $0001/10\bar{1}1$.

The crystal presents essentially the same features as No. viii., and whatever the explanation of these curious features may be it must be applicable to both crystals.

Crystal x. (Pl. i., fig. 3), Heffernan's Mine, is drawn with a face of p ($10\bar{1}1$) polar so as to show the structures exhibited by the base to advantage. The sketch represents part of the termination of a crystal of 1.5 cm. in greatest diameter; for the sake of clearness many details are omitted. It will be observed that the upper surface consists of a succession of terraces which are portions of the basal plane bounded by approximately perpendicular, deeply fluted walls, with occasional planes of p intervening. The base shows numerous hexagonal markings consisting of thin plates bounded by faces of p , as in crystals vi. and vii.; indeed if the residuals were removed and the whole surface of the lowest terrace revealed, or if the "landscape" were restored up to the level of the highest terrace, the base would then present an appearance similar in all essentials to that of Nos. vi. and vii. A number of horizontal lines will be observed on the prism faces; these are the outcrops of planes parallel to the base which are present in most of the crystals, most markedly near the terminations, and which, in some cases at least, are continuous across the width of the crystals. Whether these are cleavage planes or planes of growth they probably determine the positions of the successive terraces.

Crystal xi., from Heffernan's, measures 5.5×3.5 cm. and is of a bluish-green colour. It consists simply of base and unit prism. The base is terraced slightly and trenched, but not deeply, and the residuals have quite irregular boundaries. Small hexagonal pits appear on the smooth portions of the basal surface. A small quartz crystal projects obliquely from the base; the prism faces of the quartz are fresh but the rhombohedral faces are corroded. At one part along the periphery of the beryl the top layers have been removed, producing a narrow ledge bounded on the inner side by a steep, in parts even overhanging, cliff, slightly embayed. The floor of this ledge is composed of the much corroded base and remnants of the pyramids p and u . It is to be noted that in this specimen, as in all the others, wherever a residual has vertical, or almost vertical, walls bounding it, these are quite rough and irregular, and are not the faces of prisms; whenever a residual has straight boundaries these are the intersections of base and pyramid.

Crystal xii. (Pl. ii., figs. 4, 5) also comes from Heffernan's Mine. This fine crystal measures 5.5×4.5 cm. and is light green in colour with a yellowish tinge. The only forms identifiable by inspection are c (0001), a ($11\bar{2}0$) and m ($10\bar{1}0$). The prism faces are striated vertically, and in one place the outer prism layer has been removed to a depth of .3 cm. revealing a new surface underneath; between the two layers is a thin selvage of clay, a common feature in zoned crystals from Heffernan's Mine. Probably this clayey layer is not an original inclusion but has been subsequently squeezed in between the growth shells.

The base here presents an appearance quite unlike that of the foregoing specimens. It shows numerous hexagonal pits oriented with their boundaries parallel to the edges c/p and running into one another to form approximately rectilinear depressions traversing the basal surface with a general trend parallel to these edges. Some of the pits are .3 mm. in diameter, and some are so small as to be just visible under high magnification; the smallest pits seem circular when examined by a lens, but under the microscope they are seen to be bounded by straight edges and to have the usual hexagonal form. No dihexagonal pits are recognisable. The pits descend by steps to the bottom which is generally formed by the basal plane; this may be in its turn pitted in the same manner, but on a smaller scale, so that we have pits within pits. In other cases the pits terminate downwards in a point. The walls of the pits are sloping and though somewhat striated they reflect light fairly well. A sulphur cast of part of the base was made with excellent results, and goniometric measurement proved that the walls of the pits are formed by faces of the first order pyramid p ($10\bar{1}1$); the angle ρ averages $29^\circ 51'$, calculated $29^\circ 58'$. The marginal portions of the crystal are terraced as indicated by the irregular wavy lines resembling contour lines, this effect being apparently a result of the zonal growth, thin shells being stripped off in succession.

The pits on the base are quite similar to previously described natural and artificial etch figures³, and there is no doubt but that they are the result of the action of some solvent. As the etch pits are bounded by faces of p ($10\bar{1}1$) we may conclude that these planes are produced by the process of etching.

Crystal xiii. (Pl. ii., fig. 2) is a short section of a prism measuring 3 cm. in diameter. It is photographed as a transparency to show the zoned structure and illustrates the common feature that the nucleus and central portions of the crystal are more complex than the exterior layers.

Crystal xiv. (Pl. i., fig. 5), from Heffernan's Mine, is a composite crystal consisting of four portions in parallel position; the whole measures 5×3 cm. The terminations have been corroded and rounded so that no faces are now distinguishable except small areas of the base. It is probable that the whole crystal has been reduced in length as the result of corrosion, and the components of least diameter have been reduced most, as one should expect.

Crystal xv. (Pl. ii., fig. 1) has evidently been strongly etched so that the termination is now reduced to a series of sharp, irregularly distributed pinnacles; the prism too has been attacked and eaten into by the solvent. This specimen has considerable resemblance to that figured by Lacroix⁴, who attributes the peculiar appearance to corrosion.

³ Traube—Neues Jahrb. Min., Beil.-Bd. x., 1896, pp. 464-468; Kohlmann—*ib.*, Beil.-Bd. xxv., 1907, pp. 173-174; Honess—Amer. Journ. Sci., xliii., 1917, pp. 223-236.

⁴ Lacroix—Minéralogie de la France, ii., 1897, fig. 2, p. 11.

Penfield⁵ has described a similar feature in the case of the beryl of Mt. Antero, California, and ascribes the formation of certain very steep pyramids to solvent action. He was able to identify one of the pyramids as the form (36·24·60·5); in the case of the Torrington beryl no planes are recognisable.

Interpretation of the Markings on the Base.—Regular markings, whether pits or hillocks, on the faces of crystals may be caused by solution, or may be growth features, and it is not always easy to decide to which of these the markings are to be attributed in particular cases. Professor V. Goldschmidt, who has had much experience in this branch of crystallography, says⁶:—"Oft ist es schwer, manchmal unmöglich, Lösungsfiguren und Wachstumsfiguren zu unterscheiden. Es wird unsere Aufgabe sein Kriterien zu deren Unterscheidung festzulegen. So lange wir nicht für die einzelne Figur entscheiden können, betrachten wir derlei Gebilde als Lösungsfiguren, wenn ihre Gesamtheit darauf schliessen lässt, dass die Bildungsgeschichte des vorliegenden Krystalls mit Lösung abgeschlossen hat, umgekehrt als Wachstumsfiguren, wenn wir aus allen Anzeichen schliessen können, dass sie mit Wachsen abgeschlossen hat."

In the case of the Torrington beryl, crystal xii. (Pl. ii., figs. 4, 5) has clearly been etched by some solvent. The pits are precisely similar to the artificial etch figures which can be developed on the base when the crystal is immersed in fused caustic soda for example. It is also pretty certain that crystals xiv. and xv. have undergone considerable solution, and indeed represent a late stage in the process; in fact, we may fairly conclude that the closing chapter in the history of these crystals was one in which solution played a leading role, which *prima facie* would indicate that the peculiar features of crystals viii.-xi. are also the result of solution. Again, the narrow band shown between the pyramids and prisms in crystal No. i. (Pl. i., figs. 1, 2) is undoubtedly etched, and the fact that in crystal v. the pyramid faces have been almost obliterated indicates that the etching is progressive. It is in accordance with theory that dissolution should be most active along prominent edges, and that these should be first attacked. While it is clear that solution has taken place in these crystals I hesitate to state dogmatically that crystals viii., ix., x., and xi. owe their striking appearance to a process of etching, and must leave the decision to those who have more experience of crystal solution and growth. I shall content myself with stating the facts and indicating possible deductions therefrom.

In these crystals the pyramidal faces which bound the hillocks are smooth and brilliant, with little or no suggestion of the curvature and striation which we associate with solution faces; moreover, in etching experiments it has been found that the figure faces usually have high indices and are indeed vicinal in character. Yet regarding crystal No. viii. (Pl. ii., fig. 7) one can scarcely resist the conclusion that the gullies and pits which now diversify its surface are secondary, and, if that

⁵ Penfield—Amer. Journ. Sci., xl., 1890, pp. 488-490.

⁶ Goldschmidt—Zeits. Kryst., xl., 4, 1905, p. 379.

is so, to what cause can we attribute their formation if not to solution? An alternative hypothesis is that the faces of c (0001) and p (10 $\bar{1}$ 1) occurring at different levels in this crystal and Nos. ix.-xi. pre-existed, and are revealed when the overlying layers are dissolved away; that is, they result from zonal growth. To test this hypothesis I made several attempts to produce such an underlying surface by splitting the crystals in a direction parallel to the basal plane, but in no case did I succeed in obtaining a surface with well formed faces of c and p , even when there was strong evidence that a pronounced structure plane extended across the crystal in this direction; the fracture was invariably rough or subconchoidal. A second hypothesis which might be put forward is that these crystals consist of a number of sub-individuals in parallel position in which zonal structure is strongly developed, and the hexagonal hillocks are really forms of accretion which are now being dissolved mainly in a lateral direction, giving rise to concentric hexagonal markings and elevations. But it is difficult to imagine that an appearance such as that presented by crystal No. x. (Pl. i., fig. 3) could be thus produced.

If we assume that the pits and hillocks on these crystals result from solution, not from growth, we have to find a plausible explanation of the fact that the etch figures are in general so large, so well defined, and bounded by true, not vicinal faces, as we should expect. Our knowledge of etch figures is now extensive, but much of it has been obtained by study of the results of artificial etching, and it is possible that natural etch figures, which are in most cases produced by the long continued action of very dilute solvents, may present features which cannot be reproduced in the laboratory, where solvent action is, as a rule, rapid. One of the latest writers on etch figures⁷ holds that the point of origin and the distribution of etch figures on a crystal face have a close relation to the molecular structure, that, in fact, faces and directions of maximum cohesion are attacked much more slowly than those in which the cohesion is of a lower degree. This is in accordance with the observed fact, well illustrated in these beryl crystals (Pl. ii., figs. 4, 6, 7), that the pits are disposed in more or less straight lines which are presumably lines of weak cohesion. The occurrence of stepped pits and stepped hillocks, which are characteristic of the crystals, is readily explicable on this theory, as the terracing is determined by the presence of cleavage planes and possibly also by zonal growth planes.

As regards the figure faces, McNairn has found that these are not truly curved, but are made up of a large series of small planes inclined at low angles to one another, and that they represent as close an approximation to true crystal faces as is possible under the circumstances⁸. Following Goldschmidt, he considers that "in pit formation there are two opposing tendencies, one of which would result in the formation of round excavations if unopposed, and the other in the development of true crystal faces. Thus the net result is these faces

⁷ McNairn—*Trans. Roy. Canad. Inst.*, xi., 2, 1917, pp. 229-267.

