CRYSTALLOGRAPHY OF VALENTINITE (Sb_2O_3) AND ANDORITE(?) ($2PbS \cdot Ag_2S \cdot 3Sb_2S_3$) FROM OREGON*

WALDEMAR T. SCHALLER, *U. S. Geological Survey, Washington, D. C.*

CONTENTS

INTRODUCTION

A set of ore specimens from the Ochoco mining district, Oregon, submitted for mineralogical study by G. F. Loughlin of the U. S. Geological Survey, showed a number of unusual minerals. Their occurrence is mentioned in a recent report by Gilluly, Reed, and Park (1933). The locality is Gold Hill (Howard district), Ochoco Creek area, northeastern part of Crook County, central Oregon. The matrix of the specimens submitted was largely carbonate; calcite, manganian dolomite with ω index $=1.690$–1.693, and calcian rhodochrosite with $\omega=1.783$.

One specimen contained a few hair-like metallic crystals, which break when bent, probably due to a basal cleavage. They are provisionally assigned to jamesonite and the following measurements were obtained on one of the thicker hair-like crystals.

TABLE 1. MEASUREMENTS OF JAMESONITE

Measured	Jamesonite
$(110):(\bar{1}10)=101°51'$	101°21′
$(1\bar{1}0):(\bar{1}\bar{1}0)=$ 98 33	101 22
$(110):(120)=$ 19 26	19 17
$(110):(001)$ cleavage$=90°$–$92°$	90 00

A few of the hair-like crystals, however, were very flexible and could easily be bent double, showing the presence of a second hair-like mineral with no basal cleavage. The material seems to correspond to the mixture of "feather ore" previously called warrenite, which, however, is a mixture of jamesonite and zinckenite, as previously described by Schaller (1911).

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A single prismatic crystal of another mineral, provisionally referred to andorite and described in the following paper, was found on one specimen. Other minerals present are: aragonite, pyrite, tetrahedrite, and two other metallic minerals, one lead-gray and another prismatic dark reddish-black, which could not be identified on account of the paucity of material.

Apparently this locality might yield several of the rarer silver sulphosalts and anyone having access to the locality should make a careful search for well crystallized minerals of this character.

A number of small non-metallic crystals in one of the cavities of a specimen proved to be valentinite, antimony oxide, Sb_2O_3, and their goniometric measurements showed a large number of crystal forms, many of them new. They are described on the following pages.

VALENTINITE

The optical properties and chemical reactions of these crystals are typically those of valentinite. The optical axial planes for red and blue light are normal to each other and the negative axial angle is small, with strong dispersion. The doubly terminated crystals are small, about a millimeter in length, and have no attraction as specimens. They would probably pass unnoticed unless one was making a detailed examination of the mineralogy of the material.

Axial Ratio

The a-axis is calculated from the average measured ϕ angles of the prisms of the seven measured crystals. The measurements for $B\{340\}$ and $C\{450\}$ are omitted as they show much greater divergence from the calculated angles than do those of the other prisms. Likewise, those prisms whose ϕ angle is very large (greater than 81°) are also omitted as they are too close to $\{100\}$ to yield ratios of comparative value. The c-axis is calculated from the average measurements of the ρ angle of the new side dome $T\{0.11.8\}$. The axial ratio so obtained is $a:b:c=0.3930:1:0.4350$.

This ratio is close to those recently given by other authors, as follows:

	$a:b:c$
Spencer (1907):	0.3938:1:0.4344
Ungemach[1] (1912):	0.3928:1:0.4333
Cesàro (1925):	0.3952:1:0.4342
Schaller:	0.3930:1:0.4350

[1] Ungemach gave the axial ratio as 0.3936:1:0.4339. According to a personal communication from Prof. Palache (June 9, 1936), Cesàro, in a note, calls attention to an error in these values. The correct ratio is: 0.3928:1:0.4333.

The average of these four values gives the axial ratio of valentinite as $a:b:c=0.3939:1:0.4339$.

Forms and Angles

A total of 22 forms were found on the 7 crystals measured. These include the two pinacoids $a\{100\}$ and $b\{010\}$, nineteen prisms of which 15 are new for valentinite, and the new side dome $T\{0.11.8\}$.

