

*Studies of mineral sulpho-salts:*  
 II. *Jamesonite from Cornwall and Bolivia.*

(With Plates XXVI and XXVII.)

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JAMESONITE is described in Dana (1892, p. 122) as a soft, brittle, steel-grey to lead-grey mineral forming acicular orthorhombic crystals,  $a:b = '0.915:1'$  (in error for 0.8195:1), with perfect basal cleavage; composition,  $2\text{PbS}.\text{Sb}_2\text{S}_3$ ; principal occurrence, Cornwall. Jamesonite is taken as the type member of a group that includes cosalite, described in the first of these studies (1939), dufrenoyite, and other minerals of analogous composition.

Earlier and also later descriptions of jamesonite depart in various ways from this characterization. The symmetry of the needle-like crystals, previously assumed to be orthorhombic in the absence of terminal faces, was found to be monoclinic by Slavík (1914) whose material, however, was not definitely identified as jamesonite. Stevanović (1922), on the other hand, gave orthorhombic elements without measurements. More recently Hiller (1938) derived a monoclinic structural cell from powder and rotation photographs.

There is also disagreement on the question of the composition of jamesonite. The typical Cornish material with prominent cross cleavage, noted under 'Compact Grey Antimony' by Jameson (1820, p. 391) and named jamesonite by Haidinger (1825, p. 451), was analysed by H. Rose (1826) who obtained the formula  $3\text{PbS}.2\text{Sb}_2\text{S}_3$ . Subsequently Rose (1829) analysed a feather-ore from Wolfsberg in the Harz deriving the formula  $2\text{PbS}.\text{Sb}_2\text{S}_3$ ; this mineral was classed as plumosite by Haidinger (1845). Plumosite was united with jamesonite by Rammelsberg (1860) and thus jamesonite acquired the erroneous formula  $2\text{PbS}.\text{Sb}_2\text{S}_3$  generally adopted in the later texts. The original formula of jamesonite reappeared as  $3(\text{Pb},\text{Fe})\text{S}.2\text{Sb}_2\text{S}_3$ , given by Eakins (1888) to a supposed new mineral named domingite by Groth (1889) and warrenite by Eakins (1890). Spencer (1899, 1907a) exposed the foregoing confusion, emphasizing the fact that jamesonite needles are brittle owing to the cross cleavage,

while the flexible fibres of most feather-ores may belong to one or another of several other species. From analyses by Prior, on Bolivian jamesonite, Spencer (1907b) derived a new formula  $7(\text{Pb}_{\frac{1}{2}}\text{Fe}_{\frac{1}{2}})\text{S} \cdot 4\text{Sb}_2\text{S}_3$ , which recognized iron as an essential constituent. On felted fibres named plumosite, from Felsöbánya, Loczka (1908) obtained another formula,  $4\text{PbS} \cdot \text{FeS} \cdot 3\text{Sb}_2\text{S}_3$ ; Schaller (1911) showed that this formula agrees well with representative analyses of jamesonite collected by Spencer (1907b).

In addition to the above uncertainties regarding the fundamental properties of jamesonite there is the fact that jamesonite is notoriously difficult to distinguish from boulangerite in ore specimens. A study of typical jamesonite and other materials named jamesonite, by X-ray methods and observations on polished sections, thus promised to lead to a better definition and easier identification of the species.

#### *Materials and acknowledgments.*

Of the numerous specimens labelled jamesonite or resembling jamesonite which were examined in the course of the present work, a large proportion proved to be boulangerite; this was true of all the available Canadian examples. The following is a list of the remaining specimens which gave the X-ray powder pattern of jamesonite, the names on the labels being retained:

1. Jamesonite (Harvard Mineralogical Museum, 11501), Cornwall, England; columnar aggregates with cross cleavage.
2. Jamesonite (Dept. of Mineralogy, University of Toronto, A/471), Endellion, Cornwall; columnar aggregate with cross cleavage.
3. Jamesonite (Dept. Min., University of Toronto, A/1469), Cornwall; columnar aggregate with well-developed cross cleavage.
4. Jamesonite (Royal Ontario Museum of Mineralogy, M/14506), Itos mine, near San Felipe de Oruro, Bolivia; columnar aggregates with cross cleavage, and masses of fibres.
5. Heteromorphite (plumosite) (Royal Ontario Museum of Mineralogy, M/9164), Itos mine, Oruro, Bolivia; masses of fibres.
6. Jamesonite (Ahlfeld Collection, 552, Harvard Mineralogical Museum), Porvenir mine, Huanuni, Bolivia; columnar aggregates with cross cleavage.
7. Jamesonite (Royal Ontario Museum of Mineralogy, M/19680), Carmine mine, Araca, Bolivia; columnar aggregates with cross cleavage and fibres in quartz.
8. Jamesonite (British Museum of Natural History, 80934, 83057-8), Cerro de Ubina, Huanchaca, Potosi, Bolivia; single needles representing material described by Spencer (1907b) and analysed by Prior.
9. Zinckenite (Royal Ontario Museum of Mineralogy, M/19694), Santa Cruz mine, Poopo, Bolivia; needles and radiating fibres with cross cleavage in quartz.