⁸ McNairn—*Loc. cit.*, p. 258.

which are approximately regular, and hence are of value in the determination of the physical properties of crystals⁹." It is conceivable that under certain conditions, perhaps not realisable in laboratory experiments, the second tendency may preponderate, and etching may result in the production of true crystal faces and these of common occurrence; in fact, that solution may be simply a reversal of growth and produce the same faces. In a review of the publications dealing with natural etch figures on beryl it is observed that several crystallographers have identified certain of the figure faces as belonging to common forms. Thus Penfield¹⁰ enumerates the following forms on the beryl of Willimantic, Connecticut, as having been developed by etching, namely, (4261), (2131), (3141), (1011). Vrba¹¹ determined the faces on etch figures of beryl from Pisek and found such forms as (1122), (3032), (2021). Kohlmann¹² identified on the etch figures on the base of Brazilian beryl the forms (1011), (3031), (3·3·6·10), (3 3 6 4), (1121). Thus it is not inconceivable that etching may have led to the production of common forms on the Torrington beryl also, but, if this be so, it is necessary to assume that subsequent to their formation another type of dissolution supervened, resulting in the gradual destruction of the faces and the production of a mutilated crystal such as No. xv. (Pl. ii., fig. 1).

In the faint hope that some information of value might be obtained Crystal vii. (Pl. i., fig. 6) was etched in stages; the reagent used was fused caustic soda. Two minutes immersion produced no visible effect, but after five minutes the basal plane became pitted all over with minute, apparently circular, depressions. The preexisting markings were not accentuated in any discernible degree, but the corrosion of the edges bounding the base was increased and the pyramid faces had almost disappeared. After a second immersion of ten minutes the etch pits were distinctly hexagonal and beautifully sharp; the edges of the hexagons running parallel to the edge *c/p*. No figure faces could be as yet distinguished on the pits. The crystal was then submitted to the action of the reagent for fifteen minutes, resulting in an enlargement of the pits, some of which now showed distinct pyramidal faces. In most cases the pits terminated below in a flat expanse of the basal plane, in others they descended by steps to a point. The angles of the hexagons seemed slightly rounded, but, generally speaking, the pits were quite comparable, except in size, with the natural pits on crystal xii. (Pl. ii., figs. 4, 5). The bounding pyramidal planes of the crystal had quite disappeared. On certain portions of the base were series of pits linearly arranged and overlapping. Here and there were observed residuals in the form of narrow, flat-topped ridges. These, on being inspected by hand lens and microscope, were seen to have an irregular wavy, almost conchoidal surface. The crystal was now mounted on the goniometer

⁹ McNairn—*Loc. cit.*, p. 258.

¹⁰ Penfield—*Amer. Journ. Sci.*, xl., 1890, p. 490.

¹¹ Vrba—*Zeits. Kryst.*, xxiv., 1895, pp. 104-112.

¹² Kohlmann—*Neues Jahrb. Min., Beil.-Bd.* xxv., 1907, p. 174.

but it was found that the figure faces were too small to yield any reflection. Another immersion of twenty minutes resulted in but slight change, although the residuals were reduced in area. The crystal was then acted on for thirty minutes with the disappointing result that all regularity was destroyed, the markings being now conchoidal, resembling thumb markings, and quite devoid of symmetry. It was observed that certain depressions running in irregular directions had been developed.

Optical Characters.—In a section cut parallel to the base of a crystal from Heffernan's Mine there is a central core which is dark between crossed nicols in parallel polarised light; this is surrounded by a striated zone, the striæ parallel to the faces *a* and *m* and consisting of thin doubly refracting lamellæ alternating with thicker bands of uniaxial material. These thin lamellæ do not extinguish simultaneously, but each parallel set has straight extinction. In convergent light the interference figure is distorted, mainly uniaxial, although the cross opens out sensibly in certain areas, particularly in the striated peripheral layers. These observations are in substantial agreement with those of Bertrand¹³ and Kohlmann¹⁴ on Muzo and Brazilian beryl respectively.

The indices of refraction for sodium light were determined by the method of minimum deviation, two alternate faces of *m* forming the refracting prism. As might be expected from the lack of optical homogeneity disclosed by a basal section the signals were not very sharp, but concordant results were obtained in four independent measurements, as set forth in the following table:—

T ₁	T ₁ '	T ₂	T ₂ '	δ ₁	δ ₂	ε	ω
66 33	109 26	...	...	42 53	...	1.5640	
...	...	65 32	108 48	...	43 16	...	1.5681
66 37	109 27	...	...	42 50	...	1.5634	
...	...	67 6	110 23	...	43 17	...	1.5683
287 57	245 4	...	...	42 53	...	1.5640	
...	...	288 40	245 21	...	43 19	...	1.5686
288 24	245 28	...	...	42 56	...	1.5645	
...	...	288 0	244 38	...	43 22	...	1.5692

The average of these measurements gives $\epsilon = 1.5640$, $\omega = 1.5685$; thus the birefringence = .0045. Compared with previous determinations these values are inclined to be low, and accepting Ford's generalisation¹⁵.

¹³ Bertrand—Bull. Soc. Fr. Min., ii., 1879, p. 31.

¹⁴ Kohlmann—Neues Jahrb. Min., Beil.-Bd. xxv., 1907, p. 179.

¹⁵ Ford—Amer. Journ. Sci., xxx., 1910, pp. 128-130.

that an increase in the amount of alkalis, especially caesium, contained is accompanied by a rise in specific gravity, in refractive indices and birefringence we should expect the Torrington beryl to contain a low percentage of alkalis and to have a low specific gravity. As will be seen presently this expectation is fulfilled.

Composition and Specific Gravity.—Two analyses of Torrington beryl, probably from Heffernan's Mine, have been made by Mr. J. C. H. Mingaye¹⁶ with the following results:—

	I.	II.
Si O ₂	66·08	64·70
Al ₂ O ₃	19·86	22·22
Be O	12·96	11·84
Fe O	0·30	0·37
Mn O	tr.	tr.
Ca O	abs.	abs.
Mg O	"	0·04
Na ₂ O	0·43	0·24
K ₂ O	abs.	0·13
Li ₂ O	pres.	pres.
H ₂ O	0·58	0·60
P ₂ O ₅	abs.	abs.
Cr ₂ O ₃	"	"
V ₂ O ₃	"	"
	100·21	100·14
S. G.	2·661	2·666

Analyst's Note.—Caesium, if present, is in very small amount; strong spectroscopic reaction for lithium and strontium.

The specific gravity of the crystal from which the section was cut for optical examination was determined; the fragment weighed 3·1679 grains and its specific gravity, found by the ordinary weighing method, is 2·664.

Paragenesis.—From a study of hand specimens and the observations made at Heffernan's Mine, and the Torrington district generally, by Carne, Andrews, and Bogenrieder, it is clear that the beryl was formed in a pegmatitic phase of a granitic rock. Mr. Carne¹⁷ who has made a careful study of the ore occurrences at Torrington, is of opinion that the ore rock, which contains wolfram, quartz, felspar, mica, beryl, and topaz, is the latest phase of granitic intrusion into the sedimentary rocks. It is conceivable that there were successive invasions by mineralising vapours from the cooling magma as this would perhaps account for the marked zonal structure of the quartz and beryl crystals. Constructive pneumatolysis was followed by *destructive* pneumatolysis, the evidence for which is seen in the etching of the quartz and beryl and in the accumulation of what Mr. Carne calls decomposed micaceous rock and

¹⁶ Mingaye—Ann. Rept. Dept. Mines N.S.Wales, 1915 (1916), p. 198.

¹⁷ Carne—Dept. Mines, N.S.Wales: Min. Res., No. 15, 1912, p. 40.

Mr. Bogenrieder a stratum of clay, for this may fairly be regarded as the insoluble, more or less amorphous residue resulting from the destruction of the felspars, and the beryl crystals, quartz druses, and lumps of wolfram thus set free are now found embedded in this clayey matrix, the wolfram, as might be expected from its greater density, at a lower level than the beryl and quartz.

As to the agent or agents which have been responsible for this series of events we are more or less in the dark; in spite of the presence of topaz fluorine was probably not the etching medium, for beryl is but slightly affected by hydrofluoric acid. It is possible that some alkaline solution, such as carbonate of potash, which at a high temperature is a solvent of most silicates, may be responsible; carbonic acid is now regarded by some authorities as the active agent in the kaolinisation of felspars¹⁸, and, as McLintock and Hall¹⁹ have suggested, the alkaline carbonates thus set free would attack the other silicates, such as quartz, beryl, or topaz.

CALCITE.

Belubula Caves, near Mandurama, N.S.Wales.

(Pl. iii., figs. 1, 2; Pl. iv.)

The Belubula Caves are in Parish Malongulli, County Bathurst, about fifteen miles west from Mandurama, and two miles north of the main road from Carcoar to Canowindra. They were discovered by a man named Rittmeister, who, when kangaroo hunting, rested near the spot one winter's morning and observed steam rising from a huge cleft in the limestone. Later, with some companions, he explored the caves, descending to a depth of nearly eight hundred feet at a distance of about a mile from the entrance, finding corridors and chambers interminable. It was discovered later that this was only one of a series of caves, and no fewer than six entrances were found at different parts of the same hill. The caves were subsequently explored and described by the late C. S. Wilkinson, Government Geologist²⁰, and O. Trickett²¹.

In 1917, I was privileged to pay a short visit to the neighbourhood and to explore part of the caves, particularly the chamber where the crystals occur, under the expert guidance of Mr. W. F. Hosie, Miss Judy Hosie, and Mr. W. F. Harris; without the help of these my visit would have been practically without result, and my best thanks are due to them for their cordial assistance.

The cavern in which the calcite crystals described in this paper were discovered is reached by an opening on the slope of a limestone ridge, situated about half a mile to the north of the Belubula River, and rising about three hundred feet above the river bed. The crystal chamber is

¹⁸ Butler—Min. Mag., xv., 1908, pp. 128-146.

¹⁹ McLintock and Hall—*Ibid.*, xvi., 1912, p. 301.

²⁰ Wilkinson—Rec. Geol. Surv. N.S.Wales, iii., 1892, pp. 1, 5.