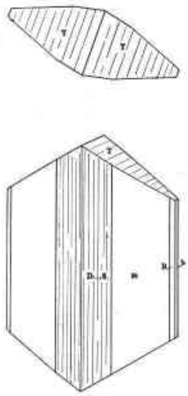

Fig. 1. Idealized drawing of valentinite from the Ochoco district, Crook County, Oregon. The crystal is about a millimeter high. Forms: $b\{010\}$, $m\{110\}$, $T\{0.11.8\}$. The narrow striated face B adjoining $b\{010\}$, shows the position of $A\{350\}$, $B\{340\}$, and $C\{450\}$. The broad striated area in front includes the prisms from $D\{10.9.0\}$ to $S\{910\}$.

The general habit and distribution of forms on these crystals are shown in Figure 1. The dominant forms are $m\{110\}$ and the new side dome $T\{0.11.8\}$ which is the only terminal form present. The prisms other than $m\{110\}$ are all line faces. The side pinacoid $b\{010\}$ is generally narrow but wider than a line face whereas $a\{100\}$ is a line face. The faces of m are vertically striated and those of $T\{0.11.8\}$ are horizontally striated parallel to their intersection. The reflections from the unit prisms were good; all the others were poor.

TABLE 2. VALENTINITE: FORMS AND ANGLES
New forms are starred

Form	No. crystals	No. faces	Average measured ϕ angle	Calculated ϕ angle	Difference
b\{010\}	7	10	0°09′	0°00′	0°09′
a\{100\}	2	2	89 42	90 00	18
*A\{350\}	3	3	56 48	56 43	05
*B\{340\}	2	2	62 44	62 18	26
*C\{450\}	3	3	64 07	63 47	20
m\{110\}	7	28	68 39	68 30	09
*D\{10.9.0\}	5	8	70 36	70 29	07
*E\{760\}	4	7	71 26	71 21	05
σ\{540\}	5	7	72 33	72 31	02
*F\{430\}	5	9	73 35	73 33	02
*G\{10.7.0\}	4	6	74 32	74 35	03
*H\{14.9.0\}	6	8	75 48	75 48	00
*J\{530\}	4	5	76 45	76 42	03
*K\{950\}	4	5	77 48	77 40	08
*μ\{210\}	4	6	78 54	78 52	02
*L\{730\}	3	4	80 24	80 25	01
*M\{830\}	3	3	81 41	81 36	05
*π\{310\}	3	4	82 42	82 31	11
*N\{410\}	3	4	84 22	84 23	01
*P\{510\}	3	3	85 47	85 30	17
*S\{910\}	3	3	87 35	87 30	05
*T\{0.11.8\}	7	7	30 53[a]	30 49[a]	04

[a] The ρ angle.

TABLE 3. VALENTINITE: MEASUREMENTS OF ϕ ANGLE OF m\{110\}

Crystal no.	Limits	Average of fair and good reflections
1	68°08′–68°25′	68°23′
2	68 32 –68 41	68 36
3	68 43 –69 03	68 46
4	68 38 –69 30	68 55
5	68 26 –68 46	68 37
6	68 34 –68 46	68 40
7	68 01 –68 38	68 37

