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New crystal-forms on Pyrites, Calcite, and Epidote.[1]

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PYRITES.

THE dyakis-dodecahedron (641) was observed on certain of the Museum specimens by Mr. Richard Elliot Steel in 1879 and again by myself in 1894; and although several memoirs on the crystallography of pyrites have been published since those dates, this form has not hitherto been recorded for the mineral.[2]

Under the register-number 31679 are a number of small specimens

[1] Communicated by permission of the Trustees of the British Museum.

[2] K. Zimányi, Földtani Közlöny, Budapest, 1912, vol. 42, pp. 729, 843, gives a complete list of 196 crystal-forms of pyrites with references to the literature up to 1912. New forms since that date are listed under the heading 'Nouvelles formes cristallines des minéraux' in the Tables annuelles de Constantes et Données numériques, Paris, 1912 *et seq.* See also the useful list by H. P. Whitlock, A list of new crystal forms of minerals. School of Mines Quarterly, New York, 1910, vol. 31, pp. 320–345, vol. 32, pp. 51–92.

Zimányi's list is based on that of G. Strüver (Mem. Accad. Sci. Torino, 1869, ser. 2, vol. 26), and contains the same errors. (211) is ascribed to Romé de l'Isle, 1783, but he himself quotes d'Agoty, 1767. (410) was recorded by Haüy in 1822. (720) and (11 . 9 . 0) are due to R. Wakkernagel (Isis, Jena, 1822, vol. 2, p. 1283). Ψ (944) should be ψ (944).

and isolated crystals of pyrites, on three of which the form in question is developed. These were purchased in 1860, and their locality is unknown. They show some matrix of black shale, and, unfortunately, are gradually being broken up by decomposition. Another small specimen showing the same form bears the number 36855. This was purchased in 1865 with the collection of General N. I. Koksharov of Petrograd. It shows a matrix of compact, purplish-brown chlorite, and is labelled as coming from Traversella in Piedmont. Finally, a specimen '36457, Iron-pyrites in coal, presented by Mr. Fielding, 1865' figures in the Museum Register and in Mr. Steel's measurement-book. He refers to it as being like No. 31679, and as it is not now to be found it has probably fallen to pieces by decomposition.

On all these five specimens the crystals are hexahedral in habit, the

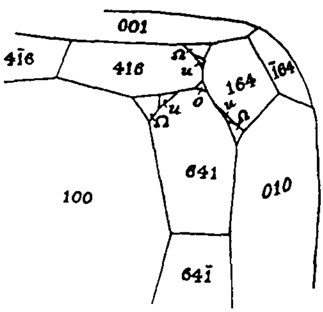


Fig. 1.

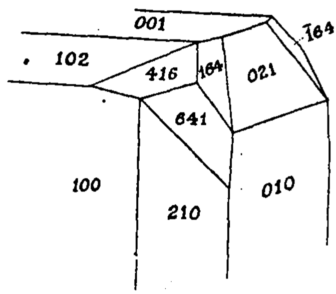


Fig. 2.

Crystals of pyrites with new form (641).

edges and corners of the cube being replaced by the form (641). The crystals measure 1 to $1\frac{1}{2}$ cm. across.

Fig. 1 represents a crystal of a small group (No. 31679) on which the new form (641) is prominently developed. The forms present on this crystal are, in order of size, *a* (100), (641), Ω (15 . 6 . 5), *u* (632), *o* (111), *l* (530)?, ν' (560)? The faces are very bright, but are somewhat roughened by low, irregular, rounded growths, this being especially the case on (100) and (15 . 6 . 5). The rare form Ω (15 . 6 . 5) lies in the zone [632, 63̄2], and its faces are rounded and striated parallel to this zone-axis. Another zone on the crystal is [100, 632, 164].

An isolated crystal of the same lot is very different in aspect owing to the larger development of the octahedron. Here the forms are *a* (100), *o* (111), (641), *t* (421)?, *e* (210). Another isolated crystal shows *a* (100), (641), *t* (421)? with small, rounded (*hk*0).

