J. C. Branner

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ART. XVII.—*Powellite—Calcium Molybdate: A new mineral Species*; by W. H. MELVILLE.

ATTENTION has been recently called in mining journals to a locality in the western part of Idaho known as the "Seven Devils" where mining operations for some time past have been actively conducted. "The 'Seven Devils' about ninety miles due north of Huntington and fifteen miles east of Snake River form a high broken chain of mountains nearly 9,000 feet above the sea level. The mineral zone is about one mile wide by four miles in length."* The ore is worked for copper and silver, and is mainly the mineral bornite, a sulphide of copper and iron. "The formation on the west of the vein of ore is syenite and quartzite, while on the east wall is a soft white granite. A short distance to the east is a lime contact which extends south for some four miles, and forms a contact with granite. Along this contact some very good chimneys of ore have been discovered."

This bornite carries silver varying in quantity from 12 to 20 ounces to the ton. In one sample of very pure bornite Mr. R. L. Packard found by assay 14 ounces of silver to the ton. A sample from which I had separated for the most part the other mineral constituents gave me 15·65 ounces of silver to the ton. It was this latter fragment of bornite, weighing about 60 grams, which Mr. Packard picked up from a dump before one of the tunnels in the mining claim called Peacock and which through this gentleman's kindness furnished the material for this paper. The specimen had evidently been exposed to weathering processes and had become friable to such an extent that between the fingers it could be crushed by slight pressure.

There were two associated minerals, one of which was identified by the following partial analysis as a lime-alumina iron garnet. It was light brown, but not crystallized. It fused easily to a black glass.

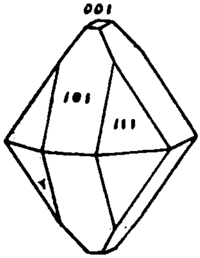
Loss on ignition	0·06 per ct.
SiO_2	38·67
Al_2O_3	10·08
Fe_2O_3	16·00
FeO	0·91
CaO	33·35
MgO	0·77
CuO	trace
	99·84

* Quotations from Engineering and Mining Journal, Nov. 22, 1890.

Crystallized dark brown garnet is found in considerable abundance throughout this locality. The crystals exhibit the usual combination of rhombic dodecahedron and tetragonal trisoctahedron.

That which proved to be the most important constituent of the specimen, about 1·5 grams, somewhat resembled scheelite at first sight, but a careful study of its characters excluded that mineral species from consideration. The strong reactions for molybdenum suggested a new species. The mineral was well crystallized and easily detached in almost absolutely pure condition from its friable matrix. Angular measurements were obtained on a number of crystals, from which the crystallographic elements were calculated. The fundamental angle (111) ∧ (11$\bar{1}$) was chosen because of its great accuracy, the signals on the goniometer being perfectly reflected from these planes. Other angles were read oftentimes between reflected signal and reflected light, and again between merely reflected light from the crystal faces. The best crystals were about 0·04 (1^{mm}) long, and others attained the maximum length of 0·10 inch. It was found that the crystals belonged to the pyramidal (tetragonal) system of crystallization, and were closely allied in habit and development to scheelite. In the following table of measurements this analogy is shown.

1.



	Powellite.		Scheelite.*
$a : c$	1 : 1·5445		1 : 1·5369
Between normals.	Observed.	Calculated.	
111 ∧ 11$\bar{1}$	49° 12′	fundamental	49° 27′
111 ∧ 001	65° 24′	65° 24′	65° 16′
111 ∧ 1$\bar{1}$1	79° 56⅜′	80° 1′	79° 56′
101 ∧ 10$\bar{1}$	65° 55′	65° 51′	66° 6′
101 ∧ 111	40° 1¼′	40° 1′	39° 58′

From this comparison of angles and axial ratio it is evident that sharp and accurate observations must be obtained in order to distinguish by crystallographic means alone between these two species. Many crystals were examined and many trials were necessary before any difference in these angles from those of scheelite could be made out.

The following forms were observed: {001} $\infty a : \infty a : c$
{111} $a : a : c$
{101} $a : \infty a : c$
{110} $a : a : \infty c$

Small rudimentary planes appear on some crystals at the lower portion of the combination edges (111) (101), thus sug-

* Dana's System of Mineralogy, 1883, p. 605.

gesting 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.