Average = 68°39′

TABLE 4. VALENTINITE: MEASUREMENTS OF ϕ ANGLE OF OTHER PRISMS

	A{350}	*B*{340}	*C*{450}	*D*{10.9.0}	*E*{760}
Calculated	56°43′	62°18′	63°47′	70°29′	71°21′
Average of measurements	56 48	62 44	64 07	70 36	71 26
Individual measurements	2— 56 13	5— 62 45	1— 63 45	3— 70 37	3— 71 36
	4— 57 31	6— 62 37	6— 64 18	3— 70 47	4— 71 25
	5— 56 39		7— 64 18	4— 70 34	4— 71 35
				5— 70 49	5— 71 46
				6— 70 15	5— 71 25
				6— 70 51	5— 71 03
				7— 70 47	6— 71 15
				7— 70 11	
	σ{540}	*F*{430}	*G*{10.7.0}	*H*{14.9.0}	*J*{530}
Calculated	72°31′	73°33′	74°35′	75°48′	76 42′
Average of measurements	72 33	73 35	74 32	75 48	76 45
Individual measurements	2— 72 27	1— 73 29	2— 74 25	1— 76 09	2— 76 21
	2— 72 30	2— 73 50	2— 74 45	2— 75 28	2— 76 51
	3— 72 30	2— 73 37	2— 74 23	2— 75 36	3— 76 39
	3— 72 20	2— 73 51	3— 74 42	4— 75 51	5— 77 17
		3— 73 26		5— 75 59	
	4— 72 57		5— 74 27		6— 76 35
		3— 73 26		6— 75 48	
		5— 73 23			
	6— 72 18		6— 74 31	6— 76 10	
		5— 73 26			
	7— 72 52	6— 73 51		7— 75 20	
	K{950}	μ{210}	*L*{730}	*M*{830}	π{310}
Calculated	77°40′	78°52′	80°25′	81°36′	82°31′
Average of measurements	77 48	78 54	80 24	81 41	82 42
Individual measurements	1— 77 42	2— 78 36	3— 80 06	1— 81 36	1— 82 29
	3— 77 44	2— 78 53	4— 80 42	2— 81 49	4— 82 07
	5— 77 25	3— 79 04	4— 80 42	4— 81 39	6— 82 55
	5— 77 59	4— 79 10	5— 80 07		6— 83 17
	6— 78 11	5— 78 24			
		5— 79 18			

	N{410}	P{510}	S{910}		
Calculated	84°23′	85°30′	87°30′		
Average of measurements	84 22	85 47	87 35		
Individual measurements	3— 83 54 4— 84 52 5— 84 19 5— 84 23	2— 85 59 4— 85 58 5— 85 24	4— 87 39 5— 87 24 7— 87 43		

Table 5. Valentinite: Measurements of T{0.11.8}

Crystal no.	Measured		Difference from calculated ρ angle	
	φ	ρ	{0.11.8}	{043}
1	0°56′	31°48′	0°59′	1°45′
2	—	32	—	—
2	—	31	—	—
3	0 42	30 42	07	39
3	0 11	30 53	04	50
4	0 34	31 12	23	1 09
4	0 34	31 09	20	1 06
5	0 52	31 01	12	58
5	0 23	30 23	26	20
6	0 10	30 51	02	48
6	0 10	30 52	03	49
7	0 39	30 15	34	12
7	0 39	30 36	13	33

Average (omitting crystal no. 2) = 30°53′.
Calculated = 30 49 .

The indices {0.11.8} seem to be the simplest which can be given to this new side dome. The calculated ρ angles for other indices, close to {0.11.8}, are as follows:

ρ
{065} = 27°30′
{043} = 30 03
{0.11.8} = 30 49
{075} = 31 17
{032} = 33 04
Average of measured angles = 30°53′

The closest calculated angle for a simple form is that for {043} a form not listed for valentinite, but not a single one of the 13 measurements is as low as 30°03′ though two measurements approach this value. As the last column in the preceding table shows, the differences between the measured angles and 30°03′ are considerable. The differences between the average measured angle for T and the nearest known forms, {065} and {032}, are also considerable.

Difference from {065} = 3°23′
Difference from {032} = 2 11

A discussion of the side dome series of forms from (001) to (010) does not help in deciding the correct indices for T. Taking the zone segment from (011) to (021), in the middle of which T lies, and reducing it to the general type $0 \cdots \infty$, T becomes $\frac{3}{7}$ instead of the normal $\frac{1}{2}$. The form {043} would yield $\frac{1}{2}$ but as just shown the measurements do not agree with these indices.

	i	—	Q	T	g	f	X
	011	098	065	0.11.8	032	053	021
	1	$\frac{9}{8}$	$\frac{6}{5}$	$\frac{11}{8}$	$\frac{3}{2}$	$\frac{5}{3}$	2
$\frac{v-v_1}{v_2-v}=$	0	$\frac{1}{7}$	$\frac{1}{4}$	$\frac{3}{7}$	1	2	∞
$N_2=$	0	$\left(\frac{1}{7}\right)$	$\left(\frac{1}{4}\right)$	$\left[\frac{3}{7}\right]$	1	2	∞

Discussion of Prism Zone

The following discussion of the prism zone follows the well known method of Goldschmidt's comparison with normal series. It not only served to confirm the correctness of the indices of many of the new prisms but it has been of greatest value in deciding the correct indices of three of the new prisms with more complex indices.