Fig. 2 represents a portion of one of the crystals on the small group from Traversella, Piedmont (No. 36855). The forms present are *a* (100), *e* (210), (641), *n* (211), *o* (111), the last two quite small and not always developed. The form (641) sometimes predominates over *e* (210). The faces of the cube and pyritohedron are somewhat rough owing to platy growths, but those of (641) are very bright and smooth. In the zone [641, 64$\bar{1}$], however, there is a tendency to oscillation, which, in the absence of the pyritohedral faces, gives rise to a peculiar rounding of the edges of the cube.

A selection of the best measured angles for the rarer forms on all these crystals is given below:

	Calculated.	Measured.
(641) : (416)	50° 6′	50° 3′, 50° 6½′, 50° 11
(641) : (64$\bar{1}$)	15 48	15 24, 15 38, 15 55
(641) : (6$\bar{4}$1)	66 39½	66 26½
(641) : (111)	29 16	29 23, 29 16
(641) : (100)	34 30	34 32, 34 30, 34 40
(632) : (326)	42 43	42 45, 42 46
(632) : (6$\bar{3}$2)	50 45	49 59
(632) : (111)	24 52	24 47, 24 59½
(632) : (100)	31 0	30 31
(15.6.5) : (6.5.15)	47 1	48
(15.6.5) : (15.6.5)	34 23½	34½
(15.6.5) : (111)	27 25	27 24, 27 19
(15.6.5) : (100)	27 30	27 47

I take this opportunity of placing on record some of the results that I obtained when working through and cataloguing the Museum series of pyrites in 1894. At that date 424 specimens, most of them well crystallized, were included under this species. The 107 specimens added to the collection since that date are not taken account of in the data given below.

In the following table are listed the several crystal-forms, 35 in number, that were detected, together with the number of specimens[1] on which each form was found. The latter are reduced to percentages for comparison with similar lists given by G. Strüver in 1869 and R. Helmhacker in 1876; but it must be borne in mind that the data given by these authors refer only to specimens from particular localities,

[1] Specimens are reckoned by the register-numbers. As a rule each of these represents a single hand-specimen with several attached crystals, though occasionally two or more similar specimens may be registered under the same number; it may also represent a single isolated crystal or several isolated crystals kept together in the same lot. The numbers are thus more or less arbitrary.

whilst those now given are for specimens from all localities represented in the collection.

Forms.	Number of specimens on which present.	Percentage.
Cube.—		
a (100)	325	76.6
Octahedron.—		
o (111)	266	62.7
Rhombic-dodecahedron.—		
d (110)	18	4.5
Direct pentagonal-dodecahedra (11).—		
α (920) ?	1	—
k (520)	2	—
e (210)	241	54.7
l (530) ?	1	—
g (320)	4	1
θ (430)	3	—
D (540)	3	—
λ (11.9.0) ?	1	—
ν (650)	3	—
σ (760)	2	—
π (870)	1	—
Inverse pentagonal-dodecahedra (4).—		
ν′ (560) ?	1	—
θ′ (340)	1	—
Inverse pentagonal dodecahedra (4).—		
g′ (230)	1	—
e′ (120)	3	—
Icositetrahedra (3).—		
ψ (944)	2	—
n (211)	22	5.2
β (322)	2	—
Triakis-octahedra (4).—		
(554)	1	—
r (332)	1	—
p (221)	6	1.4
q (331)	3	—
Direct dyakis-dodecahedra (10).—		
Ω (15.6.5)	1	—
X (11.5.2)	1	—
t (421)	35	8.5
u (632)	1	—
Z (531)	3	—
χ (532)	5	1
W (851)	1	—
(853)[1]	1	—
s (321)	148	36.1
(641)	2	—

Arranged in their order of frequency, the common forms of pyrites are thus—

a o e s t

The only simple forms found alone (i. e. not in combination with other forms) are *a*, *o*, *e*, and *s*. The relative frequency of these, and of some of the more common combinations of forms, are given below:

