

HÜHNERKOBELITE CRYSTALS FROM THE PALERMO
NO. 1 PEGMATITE, NORTH GROTON,
NEW HAMPSHIRE

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ABSTRACT

Single crystals and granular greenish-black masses, emerald green in transmitted light, of hühnerkobelite have been found in moderate abundance at the Palermo No. 1 Pegmatite, North Groton, New Hampshire, associated with numerous other phosphates.

Palermo hühnerkobelite is biaxial (+), $\alpha = 1.727 \pm .005$ and $\gamma = 1.738 \pm .003$, markedly pleochroic with X tan and Z blue-green. The crystals are monoclinic $2/m$, short prismatic along [010] or [001], give morphological $a:b:c = 0.872:1:0.527$. The structure cell gives $a:b:c = 0.868:1:0.515$, $a = 10.89$, $b = 12.54$, $c = 6.46 \text{ \AA}$ and $\beta = 97^{\circ}33'$.

This is the first reported occurrence of single crystals of hühnerkobelite and the first known occurrence of that mineral in the eastern United States.

OCCURRENCE AND PARAGENESIS

A recent excavation at the north-west corner of the Palermo No. 1 Pegmatite, North Groton, New Hampshire, exposed, near its lip, a large pod rich in rare secondary phosphates. The pod is embedded within large masses of quartz with minor mica and perthite and is in the core of the pegmatite. No traces of the parent material could be found, but on the basis of observations on other exposed pods in the pegmatite, showing a range of alterations—from nearly unoxidized triphylite to porous ferric and manganic oxide residues—the parent material is assumed to be triphylite.

Bulk composition of the pod under study supports this further, assuming Fe, Mn ions to be relatively immobile components. The greatest bulk of material is siderite, ludlamite, and vivianite. Analyses of the FeO content by $K_2Cr_2O_7$ redox titration of Palermo No. 1 Quarry triphylite, and siderite, ludlamite, and vivianite collected from the pod give FeO by weight = 30.0% (triphylite), 37.8% (siderite), 47.2% (ludlamite), and 38.4% (vivianite). This suggests a Fe:Mn ratio in Palermo No. 1 triphylite of nearly 2:1 and is reflected in the compositions of the hydrothermally reworked derivatives of that mineral—all having Fe predominating over Mn in the formulae.

The hühnerkobelite— $(Na, Ca, Fe^{2+}, Fe^{3+}, Mn^{2+})(PO_4)^1$ —occurs along one side of the pod as single and grouped lustrous greenish-black short prismatic crystals up to 3 mm across and as granular cleavable masses up to four inches across, associated with yellowish bottle green cleavage masses and single tabular crystals of ferroan dickinsonite. Both minerals

¹ This is only an approximate formula. Dr. D. J. Fisher informs me that in a forthcoming paper, a more exact formula will be presented for hühnerkobelites.

are embedded in large siderite, ludlamite and vivianite masses. Examination of crushed hand-picked single crystals and cleavage fragments of hühnerkobelite by powder and optical methods shows the mineral to be partially replaced by ludlamite with minor siderite; this was not evident in examination of the ferroan dickinsonite material.

The following paragenetic outline is based on visual observations on over 100 specimens collected from the pod and is divided into three categories, from oldest to youngest:

- I. hühnerkobelite, ferroan dickinsonite, scorzalite, quartz, siderite, pyrite, sphalerite
- II. siderite, ludlamite, vivianite, quartz
- III. ferroan fairfieldite, metastrengite, laucite, pseudolaueite, childrenite-eosphorite, frondelite-rockbridgeite, hydroxyl-apatite, strunzite, mitridatite, xanthoxenite, diadochite

MORPHOLOGY

Computations were based on measurements of 44 faces of 8 forms: $c\{001\}$, $b\{010\}$, $a\{100\}$, $k\{130\}$, $j\{310\}$, $w\{211\}$, $x\{321\}$, $f\{132\}$; and $a:b:c=0.872:1:0.527$, $\beta=97^{\circ}28'$.

Four lustrous greenish-black crystals from 0.5 to 1 mm in greatest dimension were separated from the matrix. The crystals are short prismatic, either elongated along [010] or [001] with well developed prism faces and $w\{211\}$, and poor $f\{132\}$ predominating. A c -face appeared on only one crystal and was poorly developed. The form, $f\{132\}$, gave poor reflections, and is typically ruled and pitted. Only two reflections were obtained from that form in all the crystals examined, the others being too badly damaged to measure. This appears to be due to later attack by hydrothermal solutions. One crystal observed was hollowed out by later solutions, leaving a shell composed of lustrous faces, the interior encrusted with strunzite, $f\{132\}$ being completely eaten away.