No cleavage planes could be developed by mechanical means, yet occasionally fragments exhibited interrupted planes similar to cleavage surfaces. Hardness less than scheelite, about 3·5. Sp. gr. 4·526, mean of two determinations. Color yellow with a decided green tinge. Luster resinous. Crystals semi-transparent. Brittle. The blowpipe characters are those ordinarily given under molybdates and tungstates, although the reactions of molybdenum in this case obscure those of tungsten associated with it. The mineral fuses at about 5 to a gray mass. Decomposed by nitric and hydrochloric acids.

With Powellite was associated an olive-green substance which without doubt resulted from the decomposition of calcium molybdate perhaps by water holding carbonic acid in solution, whereby molybdic ochre was formed.

The following analysis shows the unusual replacement of a part of the molybdic acid by tungstic acid. Rose's method of separating these acids was adopted, and abundant tests proved the purity of the respective products of separation. Molybdenum trisulphide was collected by reverse filtration and aliquot portions were taken for reduction. The molybdenum was weighed first as disulphide, and this weight was checked by reduction to metal in hydrogen gas by strong and long continued ignition. Mercurous tungstate was precipitated, then ignited, and tungstic acid was finally weighed.

ANALYSIS OF POWELLITE.

		CaO required.
MoO_3	58·58%	22·79
WO_3	10·28	2·48
SiO_2	3·25	
CaO	25·55	25·28
MgO	0·16	
Fe_2O_3	1·65	
Al_2O_3	trace	
CuO	trace	
S	undetermined	
	99·47 %	

Calcium molybdate has never before been observed in nature, and although the mineral under discussion contains some calcium tungstate,—according to analysis a little less than one molecule to eight molecules of calcium molybdate,—yet the molybdate is now established as a species. It fills a gap heretofore existing in the series of isomorphous minerals of which scheelite is the type. If the natural molybdate and tungstate of lime have the same molecular volume as is most probable, then the sp. gr. of pure $CaMoO_4$ should be $200 \div 46·9 = 4·267$, if the molecular volume, $288 \div 6·14 = 46·9$, is true for scheelite. By means of the equation for the determination of the sp. gr. of one constituent of a mixture containing two substances of which one is known, the sp. gr. of $CaMoO_4$ is 4·3465 assuming the sp. gr. of $CaWO_4$ to be 6·14 and that of the mixture 4·526 (sp. gr. of powellite). This close agreement in these two calculations of the sp. gr. of $CaMoO_4$ is an interesting and important confirmation of the chemical and physical data which are given above.

When this investigation was nearly completed my attention was called to a recent paper by H. Traube* in which was discussed the influence of certain varying quantities of molybdic acid in scheelite upon the physical constants, namely, sp. gr. and axial ratio. The following scheme is interesting in that it illustrates those variations which different proportions of isomorphous mixtures of $CaWO_4$ and $CaMoO_4$ produce. No mathematical law seems to exist which will express these transitions.

	$CaMoO_4$	Powellite	Scheelite			$CaWO_4$
			S. W. Africa.	Zinnwald. (1)	(2)	
% MoO_3	72	58·58	8·09 7·63	8·23	1·92	O
Sp. gr.	4·267	4·526	5·96	5·88	6·06	6·14.
a:c	1:1·5458†	1:1·5445‡		1:1·5349†		1:1·5315

I take pleasure in naming this new mineral species in honor of Major J. W. Powell, Director of the United States Geological Survey.

Chemical Laboratory of the U. S. Geological Survey, Washington, D. C., December 11th, 1890.

ART. XVIII.—*Brückner's Klimaschwankungen;* by FRANK WALDO.

DR. EDWARD BRÜCKNER, the youthful professor of Physical Geography at the University of Berne, has devoted three years to the gathering together and discussion of data concerning oscillations of climate as shown by direct observations

* Neues Jahrbuch für Mineralogie, Beilage-Band, vii, Heft 2, 1890.
† 1. Th. Hiortdahl, Zeitschr. f. Kryst. xii, 413, 1887.
‡ Neues Jahrbuch, Beilage-Band, vii.