These materials were kindly made available for study by Professor Charles Palache (Harvard University, Cambridge, Mass.), Professor A. L. Parsons (Toronto), and Mr. F. A. Bannister (British Museum,

London). Professor M. A. Peacock has variously assisted me in the course of the work and in the preparation of this paper.

*Physical properties.*

The values for the specific gravity of jamesonite, collected in Spencer (1907b), range from 5.478 to 5.719. Since good values of specific gravity are useful for identification and essential in determining cell contents, some further measurements were made on the available material, using the Berman balance. One measurement, probably the best, was made with the pyknometer. The new measurements are given below together with the previous values:—

Cornwall	5.56	Material 1	
	5.57	Material 2	
	5.58		
	5.61		
	5.56	Material 3	
	5.60		
Bolivia	5.63	Material 4 (pyknometer)	
	5.519	Spencer (1907b)	
	5.546		
Spain	5.616	Schaffgotsch (1836)	
	5.467	Genth (1879)	
Harz	5.478–5.49	(fibres)	} Zincken and Rammelsberg (1849)
	5.693–5.719	(coarse powder)	
Argentina	5.54	Stelzner (1873)	
Calculated	5.67	From X-ray data	

Considering the difficulty in obtaining a good value for the specific gravity of a fibrous mineral the above data are fairly consistent. The highest measured values for Cornwall, Bolivia, and Spain are but little short of the calculated value and are probably nearest the truth.

Polished sections of jamesonite, with vertical illumination and crossed nicols, are shown in plate xxvi. Fig. 1 shows a columnar aggregate from Cornwall; fig. 2 gives parts of two single crystals from Bolivia. Both sections show the basal cleavage, which is good rather than perfect, and also longitudinal cleavage with undetermined indices. Spencer (1907b) found no confirmation of the early noted cleavages (010) and (110). Shannon (1925), on the other hand, again noted the pinakoidal cleavage (010) and a prismatic cleavage with the angle  $62^{\circ} 51'$ ; this corresponds to the angle (120):  $(\bar{1}20) = 62^{\circ} 29'$  in our notation.

In ordinary reflected light polished sections of jamesonite are galena-white; crossed nicols reveal strong anisotropism, the polarization colours being tan, brown, light blue, dark blue. Standard etch-reactions:  $\text{HNO}_3$ ,

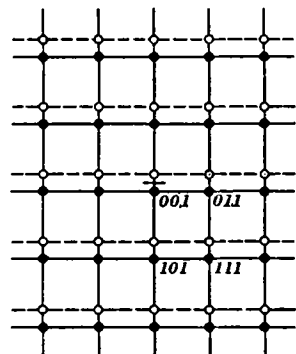
gives an iridescent stain which rubs grey and iridescent; the fumes give a brown tarnish. HCl fumes give a slight brown tarnish. KCN negative. FeCl<sub>3</sub> negative. KOH gives a faint iridescent stain which rubs off. HgCl<sub>2</sub> negative. Short (1934) gives the hardness B+ (Talmage scale).

Jamesonite may be distinguished from boulangerite by the transverse cleavage and by a microchemical test for iron, which gives a strong positive reaction with jamesonite but not with boulangerite. The reaction to KOH is also distinctive, being positive for jamesonite, negative for boulangerite.

### Structural crystallography.

The identity of the foregoing materials having been established by means of X-ray powder photographs, which gave the pattern discussed later, the structural lattice and space-group were determined from single-crystal X-ray photographs on a needle measuring  $1.5 \times 0.02-0.03$  mm. from material 4. On the reflecting goniometer the crystal gave a train of weak signals from the zone of the needle axis, taken as [001]; no terminal faces were noted. The photographs were made with unfiltered copper radiation using an equi-inclination Weissenberg X-ray goniometer with radius  $360/4\pi$  mm.

TEXT-FIG. 1. Jamesonite. Reciprocal lattice projection of the layer ( $hk1$ ) showing twinning on (100).