The poor reflections obtained from most of these new prisms with a consequent considerable variation in the measured angles do not suffice, alone, to correctly determine the indices.

Including the two pinacoids b{010} and a{100} there are now 26 forms in this zone, including the two given by Cesàro (1925). This zone consists naturally of two sections extending from b{010} to m{110} and from m{110} to a{100}. In the first section from b to m, the ϕ angles of the forms differ from adjacent ones by many degrees except for the two forms B{340} and C{450}, where the difference is only 1°29′. But for the second section from m to a, the forms are closely crowded together and are about one degree apart.

The first section is:

	b	ρ	x	n	A	B	C	m
	010	160	130	120	350	340	450	110
$\frac{h}{k}=$	0	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{3}{4}$	$\frac{4}{5}$	1
$\frac{v}{1-v}=$	0	$\frac{1}{5}$	$\frac{1}{2}$	1	$\frac{3}{2}$	3	4	∞
$N_3=$	0	$\left(\frac{1}{5}\right)$ ·	$\frac{1}{2}$ ·	1	$\frac{3}{2}$ ·	3	(4)	∞

The two forms $\rho\{160\}$ and $C\{450\}$ are extra. Splitting the zone at $n\{120\}$:

	0	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$
$2v=$	0	$\frac{1}{3}$	$\frac{2}{3}$	1
$\frac{v}{1-v}=$	0	$\frac{1}{2}$	2	∞
$N_2=$	0	$\frac{1}{2}$ ·	2	∞

R

	$\frac{1}{2}$	$\frac{3}{5}$	$\frac{3}{4}$	$\frac{4}{5}$	1
$\frac{v-v_1}{v_2-v}=$	0	$\frac{1}{4}$	1	$\frac{3}{2}$	∞
$2v=$	0	$\frac{1}{2}$	2	3	∞
$N_3=$	0 ·	$\frac{1}{2}$ ·	2	3	∞

All the forms in this section can be transferred to parts of the normal series.

The second section, from $m\{110\}$ to $a\{100\}$ is a long one with 19 forms and runs continuously with no well defined break. The form with the simplest indices, except for the two end members $m\{110\}$ and $a\{100\}$ is $\mu\{210\}$ which moreover lies in the middle of the zone. This zone is therefore split into two sections at $\mu\{210\}$, which are considered separately.

The first section from m to μ gives:

	m	D	E	σ	F	G	H	J	K	μ
	110	10.9.0	760	540	430	10.7.0	14.9.0	530	950	210
$\frac{h}{k}=$	1	$\frac{10}{9}$	$\frac{7}{6}$	$\frac{5}{4}$	$\frac{4}{3}$	$\frac{10}{7}$	$\frac{14}{9}$	$\frac{5}{3}$	$\frac{9}{5}$	2
$v-1=$	0	$\frac{1}{9}$	$\frac{1}{6}$	$\frac{1}{4}$	$\frac{1}{3}$	$\frac{3}{7}$	$\frac{5}{9}$	$\frac{2}{3}$	$\frac{4}{5}$	1
$\frac{v}{1-v}=$	0	$\frac{1}{8}$	$\frac{1}{5}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{3}{4}$	$\frac{5}{4}$	2	4	∞

$2v=$	0	$\frac{1}{4}$	$\frac{2}{5}$	$\frac{2}{3}$	1	$\frac{3}{2}$	$\frac{5}{2}$	4	8	∞
$N_4=$	0	$\frac{1}{4}$ ·	$\frac{2}{5}$ · ·	$\frac{2}{3}$ ·	1 ·	$\frac{3}{2}$ ·	$\frac{5}{2}$ · ·	4	(8)	∞

All the forms agree with the normal series N_4 except for (8), equivalent to $K\{950\}$, which is extra.