The angle table for Palermo No. 1 hühnerkobelite is presented in Table 1. Figure 1 shows two typical developments of Palermo No. 1 hühnerkobelite.

STRUCTURE CELL DATA

The structure cell was made to conform with the morphological cell. Oscillation photographs were taken from cleavage fragments, with good [001] cleavage used as a guide in orientation, and a b-axis precession photograph established β .

Discussion of structure cell orientations of alluaudite-type minerals was given by Fisher (1955). The orientation chosen here is convenient in relating to morphological data and conforms with the less oblique $I2_1/a$ cell of Fisher.

All hühnerkobelite crystals from the Palermo No. 1 Quarry are more or less replaced by ludlamite. The powder data in Table 3 were obtained

TABLE 1. HÜHNERKOBELITE, PALERMO MINE. ANGLE TABLE

		ϕ	ϕ_{calc}^1	ρ	ρ_{calc}^1	ϕ_{\pm}	$\rho=B$	C	A
c	001	90 00	90 00	7 28	7 33	71 30	90 00	—	71 30
b	010	0 00	0 00	90 00	90 00	—	0 00	90 00	90 00
a	100	90 00	90 00	90 00	90 00	0 00	90 00	82 32	—
k	130	20 51	21 11	90 00	90 00	0 00	20 51	87 21	69 09
j	310	73 58	73 59	90 00	90 00	0 00	73 58	82 49	16 02
w	211	69 00	68 50	55 31	54 56	36 21	72 49	48 36	39 41
x	321	61 57	61 54	65 51	65 25	26 56	64 36	59 19	36 21
f	$\bar{1}32$	-11 00	-12 12	39 01	38 17	(99 35)	(51 56)	(41 11)	(97 32)

¹ Based on structure cell.

() Based on structure cell.

$a:b:c = .872:1:.527$ $\beta = 97^{\circ}28'$ $p_0:q_0:r_0 = .605:.523:1$

$r_2:p_2:q_2 = 1.912:1.157:1$ $\mu = 82^{\circ}32'$ $p_0' .610, q_0' .527, x_0' .131$

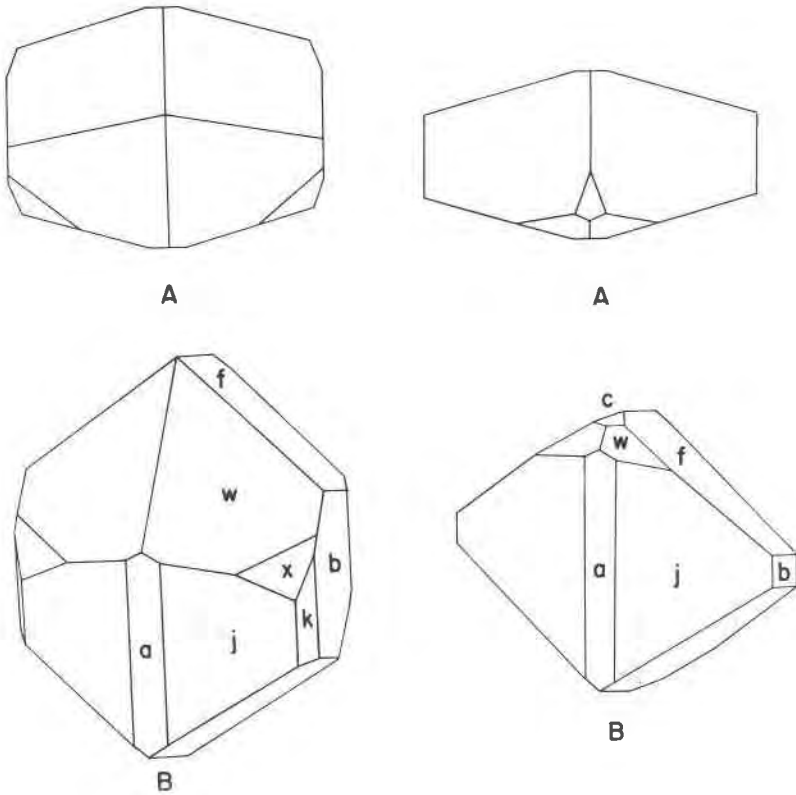


FIG. 1. Two crystals of hühnerkobelite showing the forms $c\{001\}$, $b\{010\}$, $a\{100\}$, $k\{130\}$, $j\{310\}$, $w\{211\}$, $x\{321\}$, and $f\{\bar{1}32\}$. Palermo Mine. A, plan; B, clinographic projection.