Using both the  $\alpha$  and the  $\beta$  lines from two photographs the period in the needle axis,  $c = 4.03 \pm 0.01$  Å., was obtained.

The Weissenberg photograph of the zero layer ( $hk0$ ) (pl. xxvii, fig. 2) showed orthorhombic symmetry, indicating an orthorhombic or a monoclinic lattice, with eighteen orders of ( $h00$ ) and twenty orders of ( $0k0$ ), including the orders extinguished by the space-group symmetry and the structure. These diffractions gave the spacings  $d_{100} = 15.67 \pm 0.05$  Å.,  $d_{010} = 19.01 \pm 0.05$  Å.

The Weissenberg photograph of the first layer ( $hk1$ ) (pl. xxvii, fig. 3) was found on projection (text-fig. 1) to represent a monoclinic lattice

with  $\beta = 91^\circ 48' \pm 30'$ , twinned by reflection in (100). The lattice elements are thus:

$$a = 15.68 \pm 0.05, b = 19.01 \pm 0.05, c = 4.03 \pm 0.01 \text{ \AA.};$$

$$\beta = 91^\circ 48' \pm 30'.$$

The systematically missing spectra conform to the conditions ( $h0l$ ) present only with  $h$  even, ( $0k0$ ) present only with  $k$  even, which are characteristic for only one space-group,  $C_{2h}^5 = P2_1/a$ .

### *Geometrical crystallography.*

On terminated needles doubtfully identified as jamesonite, from Kasejovic, west Bohemia, Slavík (1914) derived the monoclinic elements:

$$a : b : c = 0.8316 : 1 : 0.4260; \beta = 91^\circ 24\frac{1}{2}'$$

and a series of sixteen well-established forms, eleven of which are represented by terminal planes. Slavík's elements are related to the structural elements by the transformations:

$$\text{Slavík to Berry: } (100)/(010)/(00\frac{1}{2})$$

$$\text{Berry to Slavík: } (100)/(010)/(002).$$

Slavík's notation is thus transformed to the structural notation by simply halving his  $c$ -axis, giving the comparison:

$$a : b : c = 0.8316 : 1 : 0.2130; \beta = 91^\circ 24\frac{1}{2}' \text{ (Slavík, goniometric)}$$

$$0.8247 : 1 : 0.2120; \beta = 91^\circ 48' \text{ (Berry, X-ray).}$$

The consequent halving of the  $l$ -indices in Slavík's form symbols leads to a systematic simplification.

To support his choice of elements Slavík gives a table<sup>1</sup> of 36 measured and calculated interfacial angles. These have been re-computed with reference to the structural elements. The new calculated angles are on the whole closer to the measured angles than Slavík's calculated angles, showing that the structural elements represent the measured crystals even more closely than the geometrical elements. An abbreviated table, omitting the angles observed only once by Slavík, illustrates this point; in this table the structural notation is adopted. The new calculated prism angle,  $m(110) : m'(1\bar{1}0) = 79^\circ 00'$ , is close to Haidinger's angle,  $mm' = 78^\circ 40'$  (Cornwall), and practically identical with Spencer's angle,  $mm' = 79^\circ 01'$  (Bolivia, 23 measurements).

<sup>1</sup> In this table there are some discrepancies. Slavík gives  $ed = 35^\circ 17'$  as a fundamental angle, and later  $ed = 35^\circ 08'$  (meas.),  $35^\circ 04'$  (calc.). Also, for  $ma = 29^\circ 57'$  (meas.),  $29^\circ 44\frac{1}{2}'$  (calc.), read  $39^\circ 57'$  (meas.),  $39^\circ 44\frac{1}{2}'$  (calc.), as already noted by Niggli (1924, p. 508).

TABLE I. Jamesonite: measured and calculated interfacial angles.

	Slavík (meas.)	Slavík (calc.)	Berry (calc.)
$e(021) : e'(\bar{0}\bar{2}1)$	*46°08'	—	45°56'
$: d(\bar{2}01)$	*35 17	—	35 18
$d(20\bar{1}) : m(110)$	*70 28	—	70 23½
$c(001) : m(110)$	88 36	88°55½'	88 37
$m(110) : m'(\bar{1}\bar{1}0)$	79 07	79 28½	79 00
$: b(010)$	50 25	50 15½	50 30
$: l(210)$	16 44	16 10	17 06
$: n(120)$	19 18	19 15½	19 15½
$: e(021)$	74 04	74 15	74 18½
$e(021) : f(011)$	11 05	11 02½	11 00
$: b(010)$	67 01	66 56	67 02
$: d(\bar{2}01)$	35 08	35 04	35 18
$: s(\bar{2}31)$	25 29	25 09½	25 36
$d(\bar{2}01) : b(010)$	90 11	90 00	90 00
$: o(\bar{2}21)$	20 51	20 47½	20 54
$: q(\bar{2}11)$	10 56	10 45	10 48½
$: s(\bar{2}31)$	29 47	29 40½	29 48

The identity of Slavík's crystals is thus placed beyond question, and we can give a formal angle-table for the established forms of the species (table II). In this table the angles have the significance given in Palache (1934, fig. 1), our  $\phi_2 \rho_2$  being equivalent to Palache's  $\phi'' \rho''$ .

