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CRYSTALLOGRAPHIC STUDIES OF APATITE

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APATITE FROM BRANCHVILLE, CONNECTICUT

The material for this study is partly comprised in a small series of loose crystals of apatite, presented to the American Museum of Natural History in the spring of 1924 by Mr. F. W. Ward of Ridgefield, Connecticut. They were obtained from the quarry at Branchville, Connecticut, operated by Mr. Ward on the site of the famous locality where nearly half a century ago Edward S. Dana and George J. Brush discovered the remarkable series of manganese phosphates which included eosphorite, triploidite, dickinsonite, lithiophilite, reddingite, fairfieldite, and fillowite.[1] Four of the best crystals were selected for measurement from this lot, and two from a series of ten kindly loaned for this purpose by Dr. Frederick I. Allen, who obtained them from the quarry. The author takes this opportunity to express his indebtedness to these gentlemen for their courtesy in thus making this material available for study.

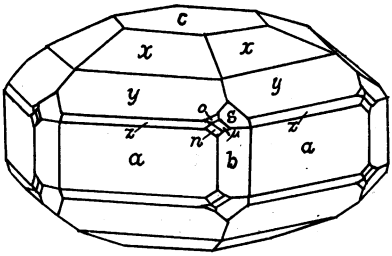

Fig. 1. Apatite from Branchville, Conn. Typical crystal in ideal proportion.

The crystals are milky white in color and somewhat stepped and rounded in outline. They are considerably flattened parallel to the base, with the prism faces shortened vertically and a strongly developed zone of the first-order pyramids. They resemble in habit and general aspect the crystals from Haddam, Connecticut.[2] The general crystal habit is shown in figure 1, drawn in ideal development. In size they range from

[1]Brush, George J., and Dana, Edward S., 1878–79, Amer. Jour. Sci., XVI, p. 33, and XVII, p. 359.
[2]Bowman, H. L., 1902, Min. Mag., XIII, p. 3.

about a centimeter to two millimeters in diameter. The crystals are remarkable for an abundance of very small bright faces in the zone comprised between *s* ($11\bar{2}1$) and *a* ($10\bar{1}0$), this zone yielding eight third-order pyramids which are new to the species.

The distribution of the forms on the six crystals measured is as follows:

Form		I	II	III	IV	V	VI	
c	0001	×	×	×	×	×	×	
a	$10\bar{1}0$	×	×	×	×	×	×	
b	$11\bar{2}0$	×	×	×	×	×	×	
z	$30\bar{3}1$	×	×	×	×	×	×	
y	$20\bar{2}1$	×	×	×	×	×	×	
x	$10\bar{1}1$	×	×	×	×	×	×	
r	$10\bar{1}2$	×	×	×	×	×	×	
s	$11\bar{2}1$	×	×	×	×	×	×	
S	$32\bar{5}2$			×		×	×	new
μ	$21\bar{3}1$	×	×	×	×	×	×	
M	$9.4.\bar{1}3.4$		×	×	×	×	×	new
M_1	$52\bar{7}2$	×	×		×	×	×	new
n	$31\bar{4}1$	×	×	×	×	×	×	
N	$72\bar{9}2$	×			×		×	new
ρ	$41\bar{5}1$	×		×	×	×	×	
T	$51\bar{6}1$		×	×	×		×	new
U	$71\bar{8}1$	×			×			new
V	$81\bar{9}1$				×		×	new
Y	$10.1.\overline{11}.1$				×		×	new
o	3142	×	×	×	×	×	×	

Arranging the new third-order pyramids with the recorded forms in the zone [$11\bar{2}1$–$10\bar{1}0$] in a series, for the purpose of testing the harmony of their relations in zone,[1] we have:

s	*S*	*μ*	*M*	Ψ	M_1	*n*	*N*	*ρ*	*T*
$11\bar{2}1$	$32\bar{5}2$	$21\bar{3}1$	$9.4.\bar{1}3.4$	$7.3.\bar{1}0.3$	$52\bar{7}2$	$3\bar{1}41$	$72\bar{9}2$	$41\bar{5}1$	$51\bar{6}1$