[1] The form (853) was found on an isolated cubo-octahedral crystal (Reg. No. 81556) from Rudnik, Serbia, acquired for the collection in 1896. It is represented by two small but well-defined faces lying between *s* and χ in the zone [*s* χ]. Measured (853) : (111) = 21° 15′, 21° 18′ (calculated 21° 4′); (853) : (321) = 2° 17′, 2° 34½′ (calculated 2° 41′). Associated forms are *a o e s t* χ *Z*. This form has recently been recorded by H. Ungemach (Bull. Soc. franç. Min., 1916, vol. 39, p. 224) on pyrites from Auriol, Bouches-du-Rhône, France.

Simple Forms and Combinations.	Number of Specimens.	Percentage.
a	50	12
o	9	2
e	10	2½
s	2	½
a o	41	10
a e	29	7
a o e	32	7½
a o s	19	4½
a e s	16	4
a o e s	55	18

The decomposition of pyrites often gives trouble in collections. It is necessary to look over the specimens occasionally, since not only are these destroyed, but the labels, trays, and cabinets are damaged. Marcasite is said to be less stable than pyrites; and when massive material decomposes it is usually assumed to be due to the presence of marcasite. Some well-developed crystals of pyrites, however, go to pieces; whilst other crystals to all appearance similar to these are not affected. Several specimens of both pyrites and marcasite bequeathed to the British Museum in 1799 by the Rev. C. M. Cracherode are still perfectly fresh and unaltered. There are also several unaltered specimens of pyrites from the collection of Baron Ignaz von Born, which were described by him in 1772 in his 'Lithophylacium Bornianum' and acquired by the British Museum in 1810.

A badly decomposing specimen should, of course, be turned out of the collection, to prevent damage to other specimens and fittings. In other cases the white efflorescence of ferrous sulphate should be brushed off. Any free acid may be neutralized by immersing the specimen in a dilute solution of ammonia. Further decomposition can sometimes be arrested by painting the specimen with gum, allowing it to soak into the cracks; or the specimen may be dipped into a gum solution. In the Museum collection all specimens showing a tendency to decomposition have been brought together in drawers in each of which a tray of quicklime is placed: this is changed every month, and has the effect of keeping the air dry and of absorbing any free acid.

Calcite.

A single isolated crystal of calcite (Reg. No. B. M. 92613), without history or any information as to locality, consists of a combination of two scalenohedra lying in the zone [*r′ e r a*], both largely developed and with an angle of only 4½° between the corresponding faces. The crystal is perfectly clear and transparent, and has all the appearance of Iceland-spar from the well-known locality in Iceland. The faces also have a dullness, like that of ground-glass, similar to that shown by the Iceland crystals. On closer inspection, however, there are seen a few minute cubes of pyrites on the surface and embedded in the crystal. So far as I know, stilbite is the only mineral found in association with Iceland-spar. The locality of the specimen, though perhaps Iceland, must therefore remain doubtful. The common scalenohedron, $v = +R3 = (20\bar{1}) = (21\bar{3}1)$, is represented by the six upper faces; while of the new scalenohedron, $+R\frac{12}{5} = (12.0.\bar{7}) = (12.7.\overline{19}.5)$ there are only three adjacent faces, also on the upper part of the crystal. Cleavages bound the lower part of the crystal, and the top is also broken off by cleavage. The portion remaining measures 4½ cm. in the direction of the vertical axis. The faces of the form $+R3$ show irregular patches which are smoother and brighter, and they give fairly good images on the goniometer. The faces of $+R\frac{12}{5}$, though large (the largest being 2 cm. across) and perfectly plane, give no reflected images. Good reflections were, however, obtained by fixing pieces of microscope cover-glass on the faces with viscous oil. The several readings, for each of which the cover-glass was refixed, showed only slight differences, and their mean values are recorded in fig. 3.