TABLE II. Jamesonite: angle-table. Monoclinic; prismatic— $2/m$ .

$$a : b : c = 0.8247 : 1 : 0.2120; \beta = 91^\circ 48'$$

$$p_0 : q_0 : r_0 = 1.2131 : 1 : 4.719; \mu = 88^\circ 12'$$

$$p'_0 = 0.2572, q'_0 = 0.2120, x'_0 = 0.0314.$$

Forms.	$\phi$ .	$\rho$ .	$\phi_2$ .	$\rho_2 = B$ .	C.	A.
$c(001)$	90°00'	1°48'	88°12'	90°00'	0°00'	88°12'
$b(010)$	0 00	90 00	0 00	0 00	90 00	90 00
$a(100)$	90 00	90 00	0 00	90 00	88 12	0 00
$n(120)$	31 14½	90 00	0 00	31 14½	89 04	58 45½
$m(110)$	50 30	90 00	0 00	50 30	88 37	39 30
$l(210)$	67 36	90 00	0 00	67 36	88 20	22 24
$f(011)$	8 25½	12 06	88 12	78 02	11 57½	88 14½
$e(021)$	4 14	23 02	88 12	67 02	22 58	88 23
$d(\bar{2}01)$	-90 00	25 47	115 47	90 00	27 14	115 47
$t(111)$	53 42	19 42	73 54	78 29	18 17	74 14
$r(\bar{1}\bar{1}\bar{1})$	-46 48½	17 12½	102 43½	78 19	18 33½	102 27½
$v(\bar{1}\bar{3}\bar{1})$	-19 33	34 01	102 43½	58 11	34 39	100 47
$z(\bar{3}\bar{5}\bar{2})$	-33 46	32 31	109 31	63 27½	33 33	107 23
$q(\bar{2}11)$	-66 18	27 48½	115 47	79 11½	29 28	115 17½
$o(\bar{2}21)$	-48 43½	32 43½	115 47	69 06	34 06	113 58½
$s(\bar{2}31)$	-37 13	38 36½	115 47	60 12	39 43½	112 10½

Uncertain:  $g(031)$ .

*Powder photographs.*

In view of the usefulness of X-ray powder photographs for the purpose of identification, several of the powder photographs of jamesonite are reproduced on plate xxvii, figs. 4-6. The photographs were made with copper radiation (nickel filter), in a camera with radius  $360/4\pi$  mm. Table III gives for each powder ring the glancing angle corrected for thickness of sample ( $\theta_{Cu}$ ), the estimated intensity ( $I_P$ ), the corresponding planar spacing ( $d_{meas.}$ ), the most probable indices ( $hkl$ ), the planar spacings corresponding to these indices ( $d_{calc.}$ ), and the intensity of the corresponding spot if it lay in the range of the Weissenberg photographs ( $I_W$ ). With large cell dimensions the indexing of a powder photograph becomes increasingly uncertain as the spacings diminish. However, the tabulation serves its main purpose in showing that most of the powder rings near the middle of the photograph correspond to strong observed single crystal diffractions.

Hiller (1938) took powder photographs with iron radiation on jamesonite from fourteen localities, including Cornwall. Using these photographs and the period  $b = 2 \times 4.27 \text{ \AA.}$ , obtained from a rotation about the needle axis, in combination with Slavik's axial angle  $\beta$ , Hiller obtained a cell with  $a = 16.16$ ,  $b = 8.60$ ,  $c = 13.75 \text{ \AA.}$ , containing  $8[\text{Pb}_2\text{Sb}_2\text{S}_5]$ . Since these data bear no resemblance to ours, except that Hiller's  $b$  is about double our  $c$ , it was of interest to see whether Hiller's powder data corresponded with ours. The last two columns in table III give Hiller's glancing angles computed for copper radiation ( $\theta_{Cu}$ ), and the recorded intensities ( $I_{P(Fe)}$ ). The far-reaching agreement shows that Hiller was indeed working with jamesonite. But in attempting to find the dimensions of a large monoclinic cell mainly from powder photographs Hiller stretched the powder method far beyond its inherent limitations.