²¹ Trickett—Ann. Rept. Dept. Mines N.S.Wales, 1908 (1909), p. 172.

reached after traversing a number of galleries and corridors to a depth of approximately three hundred feet for a distance of about eighteen chains. Across one corner of this chamber is an overhanging ledge draped with a curtain of stalactite growth and forming a sort of shelf about ten feet above the floor of the cavern; it was in this ledge that the crystals were discovered by Mr. W. F. Hosie, of Carlton, a station property in the vicinity. When the ledge was broken into from above a lense shaped opening, measuring approximately eight feet long, four feet wide, and eighteen inches high was revealed, the bottom, roof, and sides of which were studded with beautiful groups and single crystals of transparent or translucent calcite; the largest crystals, some of them eight inches in length, are clustered round the edges where the roof and floor of the cavity meet. The cavity has been broken into at both ends, and when it is illumined from one end and viewed through the other opening it presents an aspect of rare beauty.

Probably the solution from which the crystals were deposited formed at one time a quiet pool in what was then the floor of the cavern. Usually the water in limestone caves is in constant circulation, a stream flowing along the floor, and the roof and walls continually dripping with the lime-bearing solution from which the stalactites and stalagmites are formed, but these crystals could not have been deposited under such conditions. Probably the pool in which they developed was a kind of backwater, perhaps formed by the accumulation of the clayey residue of the dissolved limestone which seems to have been highly argillaceous. This pool became crusted over with a crystalline deposit which now forms the roof of the vugh and is about five inches thick. The carbonic anhydride would then escape very slowly from the saturated solution which would remain more or less constant in temperature, and the conditions generally would be favourable for the growth of well formed crystals. That the conditions were uniform throughout the period of formation of the crystals is indicated by their striking uniformity of habit.

The crystals are relatively simple, the forms represented being a (11 $\bar{2}$ 0), m (10 $\bar{1}$ 0), r (10 $\bar{1}$ 1), M (40 $\bar{4}$ 1), and f (02 $\bar{2}$ 1); of these M and f predominate and give the crystals their characteristic pointed shape (Pl. iii., figs. 1, 2; Pl. iv., fig. 5). The prism m and the rhombohedron r appear as narrow planes and are absent on many of the crystals. The second order prism a is usually present as a rounded face, convex or concave, giving on the goniometer a train of signals lying in the zone [a r], the face being striated parallel to this zone axis (Pl. iii., fig. 2; Pl. iv., fig. 5). In the beautiful groups shown in Pl. iv., figs. 2, 4, some of the crystals look like simple rhombohedra through the predominance of f , although M is also present as small triangular planes. The faces of M are smooth and brilliant but f is frequently rounded and imperfect, with triangular etch pits, the edges of which are parallel to the intersections of f with m , f' and f'' (Pl. iii., fig. 1) or irregular markings (Pl. iii., fig. 2). The crystals have usually one good termination, the other, which was the point of attachment, being broken and irregular.

The following angular measurements were obtained from four crystals:—

Form.		Measured.		Calculated.	
Goldschmidt	Dana	ϕ	ρ	ϕ	ρ
<i>b</i> 11 $\bar{2}$ 0	<i>m</i> 10 $\bar{1}$ 0	29 37	89 48	30 0	90 0
<i>a</i> 10 $\bar{1}$ 0	<i>a</i> 11 $\bar{2}$ 0	0 45	87 1	0 0	90 0
<i>p</i> 11 $\bar{2}$ 1	<i>r</i> 10 $\bar{1}$ 1	30 0	44 37	30 0	44 36
<i>m</i> 44 $\bar{8}$ 1	<i>M</i> 4041	30 0	75 46	30 0	75 47
ϕ 2 $\bar{2}$ 41	<i>f</i> 02 $\bar{2}$ 1	30 0	63 8	30 0	63 7

Near Glen Innes, N.S.Wales.

(Pl. iii., fig. 3.)

A small but very attractive specimen of crystallised calcite was obtained in a vugh during the sinking of a well through basalt. The crystals are brilliant, of a pale wine-yellow colour, and are seated on a base of chabazite crystals (Pl. v., fig. 1). The calcite crystals, which are never doubly terminated, measure up to about 1 cm. in length, and are constant in habit. Of the forms present *M* (4041) has very small faces, or may be absent altogether; the faces of *r* (10 $\bar{1}$ 1) are brilliant and give flawless signals, but *a* (11 $\bar{2}$ 0) tapers and is striated parallel to its intersections with *r*. The curious lozenge-shaped surface with triangular markings does not give a sharp reflection, ρ varying from 66° 44' to 67° 5'; this would indicate Goldschmidt's *k* (5·5·10·2), corresponding to Dana's *g* (0552), but the face is more likely to belong to Goldschmidt's ϕ (2241) = Dana's *f* (02 $\bar{2}$ 1), for which $\rho = 63^{\circ} 7'$, the discrepancy in the angle being due to the poor quality of the reflection. The face is covered with overlapping triangular plates.

The forms and angles obtained are tabulated below:—

Form.		Measured.		Calculated.	
Goldschmidt	Dana	ϕ	ρ	ϕ	ρ
<i>a</i> 10 $\bar{1}$ 0	<i>a</i> 11 $\bar{2}$ 0	0 8	85 2	0 0	90 0
<i>p</i> 11 $\bar{2}$ 1	<i>r</i> 10 $\bar{1}$ 1	30 0	44 36	30 0	44 36
<i>m</i> 44 $\bar{8}$ 1	<i>m</i> 4041	30 32	75 46	30 0	75 47
ϕ 2241	<i>f</i> 02 $\bar{2}$ 1	30 1	66 55	30 0	63 7

CHABAZITE.

Near Glen Innes, N.S.Wales.

(Pl. v., fig. 1.)

The chabazite associated with the crystals of calcite described above forms a continuous crust on the surface of decomposed basalt. The pale-yellow, translucent crystals are small, the average size being about that of the head of an ordinary pin, and they form botryoidal or stalactitic aggregates with a core of clayey decomposition products; chabazite apparently preceded calcite.

The crystal faces besides being minute are not brilliant and give rather poor reflections, but the measurements made with the reducing lens of the goniometer, were sufficient to identify the two forms s ($02\bar{2}1$) and t ($11\bar{2}3$) for which respectively the angle ρ was found to be $66^\circ 53'$ (calc. $68^\circ 16'$) and $36^\circ 39'$ (calc. $35^\circ 54'$). The only other form present is r ($10\bar{1}1$) from which however, no reflections were obtained, but there can be little doubt of its presence. The crystals are symmetrical penetration twins about the vertical axis, and the mineral would therefore be described as the phacolite variety. The twin structure is clearly revealed by the re-entrant angles in the equatorial region; these are produced by the meeting of the r and \bar{r} faces. The distribution of the faces of s is also a consequence of twinning. On the coplanar faces t and \bar{t} there is a depression, deepening towards the apex and with boundaries approximately parallel to the edges of the composite face.

To confirm the identification the water and silica percentages were determined and found to be 21.91 and 45.71 respectively; this is in close agreement with the published results of chabazite analyses.

VESUVIANITE.

Arramagong, N.S.Wales.

(Pl. v., figs. 2, 3.)

I am informed by Mr. G. W. Card, Curator of the Mining and Geological Museum, that this mineral occurs in serpentine, close to its junction with granite at the Trigonometrical Station, Arramagong, between Grenfell and Young. The crystals are prismatic, small, the figured specimen measuring 6×1.5 mm., honey-brown in colour and transparent. The forms present are c (001), a (100), m (110), f (120), ϕ (350), p (111), t (331), s (131). Of the prisms, which are striated vertically, m is the largest, f is narrow and ϕ was observed only once. The faces of s show slight striæ parallel to their intersections with p ; p gives very good reflections and from the angles obtained the axial ratio was calculated. From twelve faces the average value of ρ was found to be $37^\circ 17' 35''$ (limits $37^\circ 16' - 37^\circ 20'$) therefore the vertical axis is .53853.

The forms represented and the measured and calculated co-ordinate angles are listed below.

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>c</i> 001	0 1	0 1	0 1	0 1
<i>a</i> 100	0 1	90 0	0 0	90 0
<i>m</i> 110	45 1	90 0	45 0	90 0
ϕ 350	31 41	90 0	30 58	90 0
<i>f</i> 120	26 38	90 0	26 34	90 0
<i>p</i> 111	45 0	37 18	45 0	(37 18)
<i>t</i> 331	45 2	66 21	45 0	66 22
<i>s</i> 131	18 24	59 34	18 26	59 35

HEMATITE.

New Hebrides.

(Pl. iii., figs. 4, 5.)

A small hand specimen from an unknown locality in the New Hebrides was submitted for identification and found to be crystallised hematite, variety specular iron, composed of tabular crystals measuring up to 15 mm. and smaller equi-dimensional crystals about 3 mm. in diameter. The faces are brilliant but inclined to be curved and the crystals are aggregated into small groups arranged in parallel position. Angular measurements were made on one of these parallel aggregates and the forms present were found to be *c* (0001), *a* ($11\bar{2}0$), *r* (1011), *n* ($22\bar{4}3$), the relative development of the forms being approximately as represented in the figures.

The measured and calculated angles are given in the subjoined table.

Forms.		Measured.		Calculated.	
Goldschmidt	Dana	ϕ	ρ	ϕ	ρ
<i>o</i> 0001	<i>c</i> 0001	0 1	0 1	0 1	0 1
<i>a</i> $10\bar{1}0$	<i>a</i> $11\bar{2}0$	30 9	90 7	30 0	90 0
<i>p</i> $11\bar{2}1$	<i>r</i> 1011	0 1	57 35	0 0	57 33
λ $20\bar{2}1$	<i>n</i> $22\bar{4}3$	30 0	61 14	30 0	61 10

QUARTZ.

Howell, N.S.Wales.

(Pl. v., fig. 4.)

A fine example of quartz twinned on the Japan law from the Conrad Mine, Howell, was kindly lent for description by Mr. D. A. Porter. Each segment of the twin is about 4 cm. in length, tapers slightly to the apex and shows the usual prismatic striations. The crystals are flattened in the plane which contains the vertical axes, which seems to be an almost constant feature in twins of this kind. On the faces designated r (there are no means of distinguishing r from z) appear raised etch figures of unsymmetrical shape as shown in the figure; on the z faces there are somewhat similar hillocks but they are less distinct and their exact form cannot be made out.

The group was measured with the co-planar faces m and \bar{m} polar, as it was found impossible to mount it in the conventional position; the r and z faces were utilised in centering and the angles obtained were as follows:—

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
m 10 $\bar{1}$ 0	2 35	60 1	0 0	60 0
r z 10 $\bar{1}$ 1	90 0	38 13	90 0	38 13
	42 12	66 31	42 17	66 52
\bar{m} 10 $\bar{1}$ 0	85 22	60 0	84 33	60 0
r z 10 $\bar{1}$ 1	3 55	38 13	5 27	38 13
	43 36	66 41	42 17	66 52
	52 30	66 40	53 10	66 52
s 11 $\bar{2}$ 1	60 37	89 55	60 6	90 0

STIBNITE.

