OWYHEEITE[1]

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Owyheeite ($5PbS \cdot Ag_2S \cdot 3Sb_2S_3$) is a rare mineral sulpho-salt, descriptions of which are somewhat incomplete. New data obtained by means of *x*-ray diffraction in the laboratories of the Department of Mineralogy, Queen's University, are presented below; these not only confirm the validity of owyheeite as a mineral species but also indicate that another rare sulpho-salt, warrenite, is identical with it.

Owyheeite was first described by Burton (1868) as argentiferous jamesonite. Subsequently material from the same district (Owyhee Co., Idaho) was analysed and described by Shannon (1920, 1921), who gave it the name owyheeite. Later references to owyheeite add little to the description of the mineral, except those of Ramdohr (1937) and Short (1940) who describe etch-reactions and other data obtained from polished sections.

Eakins (1888) described a new sulpho-salt with a formula $3(Pb,Fe)S \cdot 2Sb_2S_3$ which he subsequently named warrenite (Eakins 1890). On the basis of similarity in analysis and cleavage, Spencer (1907) identified warrenite as jamesonite. *X*-ray powder photographs of specimens of warrenite from the type locality (Gunnison Co., Colorado) show that most of them are owyheeite, three are jamesonite, and one is boulangerite.

Material and Acknowledgments. The writer first became interested in the mineral when specimens collected by Mr. S. M. Roscoe from the Slocan Rambler Mine, British Columbia, and reported to be owyheeite, were turned over to him for examination. Subsequently, the following specimens were borrowed for study; the original name as given on the label is retained for each specimen.

1. Owyheeite (U.S.N.M., 94054), Poorman Mine, Silver City district, Owyhee Co., Idaho; massive material in a quartz gangue with some pyrite. This is type material described by Shannon (1920).
2. Warrenite (U.S.N.M , 48412), Domingo Mine, Gunnison Co , Colorado; blue to yellow-gray hairlike crystals coating fractures in country rock. This is original type material described by Eakins (1888).
3. Warrenite (U.S.N.M., R998), Domingo Mine, Gunnison Co., Colorado (Roebling collection); fine hairlike crystals in country rock.
4. Warrenite (U.S.N.M., 82621), Garfield (King Cole) Mine, Cascade Mts., Gunnison Co., Colorado; hairlike to acicular crystals in vugs in country rock, collected by Cross and Smith.

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5. Warrenite (U.S.N.M., 86844), Colorado; fine hairlike needles in country rock (type material).
6. Owyheeite (R.O.M., M13021), Poorman Mine, Owyhee Co., Idaho; massive material in quartz.
7. Warrenite (R.O.M., M4063), Domingo Mine, Gunnison Co., Colorado; fine hairlike crystals coating country rock.
8. Warrenite (H.M.M., 82669), Domingo Mine, Gunnison Co., Colorado; fine hairlike needles on country rock.
9. Warrenite (H.M.M., 87798), Domingo Mine, Gunnison Co., Colorado; fine hairlike needles in crevices in country rock.
10. Warrenite (B.M., 84697), Domingo Mine, Gunnison Co., Colorado; a few fine hairlike crystals in a glass vial. This is the material described by Spencer (1907).

For the specimens from the United States National Museum, the writer is indebted to Dr. W. F. Foshag. Specimens from the Royal Ontario Museum were provided through the kindness of Dr. V. B. Meen. Material from the collections of the Harvard Mineralogical Museum was loaned through the courtesy of Dr. C. Frondel, and Dr. F. A. Bannister was kind enough to provide the specimen from the British Museum. The writer also wishes to express his appreciation to Dr. L. G. Berry of Queen's University for assistance, advice, and criticism.

Physical Properties. Owyheeite occurs in quartz gangue in massive to coarsely fibrous habit and on country rock as masses of felted hairlike crystals coating crevices and fractures. Some single crystals were found embedded in quartz but none of the material examined proved to be suitable for measurement of interfacial angles. Needles are striated longitudinally and are very brittle due to basal cleavage. The mineral is light silvery gray, frequently tarnished to a blue or yellow tint.

In polished section it is slightly pleochroic and markedly anisotropic from yellowish white to gray. Hardness is slightly less than that of galena. The streak is a bright reddish brown. The writer was unable to obtain a satisfactory microchemical test for silver from the Slocan material but a semi-quantitative analysis indicated a silver content of between five and ten per cent. Standard etch-tests are not determinative; their results agree closely with those listed by Short (1940) except that a reaction with KOH was obtained yielding a vari-coloured coating after two to three minutes.

The specific gravity of owyheeite as measured by Burton (1868) is 6.03; this value is quoted in Palache, Berman & Frondel (1944). The Slocan material on which Dr. Berry was kind enough to make new determinations of specific gravity, was found to contain finely disseminated impurities, principally quartz, pyrite and a black non-metallic mineral. Several determinations were made, the lowest of which were below 6.0. However the three highest values were obtained from the cleanest material; on 4.73 mg. the specific gravity was 6.02, this material was then repicked and a cleaner residue weighing 1.58 mg. yielded specific gravities of 6.22 and 6.51. The average of these three values is 6.25 ± 0.2; since the impurities are minerals of lower specific gravity it is probable that the true value of owyheeite is slightly higher than this average.

Structural Crystallography. There is no recorded occurrence of crystals of owyheeite on which interfacial angles can be measured. Accordingly single crystal rotation photographs and Weissenberg resolutions were made about the needle-axis *c*[001] only. Rotation photographs were made from a fragment of the Slocan material, from a hairlike crystal of warrenite (U.S.N.M., 82621) and from a similar crystal of warrenite (B.M., 84697). Zero layer Weissenberg resolutions were made from the first two of these specimens.