TABLE III. Jamesonite: X-ray powder spectrum.

						Hiller	
$\theta_{Cu}$	$I_P$	$d_{meas.}$	$(hkl)$	$d_{calc.}$	$I_W$	$\theta_{Cu}$	$I_{P(Fe)}$
11.0	s	4.03	(400)	3.92	vvs	10.9	vw
11.8	s	3.76	(021)	3.71	vs	11.8	vw
13.0	vvs	3.42	(250)	3.42	vvs	12.9	vs
13.9	vw	3.20	(060)	3.17	m	—	—
			(510)	3.09	vvs		
14.3	s	3.11	(231)	3.09	vvs	14.3	m
			(350)	3.07	vvs		
15.1	w	2.95	(260)	2.92	vs	14.9	vw

TABLE III (continued).

$\theta_{Cu}$	$I_P$	$d_{meas.}$	$(hkl)$	$d_{calc.}$	$I_w$	Hiller	
						$\theta_{Cu}$	$I_{P(Fe)}$
15.9	s	2.81	(331)	2.81	vs	15.8	s
16.4	vs	2.72	(411)	2.74	vvs	16.4	s
			(360)	2.71	vvs		
			(261)	2.39	s		
18.9	vw	2.37	(080)	2.38	s	—	—
			(521)	2.36	s		
			(261)	2.36	s		
19.4	s	2.31	(640)	2.29	vvs	19.5	s
20.0	s	2.25	(560)	2.23	s	20.1	s
			(470)	2.23	s		
			(171)	2.22	vs		
20.7	vvw	2.17	(380)	2.16	m	20.9	vvw
			(271)	2.15	vs		
—	—	—	—	—	—	21.5	vw
22.0	vs	2.05	(371)	2.05	s	22.0	vs
			(081)	2.05	vvs		
22.1	vs	2.04	(181)	2.03	vs	22.4	vs
			(740)	2.02	vvs		
			(641)	1.986	vs		
23.0	vw	1.967	(471)	1.967	vs	—	—
			(800)	1.959	vs		
			(0.10.0)	1.901	vvs		
23.8	m	1.905	(0.10.0)	1.901	vvs	23.9	m
24.1	w	1.882	(651)	1.878	s	24.3	vvw
24.9	s	1.826	(760)	1.828	vvs	24.9	s
25.9	vvw	1.760	(412)	1.761	—	26.0	vvw
26.6	m	1.717	(871)	1.720	s	26.6	m
			(920)	1.713	s		
28.4	vvw	1.616	(591)	1.617	m	28.7	vvw
29.1	vvw	1.581	(0.12.0)	1.584	m	—	—
			(1.12.0)	1.576	m		
30.2	m	1.528	(552)	1.529	—	30.5	m
—	—	—	—	—	—	31.6	vvw
31.9	vw	1.455	(2.12.1)	1.452	vs	32.0	m
—	—	—	—	—	—	32.3	vvw
32.9	vw	1.415	—	—	—	33.0	m
—	—	—	—	—	—	33.8	vvw
34.4	m	1.361	—	—	—	34.4	vvw
34.8	vw	1.347	—	—	—	35.1	vvw
—	—	—	—	—	—	36.1	vvw
36.8	w	1.283	—	—	—	36.9	m
—	—	—	—	—	—	37.4	vvw
—	—	—	—	—	—	37.8	m
—	—	—	—	—	—	38.7	m
39.5	m	1.208	—	—	—	39.4	s
41.1	m	1.169	—	—	—	41.3	s

*Composition and cell content.*

The analyses best suited for a determination of the cell content of jamesonite are the two made by Prior on selected Bolivian material



described by Spencer (1907b). Table IV gives these analyses with the corresponding cell contents obtained in the usual manner, by means of the cell volume and the measured specific gravities. An alternative cell content for Prior's second analysis is given using the slightly higher specific gravity (5.63) obtained by the writer on Bolivian material.

TABLE IV. Jamesonite: composition and cell content.

	I.		II.			III.	
	Anal.	Atoms.	Anal.	Atoms.	Atoms.	Comp.	Atoms.
Pb ...	41.18	8.04	40.08	7.87	7.99	40.32	8
Fe ...	2.76	2.00	2.79	2.03	2.06	2.72	2
Cu ...	0.26	0.16	0.22	0.14	0.14	—	—
Ag ...	0.01	—	0.13	0.05	0.05	—	—
Sb ...	34.53	11.48	34.70	11.59	11.75	35.10	12
S ...	20.52	25.92	21.37	27.11	27.52	21.86	28
	<u>99.26</u>		<u>99.29</u>			<u>100.00</u>	
Sp. gr.		5.519		5.546	5.63		5.67 (calc.)