Hillgrove, N.S.Wales.

(Pl. v., figs. 5, 6.)

Stibnite occurs commonly in the Northern districts of New South Wales but the mineral is usually massive or in columnar and felted aggregates and very few well crystallised specimens are to be found in

collections; indeed, the example here described, from the Freehold Mine, is the first I have seen in which the crystals have distinct terminations. The hand specimen consists of an aggregate of prismatic crystals grouped partly in parallel or slightly divergent positions, several with terminations; some of the crystals are bent and distorted as is so commonly the case with stibnite, and in part the mineral is massive or imperfectly crystallised. Most of the crystals are slender, but a few are fairly stout, measuring nearly 1 cm. in thickness. The lustre is brilliant, resembling that of polished steel. A few small crystals of quartz are attached to the stibnite.

The measured crystal is short prismatic in habit, about 3 mm. in length and 1 mm. thick, and bent sharply not far from the terminated end. The faces are somewhat dull, probably from exposure, and the signals are not very sharp; most of the angles were measured with reducing lens. The prisms are deeply striated vertically and merge into one another.

Measured and calculated angles:—

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>b</i> 010	0 29	89 14	0 0	90 0
<i>m</i> 110	45 20	90 0	45 13	90 0
<i>n</i> 210	63 19	90 0	63 46	90 0
<i>s</i> 113	45 2	25 46	45 13	25 43
<i>e</i> 123	26 44	36 17	26 44	37 13
ψ 146	14 4	33 48	14 8	34 59

WOLFRAMITE.

Torrington, N.S.Wales.

(Pl. vi., figs. 1, 2.)

Although the wolframite mined in New South Wales is generally massive, crystals are not uncommon, particularly in the Torrington District, where, at the Wild Kate Mine, crystallised material was at one time abundant; unfortunately nearly all this material was smelted and no doubt many fine specimens were thus destroyed. Some crystals from this mine were previously described²², but they were rough, and measurement with a contact goniometer had to be relied on; the crystal

²² Anderson—Rec. Austr. Mus., v., 5, 1904, pp. 303-304.

described in this paper has smoother faces and it was found possible to measure its angles on a reflecting goniometer, but the measurements are by no means good.

Mr. E. C. Andrews describes the mine as "a large granular quartz 'blow.' Worked by means of open cuts and shafts. Irregular masses of pegmatite (large, dark, vitreous quartz, felspar and black mica) branch repeatedly through the 'quartz blow.' In these branches occur large stout crystalline masses of friable wolfram²³." The Torrington ore is apparently near the ferberite end of the wolframite series²⁴, the re-calculated analysis giving the percentage of manganous oxide as 3.95 (= Mn WO₄ 16.9%).

The crystal measures 3 × 3 cm. along the directions of the *b* and *c* axes, but it was evidently a much larger crystal before fracture. As in wolframite the angle β is fairly close to 90°, the value chosen by Goldschmidt²⁵ being 89° 32', the mean of determinations by Descloiseaux, Krenner and Seligmann, it is not easy to determine the positive or negative character of the forms when the angular measurements, as in this case, are not very accurate. The balance of the evidence favours the interpretation adopted, but, if the other setting is correct, then σ (121) and *s* ($\bar{1}21$), ω (111) and *o* ($\bar{1}11$) will be interchanged, and the form *t* ($\bar{1}02$), present as a narrow face terminating a small segment in parallel position on *a'* will become *y* (102).

The measured and calculated angles are tabulated below :—

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>a</i> 100	91 10	90 18	90 0	90 0
<i>l</i> 210	68 11	90 4	67 34	90 0
<i>m</i> 110	51 41	89 56	50 27	90 0
<i>f</i> 011	1 15	40 44	0 32	40 54
<i>t</i> $\bar{1}02$	—	26 3	$\bar{9}0$ 0	27 19
ω 111	50 2	53 24	50 40	53 49
<i>o</i> $\bar{1}11$	$\bar{5}1$ 13	53 23	$\bar{5}0$ 14	53 34
σ 121	29 30	62 59	31 24	63 46
<i>s</i> $\bar{1}21$	$\bar{3}2$ 37	62 41	$\bar{3}1$ 0	63 41

²³ Andrews—Ann. Rept. Dept. Mines, N.S.Wales, 1904 (1905), p. 143.

²⁴ Carne—Dept. Mines, N.S.Wales, Min. Res. No. 15, 1911, p. 70; Hess—Bull. U.S. Geol. Surv., 583, 1914, pp. 32-33.

²⁵ Goldschmidt—Winkeltabellen, 1897, p. 366.

MONAZITE.

Dingo Creek, Torrington, N.S.Wales.

(Pl. vi., fig. 3.)

Although never found in large quantities monazite is fairly widely distributed in the State, and has been reported from several localities in the neighbourhood of Torrington; unfortunately the percentage of thoria is low.

The figured crystal, which is drawn in orthographic projection with the positive end of the *b* axis to the front, is only a fragment, about 1 cm. in greatest diameter, and it is very irregularly developed so that the correct orientation was difficult to discover. In habit the crystal is elongated parallel to the *b* axis with a tendency to tabularity on the plane of the axes *a* and *b*; the colour is reddish brown and the lustre resinous. Some of the faces are slightly wavy and many of the reflections are poor, but the measured and calculated angles are in fair agreement.

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>c</i> 001	89 50	13 34	90 0	13 40
<i>b</i> 010	0 4	89 53	0 0	90 0
<i>a</i> 100	89 58	89 37	90 0	90 0
<i>l</i> 210	64 48	90 7	64 47	90 0
<i>m</i> 110	46 35	89 58	46 43	90 0
<i>n</i> 120	27 54	90 0	27 58	90 0
<i>g</i> 012	27 10	28 34	27 43	27 36
<i>e</i> 011	14 36	43 35	14 43	43 44
<i>u</i> 021	7 23	61 43	7 29	61 49
<i>x</i> $\bar{1}01$	$\bar{8}9$ 42	36 30	$\bar{9}0$ 0	36 29
<i>i</i> $\bar{2}11$	$\bar{6}1$ 40	62 9	$\bar{6}1$ 45	62 55
<i>v</i> 111	$\bar{3}8$ 31	49 48	$\bar{3}8$ 37	49 50
<i>d</i> $\bar{1}12$	$\bar{2}8$ 15	27 50	$\bar{2}8$ 12	27 42

CASSITERITE.

Pine Mountain, Inverell, N.S. Wales.

(Pl. vi., fig. 4.)

From this locality two untwinned crystals which present some features of interest have been lately acquired. One is fragmentary, with poor terminations, and dark brown to black in colour with honey-yellow patches, the other measures about 1.5×1 cm., is doubly terminated and almost black. An interesting feature is the presence of the base which is a comparatively rare form in cassiterite. The largest faces belong to the forms r (230) and s (111); the other forms represented are c (001), a (100), h (120), and z (231), of which a and h are very narrow. The base is rough and yielded a very blurred reflection, while the prisms are poorly developed and the measurements obtained from them are approximate only; the faces of z are smooth and brilliant and give excellent reflections.

Angles :

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
c 001	o ' —	o ' —	o ' —	o ' —
a 100	1 11	88 56	0 0	90 0
r 230	33 0	89 25	33 41	90 0
h 120	28 5	88 21	26 34	90 0
s 111	44 53	43 30	45 0	43 33
z 231	33 39	67 33	33 41	67 35

Long Gully, near Tingha, N.S. Wales.

(Pl. vi., figs. 5, 6, Pl. vii., figs. 1, 2.)

From Long Gully, three miles south east of Tingha, comes a small collection of cassiterite crystals, the habit of which is quite unusual in Australian occurrences and by no means common generally; they belong to the variety called by the Cornish miners "needle tin" or "sparable (? sparrowbill) tin," which is characterised by an acute pyramidal termination. In the Cornish crystals the termination is formed by faces of z (321) and (521)²⁶. Here the steep pyramid is z (fig. 6) which is

²⁶ Miers—Mineralogy, 1902, p. 360.

in some cases modified by small faces of s (111) at the apex (fig. 1), or truncated by a rough and uneven basal pinacoid. Most of the crystals are simple, but twinning on the usual law is exemplified (fig. 2). The crystals are small, the largest being about 1.5 cm. in length and jet black in colour. Of the forms present k (340) is a fairly large face, the other prisms a (100) and m (110) being narrow; there are indications of the prism (130) for which the measured angle ϕ was $18^\circ 6'$ and $19^\circ 3'$ (calculated $18^\circ 26'$), but, as the prisms generally are striated and the signals poor, this is not included in the list of forms. The pyramid s (111) is small when present, but the faces are brilliant and give good signals.

Forms and Angles:

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
c 001	—	—	—	—
a 100	0 15	89 52	0 0	90 0
m 110	44 57	89 57	45 0	90 0
k 340	36 28	89 59	36 52	90 0
s 111	45 0	43 33	45 0	43 33
z 231	33 39	67 31	33 41	67 35
k 340	26 52	42 11	26 44	42 12
z 231	38 36	55 0	38 32	55 23
	35 10	69 40	35 25	70 42

Tingha (?), N.S. Wales.

(Pl. vii., figs. 4, 5.)

A small collection of crystallised cassiterite, believed to be from the Tingha district, exhibits an unusual habit. Practically all the crystals are composed of three portions, one of which is relatively large, doubly terminated and carries the two smaller portions twinned to it on two opposite faces of e (101); the composite crystal is inclined to be tabular in the plane containing the twin axes, and in shape is not unlike the letter S. The crystals are all small, the figured specimen measuring about 8 mm. in greatest length, and their uniformity in shape and development is very striking. Two opposite faces of a (100) are the largest planes on the crystals; one of these, shown in front in the figures, is smooth and brilliant and gives a good signal, although it is a composite face formed by coplanar portions of the three twinned segments. The a

face at the back of the drawing is rough and irregular, and evidently the crystals were attached to the matrix by it; apparently the crystals were implanted on quartz. The base is usually present as a wavy face giving poor reflections. The faces of a (100) are smooth, with the exception of the face of attachment, but m (110) shows conchoidal markings and small etch pits.