If this zone section be further split at 1, equivalent to $F\{430\}$, the two sections will agree with N_3.

	m	D	E	σ	F
	0	$\frac{1}{4}$	$\frac{2}{5}$	$\frac{2}{3}$	1
$\frac{v}{1-v}=$	0	$\frac{1}{3}$	$\frac{2}{3}$	2	∞
$N_3=$	0	$\frac{1}{3}$ ·	$\frac{2}{3}$ · ·	2 ·	∞

	F	G	H	J	K	μ
	1	$\frac{3}{2}$	$\frac{5}{2}$	4	8	∞
$v-1=$	0	$\frac{1}{2}$	$\frac{3}{2}$	3	7	∞
$N_3=$	0 ·	$\frac{1}{2}$ · ·	$\frac{3}{2}$ ·	3	(7)	∞

For the form $D\{10.9.0\}$ the measurements alone would hardly differentiate between $\{11.10.0\}$, $\{10.9.0\}$, and $\{980\}$ as the following comparison shows.

		ϕ
D, average measured		70°36′
Calculated for	$\{11.10.0\}$	70 18
	$\{10.9.0\}$	70 29
	$\{980\}$	70 42

Of the eight measurements of D, two agree better with $\{11.10.0\}$, one better with $\{10.9.0\}$, four better with $\{980\}$, while one is half way between $\{10.9.0\}$ and $\{980\}$. But the discussion shows that $\{10.9.0\}$ is the correct symbol.

In the discussion $\{11.10.0\}$ would yield $\frac{2}{9}$ and $\{980\}$ would yield $\frac{2}{7}$ in the normal series N_4 instead of $\frac{1}{4}$, and $\{11.10.0\}$ would yield $\frac{2}{7}$ and $\{980\}$ would yield $\frac{2}{5}$ in the normal series of N_3 instead of $\frac{1}{3}$.

For the complex indices of G, namely $\{10.7.0\}$ the question might arise whether the simpler ones $\{750\}$ might not be better. The comparison of measured and calculated angles shows:

	ϕ
G, average measured	74°32′
Calculated for $\{10.7.0\}$	74 35
Calculated for $\{750\}$	74 17

Of the six faces of G measured, the angles are closer to $\{750\}$ for only two of the measurements. The discussion would yield $\frac{4}{3}$ instead of $\frac{3}{2}$ for N_4, and $\frac{1}{3}$ instead of $\frac{1}{2}$ for N_3. The discussion therefore verifies the measurements that the more complex indices {10.7.0} are to be preferred for the correct indices of G.

The most complicated indices of all the new forms here described are those of H{14.9.0}. The discussion shows however that these indices readily fall into the normal series. Simpler indices which suggest themselves are {320}, {850}, and {11.7.0}. The comparison of measured and calculated angles is as follows.

	ϕ
H, average measured	75°48′
Calculated for {850}	76 10
{11.7.0}	76 56
{14.9.0}	75 47
{320}	75 17

Of the eight measured faces of H, one (75°20′) agrees very closely with the calculated value for {320}; two agree very closely with the calculated value for {850}, and two agree closely with the calculated value for {11.7.0}. As all the reflections measured were poor, there is no justification for claiming that the measurements show four distinct forms instead of one. The only question is as to the correct indices of this form. And according to the measurements, the only question is between {14.9.0} and {11.7.0}. The measurements alone are not sufficient to decide this question as the following comparison shows. The differences (Δ) between the measurements and the calculated angles for {14.9.0} and {11.7.0} are as follows:

Crystal no.	Measurements	Δ{14.9.0}	Δ{11.7.0}
1	76°09′	+21′	+13′
2	75 28	−20	−28
2	75 36	−12	−20
4	75 51	+03	−05
5	75 59	+11	+03
6	75 48	0	−08
6	76 10	+22	+14
7	75 20	−28	−36

There is practically no choice, the measurements agreeing about as well with one as with the other.

The discussion however shows that {11.7.0} reduces to $\frac{8}{3}$ for N_4. This value of $\frac{8}{3}$ does not belong in the normal series N_4 and moreover is more complicated than $\frac{5}{2}$, derived from {14.9.0}, which does belong in N_4. In the normal series N_3, {11.7.0} becomes $\frac{5}{3}$ which does not belong in N_3 and is more complex than $\frac{3}{2}$ derived from {14.9.0}, which does belong in N_3.

