ART. XLI.—*Powellite Crystals from Michigan*; by
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POWELLITE was first described by Melville* from a specimen from the "Seven Devils" Mountains, Idaho, where it occurred associated with copper ores and garnet. This material was well crystallized and Melville was able to establish its tetragonal character and the forms $c(001)$, $p(111)$, and $e(101)$. The isomorphism with the scheelite group suggested by the close agreement between the axial ratio and angles of powellite and scheelite was not fully shown, though the author says: "Small rudimentary planes appear on some crystals at the lower portion of the combination edges (111) (101), thus suggesting hemihedrism as in scheelite. Indeed the curved surface which often replaces these edges, giving the appearance of fused edges, adds greatly to the evidence in favor of this supposition."

A second occurrence of powellite, in the South Hecla Copper Mine, Houghton County, Michigan, was described by Koenig and Hubbard.† Their material was poorly crystallized and added nothing to our crystallographic knowledge of the mineral. It differed from the Idaho mineral in its paragenesis, occurring with native copper and epidote, and in its composition, having only about $1\frac{1}{2}$ per cent of its molybdic acid replaced by tungstic acid, as against about 10 per cent in the first occurrence.

Powellite continues to be found at the Michigan locality, though in small quantities and for the most part in massive form. Through the kindness of Mr. John T. Reader, of Calumet, through Dr. L. L. Hubbard, two particularly fine crystals came into the writer's hands and their description follows.

Both crystals are removed from the matrix upon which they grew. They are perfectly free from impurity of any sort and the specific gravity of the larger one could be determined with accuracy by weighing on the hydrostatic balance. Two determinations gave 4.358 and 4.353.

The crystals are pale bluish green in color, translucent, with subadamantine luster on the crystal faces and a greasy luster on fracture surfaces.

The larger of the two crystals is a centimeter in height and has one end complete, but the faces are somewhat uneven; the smaller one is half a centimeter in height and diameter and has both ends developed though neither is quite complete. The

* This Journal, vol. xli, 1891, p. 138.

† This Journal, vol. xlvi, 1893, p. 356.

quality of its faces is sufficiently good to insure accurate measurements.

The measurements were made on a two-circle goniometer (Goldschmidt model) and the observed angles therefore appear in the form of the angular coördinates, ϕ and ρ , as used in the Winkeltabelle of Goldschmidt.

The forms observed were:

$p(111)$ $e(101)$ $h(133)$ $j(3\cdot11\cdot11)$ $k(155)$ $l(1\cdot11\cdot11)$.

and the following table shows the observed and calculated angles.

Letter.	Symbol.		Observed angle.		Calculated angle.		No. of times observed.
	Miller.	Gold't.	ϕ	ρ	ϕ	ρ	
e	011	01	00° 00'	57° 04 $\frac{2}{3}$ '	00° 00'	57° 00'	3
p	111	1	44 59	65 24	45 00	65 24	2
h	133	$\frac{1}{3}1$	18 28	58 25 $\frac{1}{2}$	18 26	58 26	2
j	3·11·11	$\frac{3}{11}1$	15 08	58 00	15 15	58 00	3
k	155	$\frac{1}{5}1$	11 19	57 38	11 18	57 35	1
l	1·11·11	$\frac{1}{11}1$	5 11	57 08	5 11	57 11	1

As shown by the accompanying figure, the pyramidal hemihedrism is strongly emphasized by the faces of $h(133)$ and $j(3\cdot11\cdot11)$, the first especially being broad and of perfect quality. The other two hemihedral forms, $k(155)$ and $l(1\cdot11\cdot11)$ were very narrow faces in the zone, and as they were each observed but once they must be considered as doubtful and were therefore not introduced into the figure. There is a tendency for these planes to form a striated or curved surface between the forms p and e such as Melville observed, but there were two zones on the crystal in which the faces were sharply enough bounded to give good measurements.

The measurements lead to the same axial ratio as those made by Melville and the isomorphism of the species with the scheelite group is thoroughly established.

With the crystals of powellite sent by Dr. Hubbard was another specimen of the mineral of quite a different appearance. It consists of a rounded mass of powellite about two centimeters in diameter, upon which are a few small fragments of rocky matrix, minute crystals of bright green epidote and two or three shreds of native copper. On the broken surfaces the powellite shows an imperfect cleavage, seemingly parallel to $e(101)$. The central part of the specimen is of the same

bluish-green color as the crystals, but the surface layer to the depth of about three millimeters appears quite black and opaque in reflected light and when examined in thin splinters is seen to be colored a deep prussian blue. The boundary between the two colors is not sharp but the darker portion shades off rapidly into the lighter part.

The dark-colored material is crystallized in a number of small individuals, all in parallel position and showing approximately the same forms as the crystals before described but with greater proportional development of the forms *e* and *h*.

An attempt was made to separate some of the darker material for chemical examination, it being assumed that the lighter colored part did not differ from the similar material analyzed by Koenig and Hubbard; but it proved impossible to obtain a sufficient amount for any satisfactory tests. A small amount (.051 gram) was however picked out in which there was a very slight admixture of light-colored substance and a few minute grains of epidote, and its specific gravity was determined to be 4.214. This determination is not wholly reliable on account of the impurities and the small amount of material, and it is probably too low; but it seems to the writer fairly certain that the specific gravity of the dark material is less than that of the light (4.355). The specific gravity of the pure calcium molybdate has been calculated to be 4.267 (Melville), a value which is rapidly raised by even small quantities of the tungstate. It seems probable, in view of these facts, that the dark blue material represents an occurrence of almost pure calcium molybdate. It is much to be hoped that more material will be found which will permit the chemical proof of the existence of this end member of the scheelite-powellite series.

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