Forms and Angles :

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
c 001	—	—	—	—
a 100	0 0	89 59	0 0	90 0
m 110	45 2	90 2	45 0	90 0
r 230	32 1	90 1	33 41	90 0
h 120	26 30	90 4	26 34	90 0
e 011	0 7	33 57	0 0	33 54
s 111	45 2	43 33	45 0	43 33
z 231	33 43	67 44	33 41	67 35
t 133	18 53	35 20	18 26	35 19
a 100	0 1	22 11	0 0	22 12
m 110	20 37	48 55	20 41	49 6
r 230	31 14	38 10	29 32	39 36
h 120	36 59	34 0	37 5	34 6
e 011	36 4	71 49	35 45	71 40
z 231	6 45	31 10	6 56	31 6
	11 34	51 54	11 44	51 46
	38 38	55 22	38 32	55 23

Pilbara, Western Australia.

(Pl. vii., fig. 3.)

This fine crystal, which is one of two kindly lent by Mr. W. T. Watkin Brown, is about 1 cm. in diameter; it is a doublet on the usual law and, since reëntrant angles are practically absent, the twin looks at first like a simple crystal of pyramidal habit with a large number of faces. The planes are mostly well adapted to goniometric measurement, and the measured and calculated angles are in good agreement.

In addition to the forms which are listed in the table below ρ (750), ν (572) and (241) are doubtfully present.

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
	° ' /	° ' /	° ' /	° ' /
<i>a</i> 100	0 1	90 0	0 0	90 0
<i>m</i> 110	44 58	90 0	45 0	90 0
<i>r</i> 230	33 41	90 5	33 41	90 0
<i>h</i> 120	26 38	90 2	26 34	90 0
<i>s</i> 111	45 1	43 24	45 0	43 33
<i>t</i> 133	18 21	35 23	18 26	35 19
<i>z</i> 231	33 41	67 37	33 41	67 35
<i>h</i> 120	37 25	33 52	37 5	34 6
<i>s</i> 111	29 18	80 14	29 40	79 48
<i>z</i> 231	35 24	70 42	35 25	70 42
	38 32	55 23	38 32	55 23
<i>t</i> 133	10 45	78 27	10 48	78 30
	33 38	82 1	33 38	82 0

CUPRITE.

Broken Hill, N.S.Wales.

(Pl. vii., fig. 6.)

In the Broken Hill lode the chief copper compounds are oxidised ores, the commonest being the blue and green carbonates and cuprite; lumps and dendritic masses of native copper and rare compounds such as marshite and miersite are also found. The cuprite occurs both massive and as well developed crystals in vughs and cracks or scattered over the surface of gossany material.

The finest specimen in the Australian Museum collection comes from the Broken Hill Proprietary Mine. The matrix in this case is a soft, black, amorphous substance which consists chiefly of lead, and reacts also for sulphur and copper, but a definite mineralogical name cannot be assigned to it; perhaps it is identical with the material which Dr. Hlawatsch, in his paper on stolzite and raspite from Broken Hill²⁷, described as decomposed galena with a black friable surface ("zersetzter Bleiglanz mit mulmiger schwarzer Oberfläche"), and with the "sooty sulphide ore" of Jaquet²⁸. The cuprite crystals, which

²⁷ Hlawatsch—Ann. d. k. k. naturhist. Hofmus. Wien, xii., 1897, p. 33.

²⁸ Jaquet—Mem. Geol. Surv. N.S.Wales—Geol. No. 5, 1894, p. 88

line cracks and cavities in the matrix, are not of large size, averaging about 3 mm. along the axes, and are octahedral in habit with long narrow faces of the dodecahedron and smaller faces of the trapezohedron *n* (211). The crystals in a freshly opened vugh are very brilliant and lustrous, some appearing almost black and metallic, others deep red and transparent, but after some years exposure they become brown and opaque. Other minerals on this hand specimen are garnet in small scattered crystals, occasional cerussite and granular or blebby quartz.

There are several specimens from the South Mine in the collection. The matrix of these is chiefly massive cuprite and limonite. The cuprite crystals, which are sometimes of fair size, measuring up to 1 cm. along the axes, are mainly octahedral in habit and dark brown to red in colour. In one hand specimen the crystals are superficially altered and covered with a dull grey film; in another, which consists of massive cuprite dusted over with yellow limonite, the crystallised cuprite is composed of numerous parallel and sub-parallel segments and partial crystals, with a small amount of the acicular chalcotrichite variety. In this specimen the crystals of cuprite are dark red to brick-red in colour and are accompanied by a little iodyrite in crystalline crusts. Professor Liversidge has previously described and figured large cuprite crystals of cubic habit from the South Mine²⁹.

An interesting specimen, of which the locality is given as Broken Hill simply, consists of massive cuprite, botryoidal malachite and granular quartz, with here and there perfect pseudomorphs of malachite after octahedral cuprite.

The figured crystal, which comes from the Proprietary Mine, yielded the following angles:—

Form.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>d</i> 101	0 4	44 56	0 0	45 0
<i>o</i> 111	45 9	54 34	45 0	54 44
<i>n</i> { 112	45 4	35 16	45 0	35 16
121	27 20	65 56	26 34	65 54

Cadia, near Orange, N.S.Wales.

(Pl. viii., fig. 1.)

Fine crystals of cuprite are found in the oxidised portion of the Cadia Copper Mine. These crystals occupy vughs in an ironstone matrix, the vughs being lined with small concretionary mammillations with a velvety black surface, which, when broken, are seen to be steel-grey in

²⁹ Liversidge—Journ. R. Soc. N.S.Wales, xxviii., 1894, p. 98.

colour, are not magnetic and readily dissolve in concentrated hydrochloric acid, the solution reacting for both ferrous and ferric iron. This crust is perhaps a mixture of magnetite and hematite. The crystals of cuprite are octahedral in habit and generally small, the largest measuring about 5 mm. in the axial directions, and the faces are in general smooth and brilliant. The variety chalcotrichite was formerly of common occurrence at Cadia, but it does not seem to be found in the present workings. The forms identified are the cube, the octahedron, the dodecahedron, and a new trapezohedron *l* (544) which was observed seven times on two crystals.

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>a</i> 100	0 2	90 3	0 0	90 0
<i>d</i> { 110	45 9	90 19	45 0	90 0
{ 101	0 13	44 57	0 0	45 0
<i>o</i> 111	45 1	54 29	45 0	54 44
<i>l</i> { 445	44 48	48 20	45 0	48 32
{ 454	38 47	58 17	38 40	58 1

Cloncurry, Queensland.

(Pl. viii., fig. 2.)

The hand specimen on which the figured crystal was obtained is composed mainly of massive cuprite and crystalline native copper. The crystals of cuprite are cubic in habit, measure up to 4 mm. along the cube edges, and are brownish red in colour; the only forms present are the cube, dodecahedron, and octahedron.

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>a</i> 100	0 5	90 5	0 0	90 0
<i>d</i> { 110	45 1	90 8	45 0	90 0
{ 101	0 20	45 0	0 0	45 0
<i>o</i> 111	44 50	54 46	45 0	54 44

Mount Lyell, Tasmania.

(Pl. viii., fig. 3.)

According to Petterd³⁰ cuprite occurs in some abundance in the neighbourhood of Mount Lyell in finely formed crystals of octahedral habit attached to or partially embedded in blocks of nodular limonite; in one of our specimens it is accompanied by native copper. Four crystals were measured, their habit conforming more or less to that of the drawing; the octahedron and dodecahedron are well developed, the cube and the trapezohedron *n* (112) are small, and in addition there are small faces belonging to a new tetrahexahedron *r* (405), which was observed five times on one crystal and three times on another, the angle ρ for the face 045 varying between the limits $37^{\circ} 45'$ and $38^{\circ} 46'$ with an average value $38^{\circ} 25'$ (calculated $38^{\circ} 40'$).

Angles:

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
	° ' /	° ' /	° ' /	° ' /
<i>a</i> 100	0 0	89 56	0 0	90 0
<i>d</i> { 110	44 59	89 59	45 0	90 0
{ 101	0 2	44 57	0 0	45 0
<i>o</i> 111	45 3	54 42	45 0	54 44
<i>n</i> { 112	45 7	36 2	45 0	35 16
{ 121	26 35	65 50	26 34	65 54
<i>r</i> * { 405	0 2	38 25	0 0	38 39
{ 504	0 3	50 0	0 0	51 20

Stanley Copper Mine, Linda, Tasmania.

(Pl. viii., fig. 4.)

Two hand specimens from this old mine are in the Australian Museum collection. The matrix is concretionary and stalactitic limonite, and the cuprite is accompanied by crystallised native copper. The crystals of cuprite are of dodecahedral habit, almost transparent, and brilliant red in colour. In the figured specimen small faces of the cube and octahedron are present, occasional narrow planes of *n* and a probable new trisoctahedron *B* (155) appears as striæ in the dodecahedral faces running parallel to their intersections with the octahedral planes. Nine measurements of *B* were obtained; of these the only two reasonably good

³⁰ Petterd—Catalogue of the Minerals of Tasmania, p. 61 (Hobart, 1910).

ones for the face 155 gave values for ϕ of $11^{\circ} 31'$ and $10^{\circ} 30'$ (calculated $11^{\circ} 19'$) and for ρ $45^{\circ} 34'$ and $45^{\circ} 33'$ (calculated $45^{\circ} 33'$). For the face 551 the mean of six measurements gave ϕ $45^{\circ} 1'$, ρ $82^{\circ} 26'$ (calculated $45^{\circ} 0'$, $81^{\circ} 57'$). In another crystal the faces of the octahedron are larger, and two very narrow planes of a possibly new tetrahexahedron *i* (307) were observed, the values obtained for ρ being $23^{\circ} 10'$ and $23^{\circ} 18'$ (calculated $23^{\circ} 12'$). These two forms require confirmation before they are accepted.

Angles:

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
<i>a</i> 100	0 1	89 59	0 0	90 0
<i>d</i> { 110	45 0	89 58	45 0	90 0
{ 101	0 0	45 0	0 0	45 0
<i>o</i> 111	45 0	54 45	45 0	54 44
<i>i</i> * 307	0 46	23 14	0 0	23 12
<i>n</i> { 112	45 3	35 9	45 0	35 16
{ 121	26 39	65 48	26 34	65 54
* <i>B</i> { 551	45 1	82 26	45 0	81 57
{ 155	11 0	45 33	11 19	45 33

MIMETITE.

Mount Bonnie, Northern Territory.

(Pl. viii., figs. 5, 6, 7.)

The Mount Bonnie Mine is in the Margaret District of the Woggaman Province, about four miles south of the point where the Darwin to Pine Creek railway crosses the Margaret River. According to Dr. H. I. Jensen³¹ the lode may be regarded as a gash vein formed by strong movements on two fissure directions, and the surface shows a huge gossany ironstone outcrop containing small amounts of lead, gold, and silver. In a fifty feet shaft very good carbonated lead ore was encountered in a red vughy gossan. A tunnel was subsequently driven cutting the lode two hundred feet below the outcrop, but apparently the primary sulphide ore has not yet been reached.