I and II, Cerro de Ubina, Bolivia; anal. Prior, in Spencer (1907b, p. 311). In analysis I 'there may possibly have been a slight loss of sulphur'.

III. Ideal composition and cell content.

Since there are only two-fold and four-fold positions in the space-group  $C_{2h}^5$  found for jamesonite, and the sulphur value in analysis I may be low, the cell content  $Pb_8Fe_2Sb_{12}S_{28} = 2[4PbS.FeS.3Sb_2S_3]$  is rather clearly indicated.

A wider view of the composition of jamesonite is gained by reducing the available analyses to atomic proportions with reference to 28 atoms of sulphur indicated for the cell content, as shown in table V. In selecting analyses for this table, analyses almost certainly representing boulangerite<sup>1</sup> were neglected. Only those analyses marked with an asterisk were accepted as certainly jamesonite analyses by Spencer (1907b).

The average number of Pb atoms is 8.0 which in turn confirms the number of sulphur atoms as 28; Fe and Sb fall close to 2 and 12 respectively, and thus the composition  $4PbS.FeS.3Sb_2S_3$  is confirmed. This is the composition found by Loczka (1908) and, independently, by Schaller (1911).

<sup>1</sup> As indicated by the much higher lead content of boulangerite and, in some cases, by X-ray powder photographs on materials from the localities in question.

TABLE V. Jamesonite: analyses reduced to 28 atoms of sulphur.

	1*.	2*.	3*.	4*.	5*.	6*.	7*.	8.	9.
Pb ...	8.0	7.6	7.6	7.9	8.1	8.9	7.8	8.1	8.1
Fe ...	1.7	1.9	2.1	2.7	—	2.2	1.5	2.1	2.5
Cu ...	0.1	0.1	0.1	—	—	0.7	2.2	—	—
Zn ...	—	—	—	0.3	0.2	1.2	0.4	—	—
Ag ...	—	—	—	—	—	—	0.5	—	—
Sb ...	11.4	11.4	10.7	11.0	11.3	11.3	10.8	12.2	11.6
Bi ...	—	—	—	0.2	—	—	—	—	—
As ...	—	—	—	—	—	—	0.1	—	0.2
S ...	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0

	10.	11.	12.	13.	14*.	15*.	16.	17.	Average.
Pb ...	7.8	7.5	7.5	8.2	8.7	8.1	7.9	8.2	8.0
Fe ...	(4.9)	(3.7)	1.8	2.7	2.2	2.1	2.0	2.8	2.1
Mn ...	—	—	—	—	—	—	0.1	—	—
Cu ...	—	—	trace	0.2	0.2	0.1	trace	—	—
Zn ...	—	—	—	—	—	—	0.1	—	—
Ag ...	—	—	0.1	trace	trace	trace	—	—	—
Sb ...	11.2	11.2	11.7	11.9	12.4	12.0	12.2	11.3	11.5
S ...	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0

1, 2, 3, Cornwall; anal. Rose (1826, 1829). 4, 5, Spain; anal. Schaffgotsch (1836). 6, Harz; anal. Rammelsberg, in Zincken and Rammelsberg (1849, p. 242). 7, Argentina; anal. Siewert, in Stelzner (1873, p. 248). 8, Arkansas; anal. Dunnington (1877) (less ZnS). 9, Tirol; anal. Sarlay, in Pichler (1877). 10, Bolivia; anal. Kiepenheuer, in vom Rath (1879). 11, Spain; anal. Genth (1879) (less pyrite). 12, Arkansas; anal. Wait (1879). 13, Italy; anal. Lotti, in Novarese (1902). 14, 15, Bolivia; anal. Prior, in Spencer (1907b). 16, Felsőbánya; anal. Loczka (1908). 17, Idaho; anal. Shannon (1925).