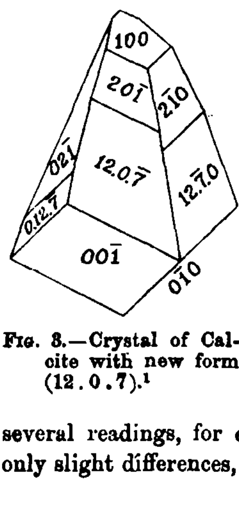


Fig. 3.—Crystal of Calcite with new form (12.0.7).[1]

		Measured.	Calculated.
	$(2\bar{1}0):(12.\bar{7}.0)$	4° 34′	4° 33′
	$(20\bar{1}):(12.0.\bar{7})$	4 33	
	$(02\bar{1}):(0.12.\bar{7})$	4 57	
$+R3$	$(20\bar{1}):(02\bar{1})$ (edge X)	75 21½	75 22
	$(20\bar{1}):(2\bar{1}0)$ (edge Y)	35 39	35 36
	$(20\bar{1}):(10\bar{2})$ (edge Z)[2]	47 0, 46° 54′, 46° 59′	47 1½
$+R\frac{12}{5}$	$(12.0.\bar{7}):(0.12.\bar{7})$ (edge X)	73 18½	73 21½
	$(12.0.\bar{7}):(12.\bar{7}.0)$ (edge Y)	40 49	40 47
	$(12.0.\bar{7}):(7.0.\overline{12})$ (edge Z)[2]	37 52, 37° 43′, 37° 5′	37 55
	rr' (cleavage-angle)	74 55½	74 55

[1] The drawing is an elevation. This simple method of representing rhombohedral crystals has been dealt with by Prof. W. J. Lewis in this Magazine, 1908, vol. 15, p. 62.

[2] Deduced from the angle measured to the adjacent cleavage-face.

The measured angles agree closely with the calculated values with the exception of those for the face $(0\,.\,12\,.\,7)$; this being slightly out of position in the zone $[02\bar{1}\,,\,00\bar{1}]$, the measured angle $(0\,.\,12\,.\,7):(00\bar{1})$ being 71° 5′ (calculated 71° 30′).

The new form $+\mathrm{R}\frac{19}{5} = (12\,.\,0\,.\,7) = (12\,.\,7\,.\,\bar{19}\,.\,5)$ is thus well established and adds one more to the already very long list for calcite. Whitlock[1] enumerated 313 forms for this species, with an additional list of 115 doubtful forms; whilst Goldschmidt[2] gives a list of 148 forms and a supplementary list of 381 rare and doubtful forms (a total of 529).

Epidote.

In 1897 the late Mr. T. J. Gibb, formerly a member of this Society, showed me a crystal which he wished to have identified. For this purpose it was measured on the goniometer and was proved to be epidote. Being an unusual crystal and showing in addition a form not previously, or since,[3] recorded for this species, he generously presented it for the Museum collection (reg. No. 83831). In appearance it resembles very closely the transparent, brownish-yellow, prismatic crystals of anatase from the Binnenthal in Switzerland, which are bounded by a square prism of one order and a low tetragonal pyramid of the other order; and, in fact, it had previously been regarded as anatase. This habit is shown in fig. 5, which represents the crystal in its actual size (11 × 6 × 6 mm.). On the side shown, the form is somewhat disturbed by a parallel repetition growth of one portion of the crystal.

The following measurements serve in the first place to orientate the crystal (the orientation and letters for the faces being those used by Dana, System of Mineralogy, 6th edit., 1892, p. 516). In the last column is shown the close correspondence of these angles with certain of the angles of anatase.

	Measured.	Calculated.	Anatase.	
cl = (001) : $(\bar{2}01)$	89° 30′	89° 26′	(100) : (010)	(110) : $(1\bar{1}0)$
cl' = (001) : $(20\bar{1})$	90 28	90 34	90° 0′	90° 0′
cm = (001) : (110)	75 38	75 45	(100) : (117)	(110) : (105)
cn = (001) : $(\bar{1}11)$	75 20	75 11	76° 10½′	76° 18′

[1] H. P. Whitlock, Calcites of New York. New York State Museum, 1910, Memoir 13.