The mimetite occurs in a reddish or yellowish gossan, the best crystals being found in vughs which are sometimes lined with botryoidal

³¹ Jensen—Bull. North. Terr., No. 16, 1916, pp. 36, 37.

limonite, or, in one case, with a dull, steel-grey crust of psilomelane. The mimetite is well crystallised, and two somewhat different habits can be recognised; the larger crystals are tabular on the base, the prisms being short or absent, and measure up to 20 mm. in diameter, but these crystals are usually coarse and have a frosted appearance. The smaller crystals are prismatic and attain a length of 6 mm. with a diameter of about 3. Most of the crystals are almost white, with a slight yellowish or buff tinge, but on one hand specimen the mineral is distinctly yellowish and on another green. The crystals on these two specimens are thin tabular on the base and imperfectly formed, many consisting of an aggregate of parallel or sub-parallel groupings.

Nine crystals were measured, and the following forms, one of which, r ($10\bar{1}2$), is new, were identified:— c (0001), m ($10\bar{1}0$), r ($10\bar{1}2$), x ($10\bar{1}1$), y ($20\bar{2}1$). Of these the base is never wanting and is usually a fairly large face; m is generally well developed though slightly striated horizontally, or it may be quite small or absent altogether; of the pyramids x is always present, y was found on three crystals and r on eight, both as long narrow faces. The new form r ($10\bar{1}2$) has been recorded for the closely allied species apatite and pyromorphite, but apparently has not hitherto been found on mimetite or vanadinite; the co-ordinate angles for r were found to be ϕ $0^\circ 4'$, ρ $22^\circ 49'$ (calculated $0^\circ 0'$ and $22^\circ 47'$). These figures are the means derived from 23 measurements, the limiting values for ρ being $22^\circ 9'$ and $23^\circ 16'$; the form may be considered established.

Angles:

Forms.	Measured.		Calculated.	
	ϕ	ρ	ϕ	ρ
c 0001	—	—	—	—
m $10\bar{1}0$	0 2	90 0	0 0	90 0
r^* $10\bar{1}2$	0 4	22 49	0 0	22 47
x $10\bar{1}1$	0 1	39 58	0 0	40 2
y $20\bar{2}1$	0 4	59 17	0 0	59 14

To confirm the identification of the mineral as mimetite a quantitative analysis was made of a crystal which appeared to be homogeneous and pure. For estimation of the lead, arsenic and phosphorus, 1.1024 gram was dissolved in caustic potash, the lead precipitated by ammonium sulphide and weighed in a Rose crucible. From the filtrate sulphide of arsenic was precipitated by addition of hydrochloric acid, filtered, washed, and oxidised by strong nitric acid. The arsenic acid was precipitated by addition of ammonia and magnesia mixture, and weighed as magnesium

pyro-arsenate. The filtrate from sulphide of arsenic was evaporated, rendered alkaline with ammonia, and phosphoric acid precipitated by magnesia mixture. Chlorine was determined in another portion weighing .9595 gram, which was dissolved in nitric acid and precipitated with silver nitrate. The result was as follows:—

	%
Pb O	76.22
As ₂ O ₅	20.55
P ₂ O ₅	1.41
Cl	2.00
	<hr/>
	100.18
Less oxygen equivalent to chlorine ... ..	.45
	<hr/>
	99.73
	<hr/> <hr/>

In conclusion, I have to record my indebtedness to Messrs. W. T. Watkin Brown, D. A. Porter and G. Smith for the loan of specimens, and to Messrs. B. J. Smart, B.Sc., and H. E. M. Curry, of the Testing Branch, Department of Public Works, through whose kind offices the artificially etched crystal of beryl was photographed.

EXPLANATION OF PLATE I.

Beryl, Torrington, N.S.Wales.

Figs. 1, 2. Crystal i.; Note the etched band between prisms and pyramids.

Fig. 3. Crystal x.; The crystal is tilted so as to show the elevations and markings on the base.

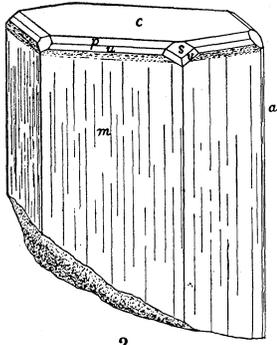
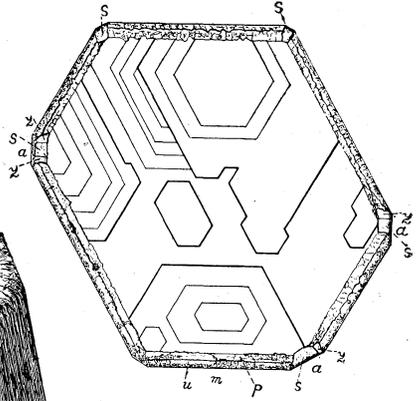
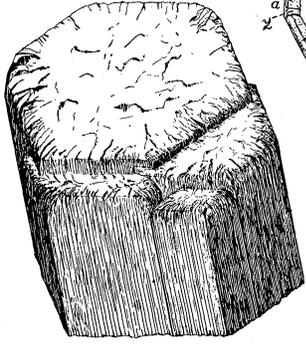
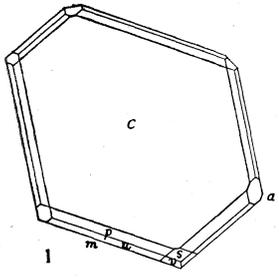
„ 4. Crystal vi.; this shows the etching between prisms and pyramids and hexagonal markings on the base.

„ 5. Crystal xiv.; this is a composite crystal, consisting of four individuals, the terminations rounded and pyramid faces completely obliterated.

„ 6. Crystal vii.; here the pyramids have been strongly attacked but are still identifiable, and the hexagonal markings on the base are strongly marked.

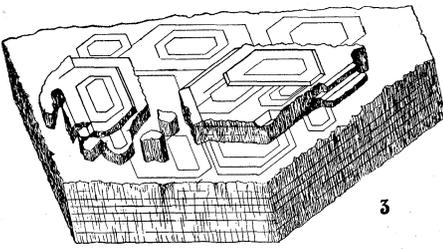
Figs. 7, 8. Crystal viii.; in these figures the markings on the base are not shown (compare Pl. ii., fig. 7).

Forms:— c (0001), a ($11\bar{2}0$), m ($10\bar{1}0$), p ($10\bar{1}1$) u ($20\bar{2}1$), s ($11\bar{2}1$),
 v ($21\bar{3}1$), z ($42\bar{6}3$), n ($31\bar{4}1$).

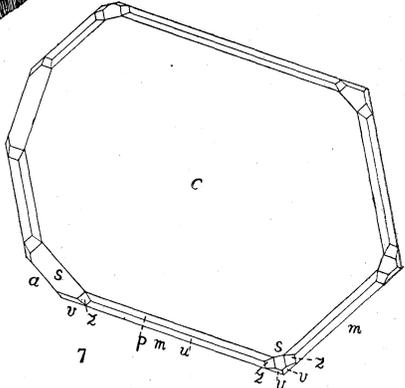


5

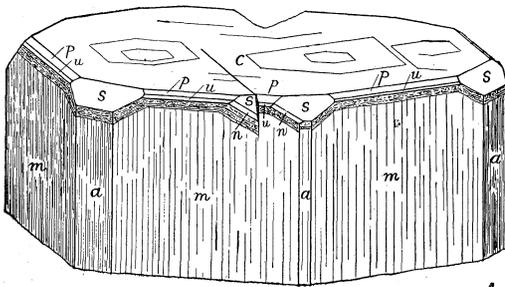
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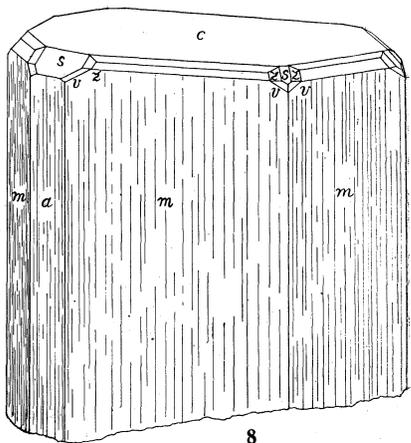
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7



4



8

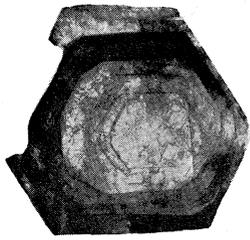
EXPLANATION OF PLATE II.

Beryl, Torrington, N.S. Wales.

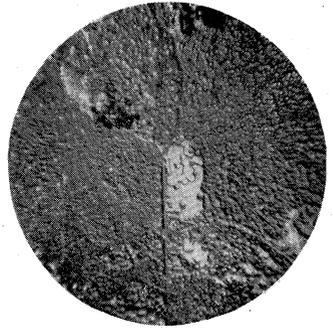
- Fig. 1. Crystal xv.; this crystal, the termination of which is directed downwards, shows signs of prolonged etching, the prism faces being deeply fluted and the base reduced to a number of isolated pinnacles.— $\frac{1}{1}$
- „ 2. Crystal xiii.; showing zonal growth.—about $\frac{6}{5}$
- „ 3. Base etched with caustic soda.— $\frac{20}{1}$
- „ 4. Crystal xii.; natural etch figures on the base. The figures are hexagonal depressions disposed in an approximately linear manner.—about $\frac{9}{4}$
- „ 5. Etch figure on base of crystal xii. enlarged.
- „ 6. Crystal ix.; the base of this crystal is intersected by “gullies” separating elevations of hexagonal form.—about $\frac{1}{1}$
- „ 7. Crystal viii.; base with numerous hexagonal elevations and markings and linear depressions.—about $\frac{3}{2}$



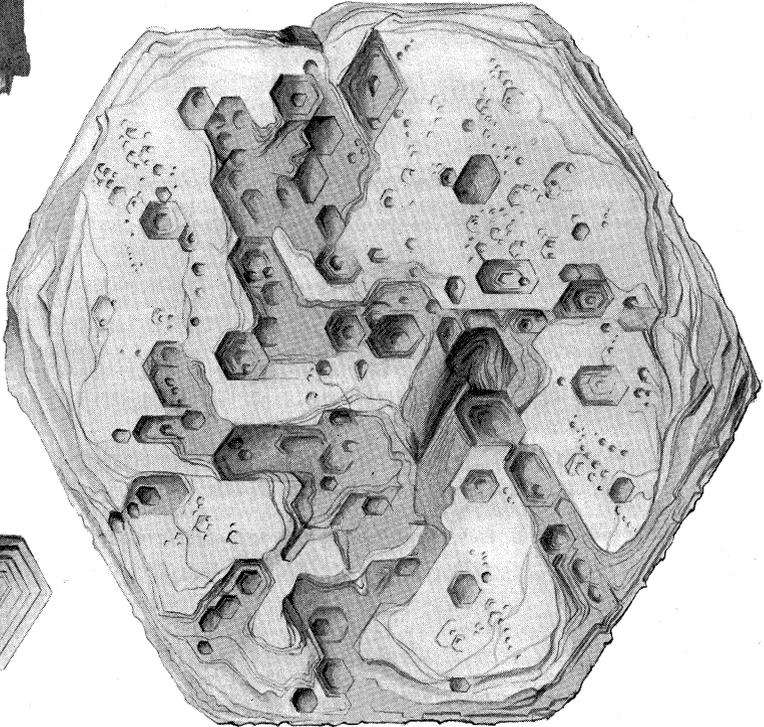
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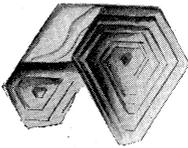
2



3



4



5



6



7

PHYLLIS F. CLARKE (4, 5,)del.
H. E. M. CURRY (3) photo.
C. CLUTTON (1, 2, 6, 7) photo.