TABLE 2. HÜHNERKOBELITE, PALERMO MINE. STRUCTURE CELL DATA

a	$10.89 \pm .08$	Å
b	$12.54 \pm .04$	
c	$6.46 \pm .05$	
β	$97^\circ 33'$	
s.g.	$I2_1/a$	
$a:b:c$	$.868:1:.515$	

from a ground crystal with apparently little, if any, ludlamite present and the calculated spacings obtained from the structure cell data of Table 2.

Ferroan dickinsonite gives $a = 16.64 \pm .08$, $b = 9.98 \pm .04$, $c = 24.5 \pm .1 \text{ Å}$, $\beta = 106^\circ 20'$, $C2/c$ space group, derived from morphology and precession photographs.

COMPOSITION AND OPTICS

The relative proportions of FeO, Fe₂O₃, and MnO content are essential in determining the proper member of the hühnerkobelite (Fe²⁺ domi-

TABLE 3. HÜHNERKOBELITE, PALERMO MINE. POWDER DATA
114.6 mm camera diameter, NaF internal std. Visual I/I

I/I_0	d_{obs}	d_{calc}	hkl
4	8.18	8.18	110
7	6.24	6.27	020
5	5.41	5.40	200
2	3.465	3.46	310
3	3.196	3.20	002
$5\frac{1}{2}$	3.085	3.09	$11\bar{2}$
2	3.035	3.04	$23\bar{1}$
3	2.938	2.94	$32\bar{1}$
5	2.876	2.89	112
2	2.841	2.84	231
2	2.760	2.76	$14\bar{1}$
10	2.703	2.71	240
2	2.659	2.65	$22\bar{2}$
2	2.601	2.57	$41\bar{1}$
5	2.531	2.53	$13\bar{2}$
2	2.481	2.50	$31\bar{2}$
1	2.360		
1	2.192		
2	2.135		
4	2.102		
3	2.055		
2	1.978		
2	1.945		

nant)—varulite (Mn^{2+} dominant)—alluaudite (Fe^{3+} dominant) series. A dozen crystals were crushed and examined microscopically for impurities—particularly ludlamite and siderite. Only four crystals appeared sufficiently pure for a meaningful analysis. Total iron and total manganese were determined by electron microprobe analysis, a pre-analyzed triphylite-lithiophilite being used as a standard. Ferrous iron was determined on the remainder of the crushed crystals, employing $\text{K}_2\text{Cr}_2\text{O}_7$ redox titration. Ferric iron was determined by difference. The results, in weight per cent, are $\text{FeO} = 19.2 \pm .2$; $\text{Fe}_2\text{O}_3 = 11.4 \pm .5$; $\text{MnO} = 8.0 \pm .4$.

The hühnerkobelite grains examined optically nearly always lie on their [001] cleavage planes and possess near-maximum birefringence. Determinations give $\alpha = 1.727 \pm .005$ and $\gamma = 1.738 \pm .003$; biaxial positive; marked pleochroism with X tan and Z blue-green. The combination of the chemical analyses and the optical properties verify the Palermo No. 1 material as the hühnerkobelite side of the series. It is interesting to note that the material is similar, in composition and optics, to the material from Norrö, Sweden (Berggren, in Palache *et al.*, 1960).

FURTHER REMARKS

Hühnerkobelite and the other members of the series, varulite, alluaudite, and manganalluaudite appear to be of fairly common occurrence in phosphate-bearing pegmatites with Fe-phases predominating. Though the characteristics of these minerals have been elucidated only recently, they have been reported from no less than 10 occurrences, at least 4 in the United States.

Apparently, the hühnerkobelite clan can be either of primary or secondary origin, analogous to the closely related members of the dickinsonite series.

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REFERENCES

- FISHER, D. J. (1955) Alluaudite. *Am. Mineral.* **40**, 1100-1109.
LINDBERG, M. L. (1950) Arrojadite, hühnerkobelite and graftonite. *Am. Mineral.* **35**, 59-76.
PALACHE, C., H. BERMAN AND C. FRONDEL (1960) *The System of Mineralogy*, II. John Wiley & Sons, Inc., N.Y., 665-670.
WOLFE, C. W. (1941) Crystallographic procedures. *Am. Mineral.* **26**, 55-73.

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