U	*V*	*Y*	*a*
$71\bar{8}1$	$81\bar{9}1$	$10.1.\overline{11}.1$	$10\bar{1}0$

Assuming the Goldschmidt indices, and discarding the common second index, the series becomes:

s	*S*	*μ*	*M*	Ψ	M_1	*n*	*N*
$\bar{1}$	$\frac{3}{2}$	2	$\frac{9}{4}$	$\frac{7}{3}$	$\frac{5}{2}$	3	$\frac{7}{2}$

ρ	*T*	*U*	*V*	*Y*	*a*
4	5	7	8	10	∞

[1] A brief exposition of the method of developing normal series, originated by Dr. Victor Goldschmidt of Heidelberg, will be found in Whitlock, H. P., 1915, Proc. Amer. Acad. of Arts and Sciences, I, p. 289.

The pole n $(31\bar{4}1)$ is a prominent zone intersection and may be assumed as a knot point. Splitting the zone at this point and developing the first fragment into a series:

	s	S	μ	M	Ψ	M_1	n
	1	$\frac{3}{2}$	2	$\frac{9}{4}$	$\frac{7}{3}$	$\frac{5}{2}$	3
$\frac{v-v_1}{v_2-v}$	0	$\frac{1}{3}$	1	$\frac{5}{3}$	2	3	∞

In this development, the only term of a higher series than normal series N_3 is $\frac{5}{3}$, which falls in normal series N_4. This agrees in general with the zonal relations of the poles of the new forms, since S $(32\bar{5}2)$ marks the intersection of the zone under consideration with $[20\bar{2}1.\bar{1}2\bar{1}0]$ and $[30\bar{3}1.02\bar{2}1]$, and M_1 likewise marks the intersection of $[30\bar{3}1.\bar{1}2\bar{1}0]$ and $[10\bar{1}2.31\bar{4}2]$; whereas M_1 $(9.4.\overline{13}.4)$ falls at no zone intersection.

Considering the second fragment of the zone $[11\bar{2}1.10\bar{1}0]$, this fragment may be developed into a series as follows:

	n	N	ρ	T	U	V	Y	a
	3	$\frac{7}{2}$	4	5	7	8	10	∞
v-3	0	$\frac{1}{2}$	1	2	4	5	7	∞

In this development, the pole of the well established form ρ $(41\bar{5}1)$ falls in normal series N_1, those of the new forms N $(72\bar{9}2)$ and T $(51\bar{6}1)$ in normal series N_2, and those of the new forms U $(71\bar{8}1)$, V $(81\bar{9}1)$, and Y $(10.1.\overline{11}.1)$ in increasingly higher series as these poles approach that of the prism a $(10\bar{1}0)$.

N $(72\bar{9}2)$ lies at the intersection of the zone under discussion with $[2\bar{2}01.30\bar{3}1]$, both poles of prominent forms in the Branchville habit. Furthermore, the zone connecting the poles $[72\bar{9}2.\bar{2}752]$ contain that of $03\bar{3}1$, also a prominent form of this habit.

Similarly, T $(51\bar{6}1)$ marks the intersection of the zone $[1\bar{1}01.30\bar{3}1]$ with that under discussion.

The poles of the forms U $(71\bar{8}1)$, V $(81\bar{9}1)$, and Y $(10.1.\overline{11}.1)$ do not lie at any zone intersections, and consequently the validity of these forms must rest upon the unsupported evidence of the agreement of their measured angles with theory.

The following measurements made with a Goldschmidt 2-circle goniometer, served to identify the new forms recorded.

	M	N[1]	Measured ϕ	Measured ρ	Calculated ϕ	Calculated ρ
S	(3252)	6	23° 14′	61° 34′	23° 25′	61° 34′
M	(9.4.13.4)	7	17° 11′	67° 53½′	17° 29′	67° 44′
M_1	(5272)	9	16° 9′	69° 9½′	16° 6′	69° 17′
N	(7292)	8	12° 4′	74° 11½′	12° 13′	73° 54′
T	(5161)	4	8° 38′	77° 48′	8° 57′	77° 50½′
U	(7181)	4	6° 32′	80° 43′	6° 35′	81° 7′
V	(8191)	3	5° 34′	82° 28′	5° 49′	82° 8′
Y	(10.1.11.1)	5	4° 34½′	83° 37′	4° 43′	83° 36′

[1]Number of times observed in the series of readings.