EXPLANATION OF PLATE III.

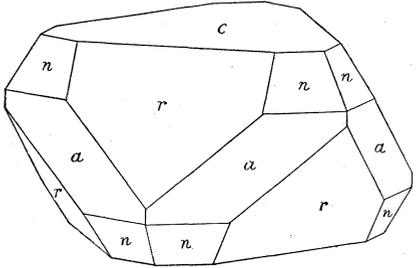
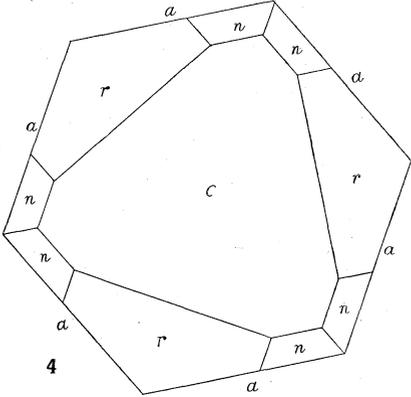
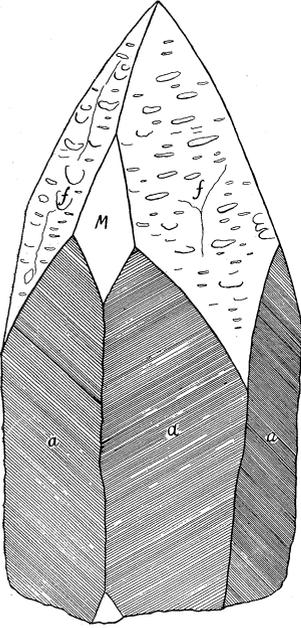
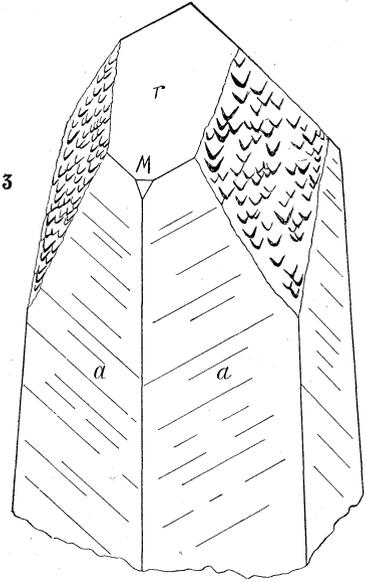
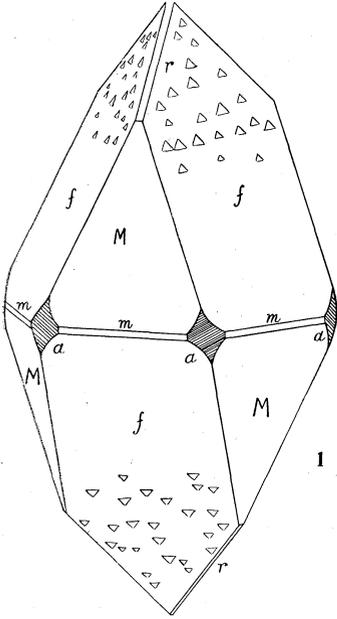
Figs. 1, 2. Calcite, Belubula Caves, near Mandurama, N.S.Wales.

Fig. 3. Calcite, near Glen Innes, N.S.Wales.

Forms :— a ($11\bar{2}0$), m ($10\bar{1}0$), r ($10\bar{1}1$), M ($40\bar{4}1$), f ($02\bar{2}1$).

Figs. 4, 5. Hematite, New Hebrides, West Pacific.

Forms :— c (0001), a ($11\bar{2}0$), r ($10\bar{1}1$), n ($22\bar{4}3$).



EXPLANATION OF PLATE IV.

Calcite, Belubula Caves, near Mandurama, N.S.Wales ; all figures about natural size.

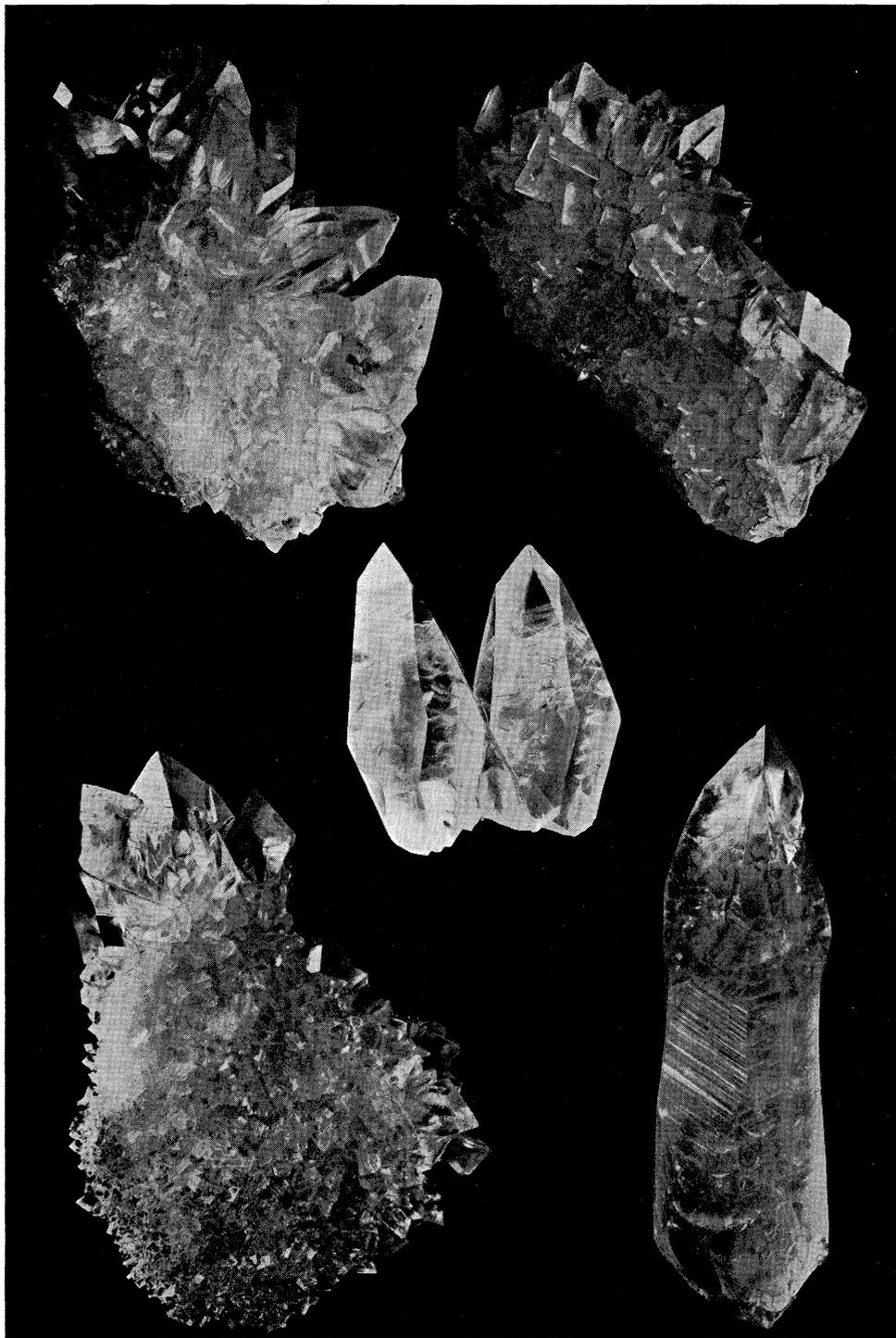
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2

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4



C. CLUTTON, photo.

EXPLANATION OF PLATE V.

Fig. 1. Chabazite, near Glen Innes, N.S.Wales; phacolite type, twinned on vertical axis.

Forms:— r ($10\bar{1}1$), s ($02\bar{2}1$), t ($11\bar{2}3$).

Figs. 2, 3. Vesuvianite, Arramagong, N.S.Wales.

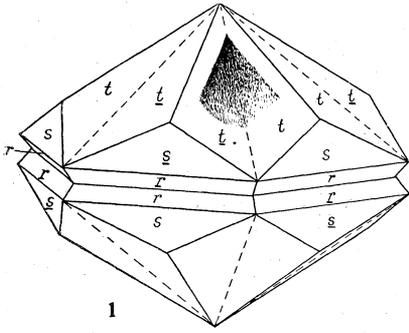
Forms:— c (001), a (100), m (110), ϕ (350), f (120),
 p (111), t (331), s (131).

Fig. 4. Quartz, Howell, N.S.Wales; twinned on $11\bar{2}2$ (Japan Law).

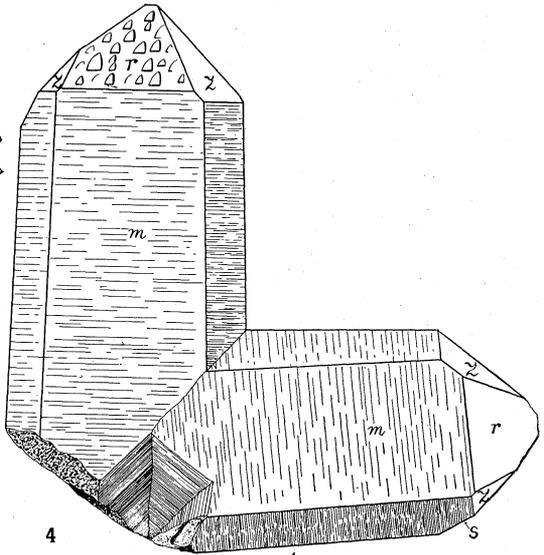
Forms:— m ($10\bar{1}0$), r ($10\bar{1}1$), z ($01\bar{1}1$), s ($11\bar{2}1$).