### Summary.

Jamesonite from Cornwall (type locality) and several localities in Bolivia gives identical X-ray powder photographs. Rotation and equi-inclination Weissenberg photographs on a needle from the Itos mine, near San Felipe de Oruro, Bolivia, give monoclinic symmetry. Space-group,  $C_{2v}^5 = P2_1/a$ . Cell edges,  $a$   $15.68 \pm 0.05$ ,  $b$   $19.01 \pm 0.05$ ,  $c$  (needle axis)  $4.03 \pm 0.01$  Å.;  $\beta$   $91^\circ 48' \pm 30'$ . Twin-plane (100). Cell content,  $Pb_8Fe_2Sb_{12}S_{28} = 2[4PbS.FeS.3Sb_2S_3]$ . Sp. gr. 5.63 (highest of 7 measurements on different samples), 5.67 (calculated). Polished sections are white, strongly anisotropic; they show good basal and longitudinal cleavage. The powder pattern agrees with that obtained by Hiller (1938) on jamesonite from fourteen localities. Jamesonite may be distinguished from boulangerite by a microchemical test for iron, which gives a strong positive reaction with jamesonite, and by a positive etch-test with KOH on polished sections.

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## DESCRIPTION OF PLATES XXVI AND XXVII.

PLATE XXVI. Jamesonite. Polished sections with vertical illumination and crossed nicols.

FIG. 1. Cornwall (material 3), showing the needle-like to columnar habit and the transverse (basal) and longitudinal cleavages. The anisotropism is also clearly shown.  $\times 92$ .

FIG. 2. Bolivia (material 4), parts of two crystals showing the basal and longitudinal cleavages.  $\times 33$ .

PLATE XXVII. Jamesonite. X-ray photographs with copper radiation, radius of camera  $360/4\pi$  mm. (1 mm. = 1 degree  $\theta$ ).

FIG. 1. Rotation about the needle-axis  $c$  [001]. 3.9 KWH. (unfiltered).

FIG. 2. Weissenberg photograph of the zero layer-line ( $hk0$ ). 21.2 KWH. (unfiltered).

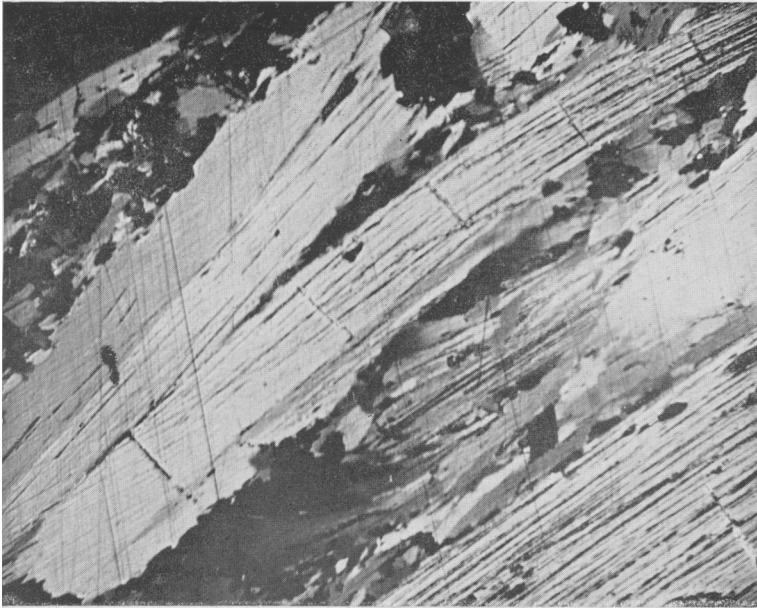
FIG. 3. Weissenberg photograph of the first layer-line ( $hk1$ ), showing the duplication of  $\alpha$  spots due to twinning. 25.9 KWH. (unfiltered).

FIG. 4. Cornwall (material 2). Powder photograph. 5.0 KWH. (nickel filter).

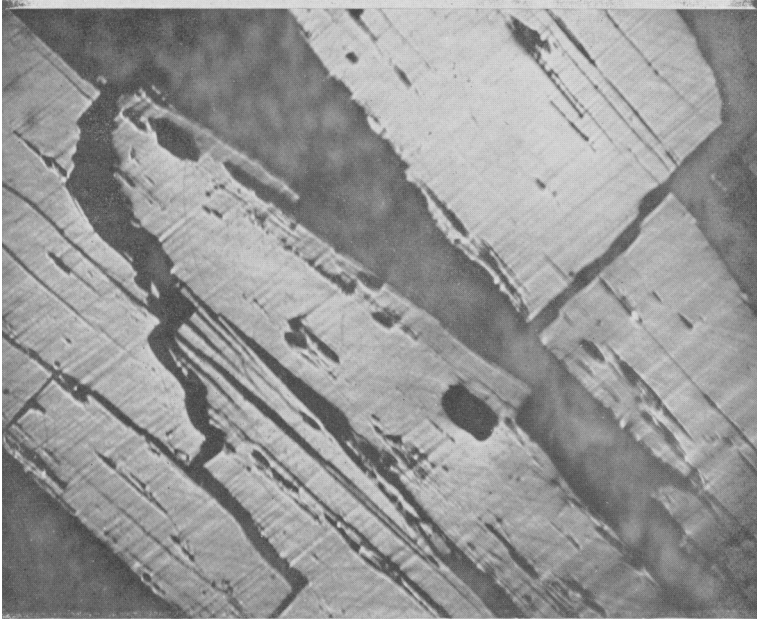
FIG. 5. Bolivia (material 4, needles). Powder photograph. 7.9 KWH. (nickel filter).