Rotation photographs about *c*[001] show strong layer lines and very weak intermediate layer lines yielding a pseudo-period $c' = c/2 = 4.095$ Å. Since it was found to be impracticable to resolve the true first layer line, a Weissenberg resolution of the first layer line of the pseudo-cell was made from the Slocan fragment. These photographs indicate that owyheeite is orthorhombic and yield the following dimensions[3] of the unit cell:

$$a = 22.82 \qquad b = 27.20 \qquad c = 8.19 \text{ Å}$$

Systematically missing spectra for the pseudo-cell abc' conform to those for the space group $Pnam - D_{2h}^{16}$. The axial ratio becomes:

$$a:b:c = 0.8390:1:0.3011$$

X-ray powder photographs of the three specimens of owyheeite are identical with those of warrenite specimens U.S.N.M., R998, 82621, and R.O.M., M4063. There was insufficient material for a powder photograph to be made of warrenite from the British Museum; its identity with owyheeite was established on the basis of rotation photographs. Material from warrenite specimens U.S.N.M., 48412 and H.M.M., 82669 and 87798 yielded *x*-ray photographs identical with those of jamesonite. Material from warrenite specimen U.S.N.M., 86844 gives a powder photograph identical with that of boulangerite.

Table 1 gives the *x*-ray powder pattern of owyheeite indexed to $\theta(\text{Cu}) = 15.75°$ with reference to the pseudo-cell abc'.

Table 2 presents the two available analyses of owyheeite and the ideal composition for $Pb_5Ag_2Sb_6S_{15}$ together with the corresponding numbers of atoms in the pseudo-cell abc'. Iron and copper have been included with silver and a specific gravity of 6.25 was used in the calculations. The

[3] Using λ Cu$K\alpha = 1.5418$ Å and the mass factor 1.6602.

TABLE 1. Owyheeite: $5PbS \cdot Ag_2S \cdot 3Sb_2S_3$. *X*-RAY POWDER PATTERN

Orthorhombic, *Pnam*; $a=22.82$, $b=27.20$, $c/2=4.095$ Å; $Z=4$

I	θ(Cu)	*d*(meas.)	(*hkl*)	*d*(calc.)
½	10.6°	4.19 Å	(260)	4.215 Å
½	11.0	4.04	(011)	4.050
2	11.35	3.92	(450)	3.942
			(360)	3.898
			(170)	3.847
1	11.65	3.82	(211)	3.817
			(600)	3.803
			(540)	3.797
			(221)	3.709
2	12.05	3.69	(131)	3.682
			(270)	3.679
			(620)	3.671
1	12.45	3.57	(311)	3.575
			(460)	3.552
			(630)	3.515
7	12.75	3.49	(550)	3.501
			(321)	3.488
			(180)	3.373
4	13.2	3.37	(241)	3.352
			(331)	3.351

I	θ(Cu)	*d*(meas.)	(*hkl*)	*d*(calc.)
			(051)	3.271 Å
			(280)	3.258
10	13.7°	3.25 Å	(710)	3.241
			(151)	3.240
			(421)	3.233
			(251)	3.145
1	14.2	3.14	(431)	3.123
			(650)	3.122
			(161)	3.011
2	14.85	3.01	(351)	3.008
			(190)	3.004
			(441)	2.991
			(290)	2.921
5	15.4	2.90	(660)	2.917
			(531)	2.892
			(800)	2.852
6	15.75	2.84	(810)	2.842
			(451)	2.839

I	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)	*I*	θ(Cu)	*d*(meas.)
½	16.25°	2.75 Å	5	20.2°	2.23 Å	3	26.42°	1.732 Å
½	16.65	2.69	3	21.25	2.13	1	27.3	1.681
1	17.15	2.61	1	21.5	2.10	½	28.3	1.626
½	17.6	2.55	6	22.05	2.05	1	30.85	1.503
½	18.35	2.45	2	22.5	2.01	1	31.7	1.467
½	18.8	2.39	1	23.35	1.945	½	32.1	1.451
1	19.35	2.33	2	24.42	1.864	1	34.52	1.360
2	19.75	2.28	3	25.85	1.768			

TABLE 2. OWYHEEITE: ANALYSES AND CELL CONTENT

	1		2		A	B	
Pb	40.77	18.67	43.86	20.25	19.46	20	42.18
Ag	7.40	6.51	6.14	5.45		8	8.80
Cu	0.75	1.13	1.55	2.33	8.15 (Ag+Cu+Fe)		
Fe	0.46	0.79	0.05	0.09			
Sb	30.61	23.85	29.26	23.01	23.43	24	29.41
S	20.81	61.62	19.06	57.00	59.31	60	19.61
	100.80		99.92				100.00

1. Poorman mine, Owyhee Co., Id., Shannon (1920). 2. Sheba mine, Star City, Nev., Burton (1868). A. Average content of unit cell. B. Cell content and percentage composition for $4(5PbS \cdot Ag_2S \cdot 3Sb_2S_3)$.

average content of the pseudo-cell *abc′* is nearly $4(5PbS \cdot Ag_2S \cdot 3Sb_2S_3)$ which gives a calculated specific gravity of 6.43. The true cell *abc* contains $8(5PbS \cdot Ag_2S \cdot 3Sb_2S_3)$.

Although the name warrenite has precedence in time, having been proposed by Eakins in 1890, the material described by him was in fact jamesonite. Subsequently the name warrenite was applied erroneously to owyheeite. It seems proper, therefore, to retain the name owyheeite, which was proposed for the silver-bearing mineral, and to discard the name warrenite.

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