The discussion therefore shows that the correct indices for H are {14.9.0}, a fact which cannot be determined from the measurements alone.

Although the form K{950} is extra in both N_1 and N_3, it causes no disturbance in the normal series and the measurements of the five faces of K, three of which agree closely with the calculated value, fully substantiate this form.

The second section of the zone, from μ{210} to a{100}, is as follows:

	μ	L	M	π	—	R	N	P	S	a
	210	730	830	310	17.5.0	720	410	510	910	100
$\frac{h}{k}=$	2	$\frac{7}{3}$	$\frac{8}{3}$	3	$\frac{17}{5}$	$\frac{7}{2}$	4	5	9	∞
$\frac{v}{2}=$	1	$\frac{7}{6}$	$\frac{4}{3}$	$\frac{3}{2}$	$\frac{17}{10}$	$\frac{7}{4}$	2	$\frac{5}{2}$	$\frac{9}{2}$	∞
$v-1=$	0	$\frac{1}{6}$	$\frac{1}{3}$	$\frac{1}{2}$	$\frac{7}{10}$	$\frac{3}{4}$	1	$\frac{3}{2}$	$\frac{\ }{2}$	∞
$2v=$	0	$\frac{1}{3}$	$\frac{2}{3}$	1	$\frac{7}{5}$	$\frac{3}{2}$	2	3	7	∞
$N_3=$	0	$\frac{1}{3}$ ·	$\frac{2}{3}$	1	$\left(\frac{7}{5}\right)$	$\frac{3}{2}$	2	3	(7)	∞

This section of the zone gives nearly a perfect normal N_3 series, with only one member ($\frac{1}{2}$) missing and two extras. The form {720} of Cesàro, to which the letter R is assigned, fits in perfectly. The form {17.5.0} is undoubtedly vicinal to {720}, Cesàro giving a calculated difference of only 0°11′.

The form S{910} is extra in the normal series but is well substantiated by the measurements of three faces.

Combinations

The combinations observed on the seven measured crystals of valentinite are shown in the following table.

TABLE 6. VALENTINITE: COMBINATIONS OBSERVED ON THE SEVEN MEASURED CRYSTALS

Form	1	2	3	4	5	6	7
b{010}	*b*	*b*	*b*	*b*	*b*	*b*	*b*
a{100}	*a*	—	—	*a*	—	—	—
A{350}	—	*A*	—	*A*	*A*	—	—
B{340}	—	—	—	—	*B*	*B*	—
C{450}	*C*	—	—	—	—	*C*	*C*
m{110}	*m*	*m*	*m*	*m*	*m*	*m*	*m*
D{10.9.0}	—	—	*D*	*D*	*D*	*D*	*D*
E{760}	—	—	*E*	*E*	*E*	*E*	—
σ{540}	—	σ	σ	σ	—	σ	σ
F{430}	*F*	*F*	*F*	—	*F*	*F*	—
G{10.7.0}	—	*G*	*G*	—	*G*	*G*	—
H{14.9.0}	*H*	*H*	—	*H*	*H*	*H*	*H*
J{530}	—	*J*	*J*	—	*J*	*J*	—
K{950}	*K*	—	*K*	—	*K*	*K*	—
μ{210}	—	μ	μ	μ	μ	—	—
L{730}	—	—	*L*	*L*	*L*	—	—
M{830}	*M*	*M*	—	*M*	—	—	—
π{310}	π	—	—	π	—	π	—
N{410}	—	—	*N*	*N*	*N*	—	—
P{510}	—	*P*	—	*P*	*P*	—	—
S{910}	—	—	—	*S*	*S*	—	*S*
T{0.11.8}	*T*	*T*	*T*	*T*	*T*	*T*	*T*

ANDORITE(?)

The single prismatic crystal referred to in the introduction to valentinite was about a millimeter long and of a dark gray to nearly black

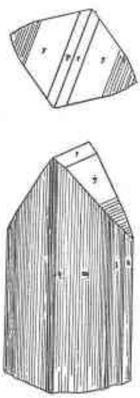

FIG. 2. Idealized drawing of crystal of andorite(?). Crystal about a millimeter high Forms: *k*{120}, *l*{230}, *m*{110}, *o*{320}, *y*{031}, γ{021}, *F*{052}.

color. It was detached and measured on the goniometer with the results shown below. The crystal was lost when it was attempted to apply microchemical tests.