„ 5. Stibnite, Hillgrove, N.S.Wales.

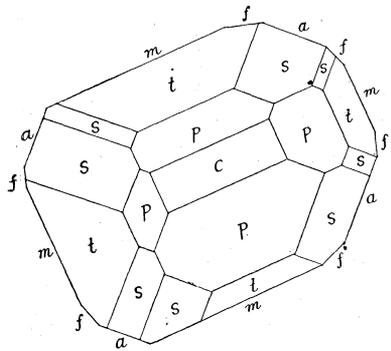
„ 6. Forms:— b (010), m (110), n (210), s (113), e (123),
 ψ (146).



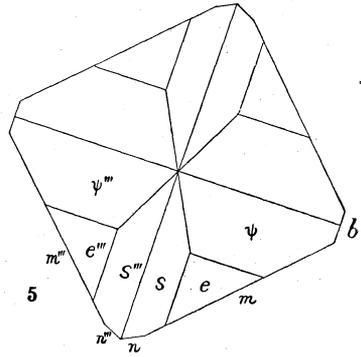
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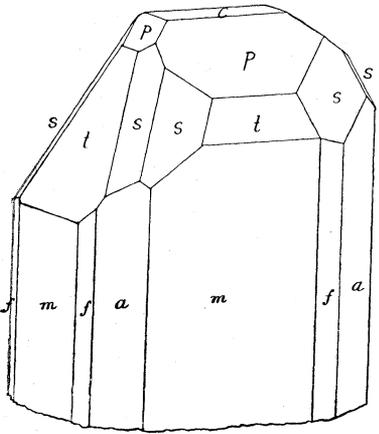
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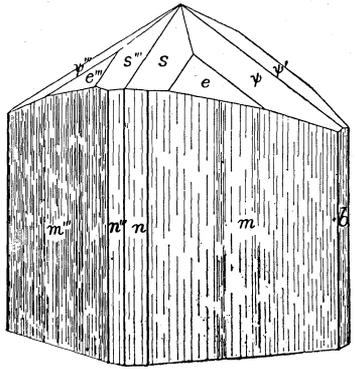
2



5



3



6

EXPLANATION OF PLATE VI.

Figs. 1, 2. Wolframite, Wild Kate Mine, Torrington, N.S.Wales.

Forms:— a (100), l (210), m (110), f (011), t ($\bar{1}02$),
 ω (111), o ($\bar{1}\bar{1}1$), σ (121), s ($\bar{1}21$).

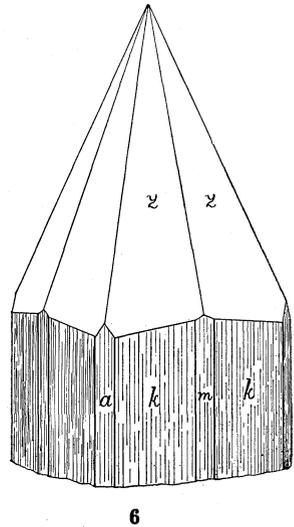
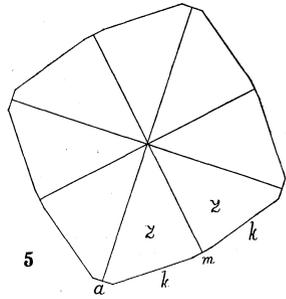
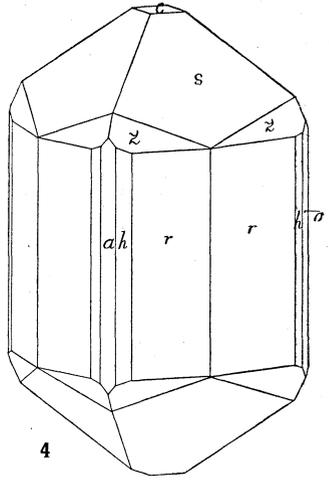
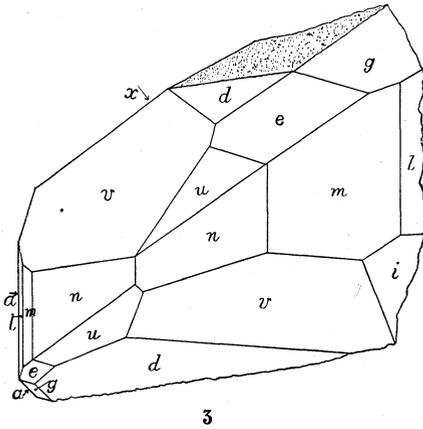
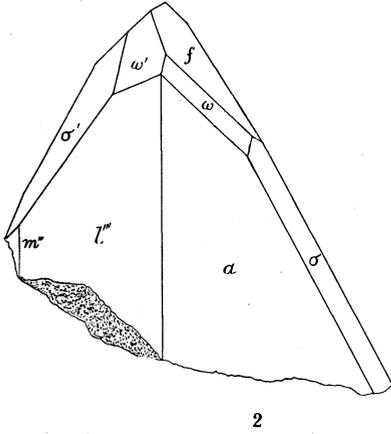
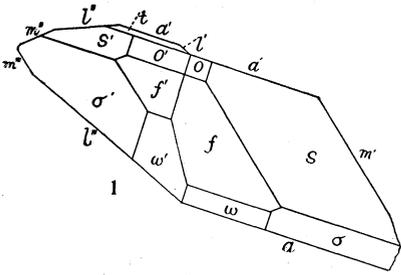
Fig. 3. Monazite, Dingo Creek, Torrington, N.S.Wales.

Forms:— c (001), b (010), a (100), l (210), m (110),
 n (120), g (012), e (011), u (021), x ($\bar{1}01$),
 i ($\bar{2}11$), v (111), d ($\bar{1}12$).

„ 4. Cassiterite, Pine Mountain, Inverell, N.S.Wales.

Figs. 5, 6. Cassiterite, Long Gully, near Tingha, N.S.Wales.

Forms:— c (001), a (100), m (110), k (340), r (230),
 h (120), s (111), z (231).



EXPLANATION OF PLATE VII.

Figs. 1, 2. Cassiterite, Long Gully, near Tingha, N.S.Wales; fig. 2 twinned on *e*.

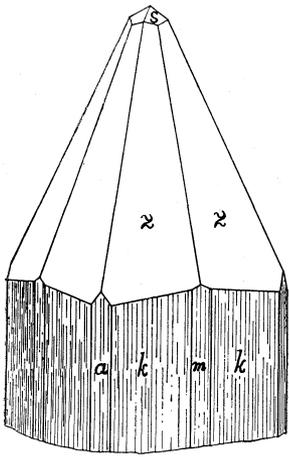
Fig. 3. Cassiterite, Pilbara, Western Australia; doublet on *e*.

Figs. 4, 5. Cassiterite, Tingha (?), N.S.Wales; triplet on *e*.

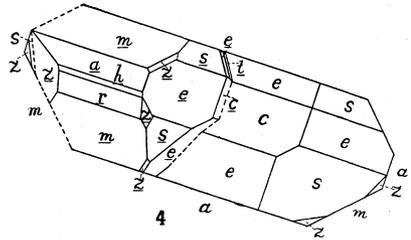
Forms:—*c* (001), *a* (100), *m* (110), *k* (340), *r* (230),
h (120), *e* (011), *s* (111), *z* (231), *t* (133).

Fig. 6. Cuprite, Broken Hill, N.S.Wales.

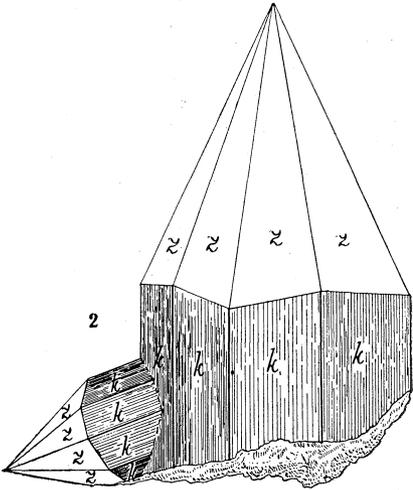
Forms:—*d* (110), *o* (111), *u* (112).



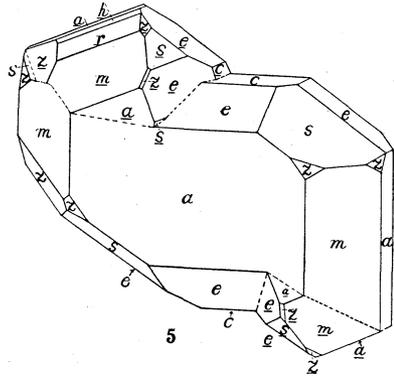
1



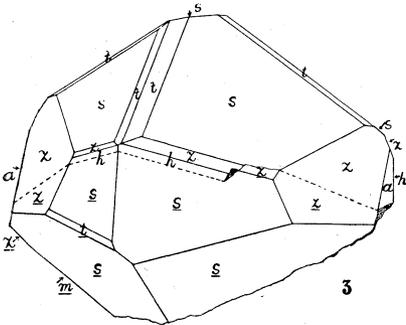
4



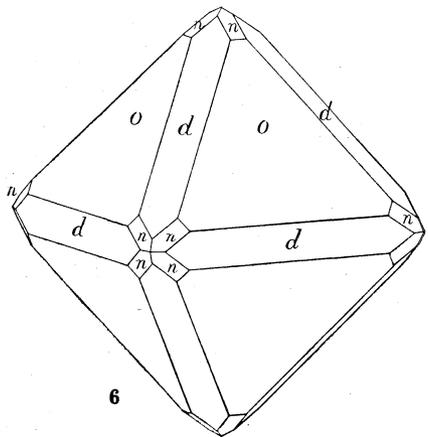
2



5



3



6

EXPLANATION OF PLATE VIII.

- Fig. 1. Cuprite, Cadia, near Orange, N.S.Wales.
,, 2. Cuprite, Cloncurry, Queensland.
,, 3. Cuprite, Mount Lyell, Tasmania.
,, 4. Cuprite, Stanley Mine, Linda, Tasmania.

Forms:— a (100), d (110), r (045), o (111), n (112),
 l (445), B (155).

- Figs. 5, 6, 7. Mimetite, Mount Bonnie, Northern Territory.

Forms:— c (0001), m (10 $\bar{1}$ 0), r (10 $\bar{1}$ 2), x (10 $\bar{1}$ 1), y (20 $\bar{2}$ 1).