[2] V. Goldschmidt, Atlas der Krystallformen. Heidelberg, 1913, vol. 2, p. 5.

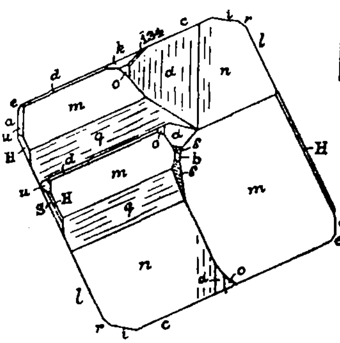
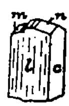
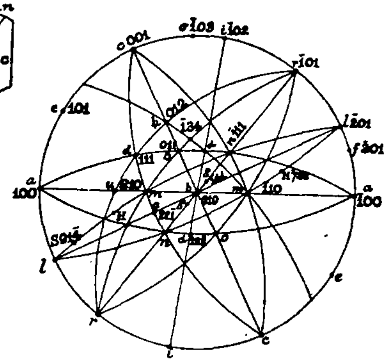
[3] A list of 299 forms for epidote is given by F. Zambonini, Zeits. Kryst. Min., 1902, vol. 37, p. 16; many are, however, vicinal faces with high indices.

The twenty-one forms determined are:

c (001)	*e* (101)	*k* (012)	$\alpha\ (\bar{1}22)$
a (100)	$\sigma\ (\bar{1}03)$	*o* (011)	$\delta\ (\bar{1}41)$
b (010)	$i\ (\bar{1}02)$		$H\ (\bar{7}32)$
	$r\ (\bar{1}01)$	*d* (111)	$S\ (\bar{9}14)$
u (210)	$l\ (\bar{2}01)$	$n\ (\bar{1}11)$	$(\bar{1}34)$
m (110)	$f\ (\bar{3}01)$	$q\ (\bar{2}21)$	

Only the faces *c l m n q a* are of any appreciable size; all the others are quite small and their size has had to be exaggerated in fig. 4. The new form $(\bar{1}34)$ is represented by one very small, but bright, face replacing edge *k a*, and it also lies in the zone [*o r*]; angles measured from it are:

	Measured.	Calculated.
$(\bar{1}34)$: *o* (011)	10° 27′	11° 5′
$(\bar{1}34)$: *k* (012)	18 31	17 36

Crystal of Epidote with new form $(\bar{1}34)$.

FIG. 4.—Orthographic projection on the plane of symmetry.

FIG. 5.—Clinographic drawing in the anatase position; actual size.

FIG. 6.—Stereographic projection of all the faces present.

As represented in the figures, the crystal is prismatic in the direction of the axis of symmetry, and is terminated at only one end. Pleochroism is readily noticeable by the unaided eye: when the crystal is viewed through the face *c* the colour is brownish-yellow, and when viewed through *l* it is greenish-yellow. There is also a marked difference in the surface characters of the two pairs of parallel faces of the approximately square prism. The faces *l* are deeply striated parallel to their length and they bear triangular etch-figures; whilst the faces *c* are smooth and are parallel to a cleavage. These differences at once distinguish the crystal from anatase.

Unfortunately, there is no information as to the locality of the crystal; but it bears some resemblance to specimens from Ala in Piedmont. A crystal from Ala in the Museum collection (reg. No. 30692) of much the same habit except that the faces *l* are less prominently developed, was measured at the same time for comparison. This shows the following twenty forms: *c* (001), *a* (100), *m* (110), *e* (101), *h* (201), σ ($\bar{1}03$), *r* ($\bar{1}01$), *l* ($\bar{2}01$), *k* (012), (023), *o* (011), *d* (111), (122), *n* ($\bar{1}11$), *q* ($\bar{2}21$), α ($\bar{1}22$), ϕ ($\bar{1}21$), *B* ($\bar{2}33$), *E* ($\bar{1}51$), *H* (732).