A striated prism zone, terminated essentially only by side domes, giving poor reflections, made it impossible to decide whether the symmetry was orthorhombic or monoclinic. An extended comparison of the measured angles with those listed in the literature supplemented by a comparison of the habit with those of possible minerals, as given by Goldschmidt's *Atlas der Krystallformen*, lead to the conclusion that the measured crystal was either andorite, $2PbS \cdot Ag_2S \cdot 3Sb_2S_3$, or freieslebenite, $3PbS \cdot 2Ag_4S \cdot 2Sb_2S_3$, with a considerable preference for andorite.

A total of 40 faces were measured, of which about half could be correlated with 13 forms of andorite and with 15 forms of freieslebenite.

The faces measured are listed below in the order of measurement, with the corresponding forms and angles for andorite and for freieslebenite. No attempt was made to interpret the measurements of these prism faces (nos. 7, 9, 17, 23, 26, and 34) for which no agreement could be noted with the known forms of either andorite or freieslebenite.

The axial ratios used are, for andorite, $a:b:c=0.6771:1:0.4458$, and for freieslebenite, $a:b:c=0.5871:1:0.9277, \beta=87°46'$.

TABLE 7. ANDORITE AND FREIESLEBENITE: COMPARISON OF MEASURED ANGLES

No.	Note book letter	Measured		Andorite			Freieslebenite		
		ϕ	ρ	Form	ϕ	ρ	Form	ϕ	ρ
1	a_1	44°06′	90°00′	230	44°34′	90°00′	350	45°39′	90°00′
2	a	45 22	90 00						
3	b	66 34	90 00	320	65 43	90 00	430	66 15	90 00
4	c	85 22	90 00	—	—	—	810	85 48	90 00
5	d	87 24	90 00	100	90 00	90 00	100	90 00	90 00
6	e	82 20	90 00	510	82 18	90 00	510	83 18	90 00
7	f_1	68 12	90 00	—	—	—	—	—	—
8	f_2	66 04	90 00	320	65 43	90 00	430	66 15	90 00
9	f_3	64 47	90 00	—	—	—	—	—	—
10	f_4	63 07	90 00	430	63 05	90 00	—	—	—
11	f_5	61 39	90 00	—	—	—	110	59 36	90 00
12	f_6	54 17	90 00	110	55 54	90 00	560	54 51	90 00
13	f_7	45 12	90 00	230	44 34	90 00	350	45 39	90 00
14	g	36 54	90 00	120	36 27	90 00	—	—	—
15	g_1	35 29	90 00	—	—	—	250	34 17	90 00
16	z	36 36	90 00	120	36 27	90 00	—	—	—
17	y	38 33	90 00	—	—	—	—	—	—
18	x	40 37	90 00	—	—	—	120	40 26	90 00
19	w	43 00	90 00	230	44 34	90 00	—	—	—

TABLE 7. (*Concluded*).

No.	Note book letter	Measured		Andorite			Freieslebenite		
		ϕ	ρ	Form	ϕ	ρ	Form	ϕ	ρ
20	*v*	46 11	90 00	—	—	—	350	45 39	90 00
21	*u*	53 59	90 00	—	—	—	450	53 45	90 00
22	*t*	56 08	90 00	110	55 54	90 00	560	54 51	90 00
23	*s*	57 04	90 00	—	—	—	—	—	—
24	*r*	58 17	90 00	—	—	—	110	59 36	90 00
25	*q*	63 12	90 00	430	63 05	90 00	—	—	—
26	*p*	68 12	90 00	—	—	—	—	—	—
27	*o*	70 20	90 00	210	71 18	90 00	—	—	—
28	*n*	66 33	90 00	320	65 43	90 00	430	66 15	90 00
29	*m*	64 03	90 00	430	63 05	90 00	—	—	—
30	*l*	57 05	90 00	110	55 54	90 00	—	—	—
31	*k*	54 22	90 00	—	—	—	560	54 51	90 00
32	*j*	44 49	90 00	230	44 34	90 00	350	45 39	90 00
33	*i*	36 32	90 00	120	36 27	90 00	—	—	—
34	*h*	37 15	90 00	—	—	—	—	—	—
35	*B*	0 19	52 23	031	0 00	53 13	032	1 36	54 18
36	*D*	0 19	52 27	031	0 00	53 13	032	1 36	54 18
37	*C*	0 19	47 07	052	0 00	48 06	054	1 55	49 14
38	*E*	2 55	38 20	021	0 00	41 43	011	2 24	42 52
							034	3 12	34 52
39	E_1	75 51	41 08	524[a]	74 51	41 07	214[b]	74 21	40 41
				312	77 17	45 21			
40	*F*	19 31	60 09	141[a]	20 16	62 15	153[b]	19 54	62 22