FIG. 6. Bolivia (material 5, hair-like fibres). Powder photograph. 8.9 KWH. (nickel filter).

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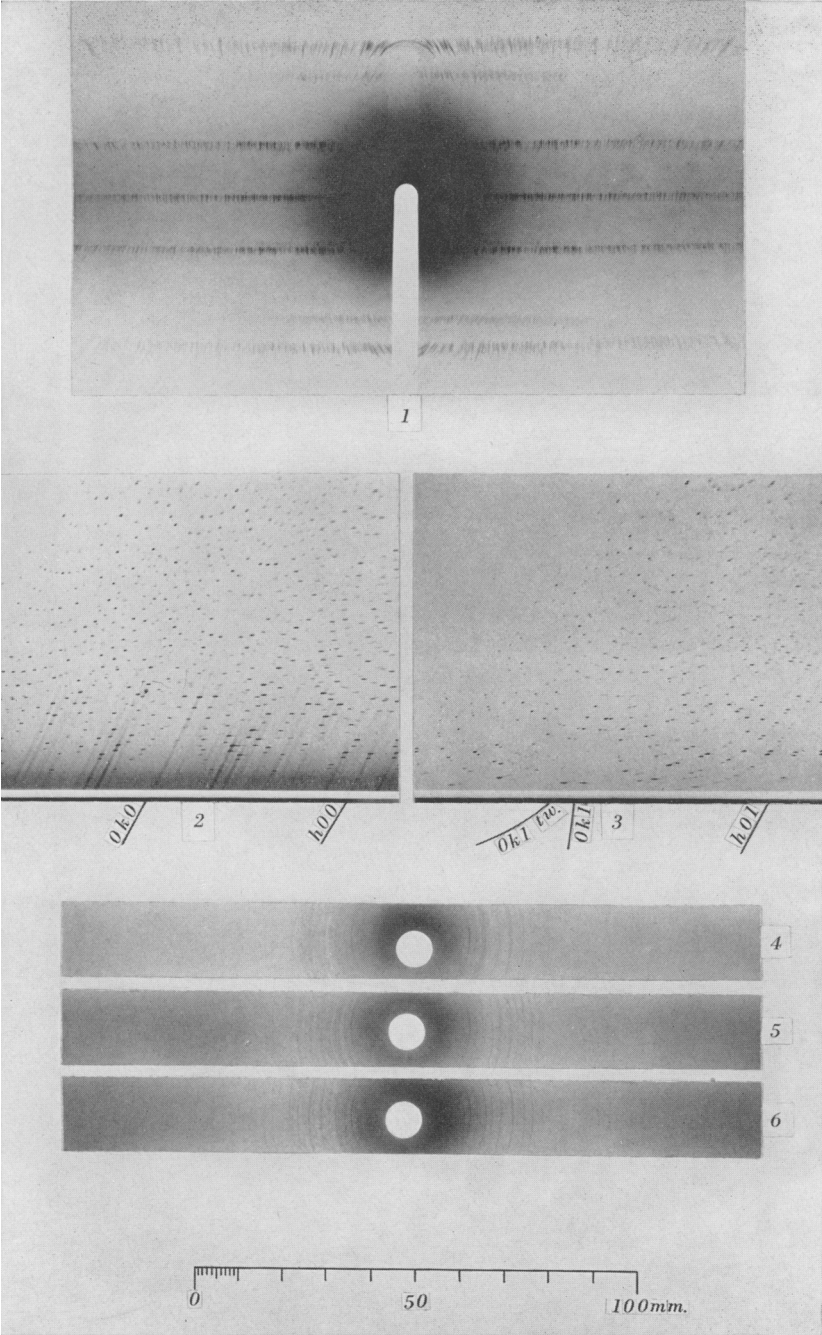


1



2

L. G. BERRY: POLISHED SECTIONS OF JAMESONITE.



L. G. BERRY : X-RAY PHOTOGRAPHS OF JAMESONITE.