[a] Form not known for andorite.
[b] Form not known for freieslebenite.

Faces number 39 and 40 are extremely minute; they appear as mere bright specks on the goniometer but gave distinct though poor reflections. The measurements agree fairly well with the calculated values for pyramids of fairly simple indices for both andorite and freieslebenite, though none of these pyramids are known forms for either mineral.

Grouping the measurements of faces of the known forms together, on the assumption that the crystal measured was andorite, the results shown in the following table are obtained. The closest corresponding angle for freieslebenite is added to the last column.

TABLE 8. ANDORITE(?): COMPARISON OF MEASURED AND CALCULATED ϕ ANGLES OF KNOWN PRISMS

Form	Measurements	Average of measurements	Calculated andorite	Calculated freieslebenite
$k\{120\}$	36°32′–37°15′ 35 29 –38 36 36 54	36°57′	36°27′	{250} = 34°17′
$l\{230\}$	44 06 –45 22 44 49 40 37 –46 11 45 12	44 32	44 33	{350} = 45 39
$m\{110\}$	54 22 –57 05 53 59 –58 17 54 17	55 23	55 54	{560} = 54 51
$o\{320\}$	64 03 –66 33 63 12 –68 12 61 39 –68 12 66 34	65 38	65 42	{430} = 66 15
$n\{210\}$	70 20	70 20	71 18	
$\psi\{510\}$	82 20	82 20	82 18	{510} = 83 18

A closer agreement of the measured prism angles with those of freieslebenite can be obtained by turning the measured crystal 90° around the c-axis, though then there is no agreement between the dome faces.

TABLE 9. ANDORITE (?): COMPARISON OF MEASURED PRISM ANGLES, IF CRYSTAL IS TURNED 90° AROUND THE c-AXIS

Form	90°-ϕ	Freieslebenite
$k\{120\}$	53°03′	{450} = 53°45′
$l\{230\}$	45 28	{350} = 45 39
$m\{110\}$	34 37	{250} = 34 17
$o\{320\}$	24 22	[a]{140} = 23 05
$n\{210\}$	19 40	{150} = 18 49
$\psi\{510\}$	7 40	—

[a] Form not known for freieslebenite.

An idealized drawing of the crystal is shown in Figure 2. The faces of the unit prism $m\{110\}$ are drawn as distinct faces, whereas actually they are rounded and strongly striated vertically. The forms $\{120\}$, $\{230\}$, $\{110\}$, $\{430\}$, and $\{320\}$ are the common prisms, each occurring with at least three faces. The lower portions of both faces of $y\{031\}$ are striated.

The crystal from the Ochoco district resembles in general habit Figure 2 of andorite and Figure 17 of freieslebenite, as listed in Goldschmidt's *Atlas der Krystallformen.*

The absence of any pinacoids (the measurement of face No. 5, with $\phi=87°24'$ does not necessarily demonstrate the occurrence of $\{100\}$) favors the reference to freieslebenite, for andorite crystals commonly have pinacoids present, especially the side pinacoid $b\{010\}$. Thus, in the 15 combinations listed by Koch (1928) b is present on every crystal of andorite as it likewise is in the five drawings listed in Goldschmidt's Atlas der Krystallformen. Faces of $b\{010\}$ are frequently absent on crystals of freieslebenite.

The generally better agreement of the measured angles with those of andorite, however, would seem to favor the reference of the measured crystal to andorite. Additional and better material, though, needs to be examined before a definite identification can be made.

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