CRYSTALLOGRAPHY OF STIBNITE AND ORPIMENT FROM MANHATTAN, NEVADA

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A collection of the arsenical ores of the White Caps Mine at Manhattan, Nevada, secured for the Harvard Mineralogical Museum from H. G. Clinton, contained well crystallized stibnite and orpiment. The study of these crystals has added to our knowledge of the crystallography of these minerals and is therefore presented here in some detail. The geology of the district has been described by Ferguson.[1] The ores occur as replacement deposits in a Cambrian limestone.

STIBNITE

The following quotation from Ferguson describes the various modes of occurrence of stibnite in the White Caps Mine.

"Stibnite is found throughout the deposit, but is more prominent in the western part of the mine. Small crystals are frequently found in the vugs of the dark quartz. Its most usual occurrence is in roughly radiate crystalline masses, in places several inches in diameter, which replace the limestone or coarse calcite, or more rarely the dark quartz. In places small 'sunbursts' of stibnite crystals occur along cleavage planes of the coarse calcite and small needles were found in the fault gouge of the later faults. In all these positions, particularly in the eastern ore body, stibnite may be closely intergrown with realgar. A rare occurrence of stibnite is in the form of delicate hair-like crystals found in cavities in the calcite and rarely in the quartz. Orpiment is found in this same habit and association, but not realgar. Although the stibnite is practically barren of gold it is confined to the ore bodies. Only rarely do small clusters of stibnite crystals occur outside of the mineralized areas."

Specimens of all these types of occurrence are in the collection studied. The best crystals came from vugs in quartz.

The measured crystals are generally small, ranging from hair-fine needles to stout peg shapes up to two or three millimeters diameter. Many crystals in the vugs are distorted and twisted so that the faces are warped. There is little alteration visible; on some there is a delicate iridescent film which rarely destroys the reflecting power of the crystal faces.

The crystals are of three principal habits:

(a) very slender needles with simple terminations, Figure 1.

(b) stouter crystals with simple terminations dominated by a new orthodome (503) very characteristic for the locality. Figure 2 and figure 4.

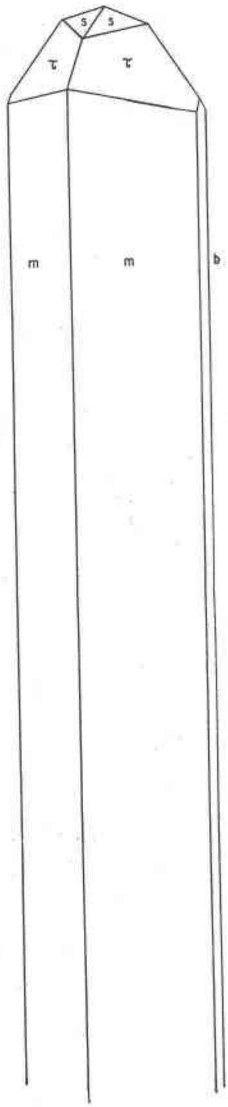

FIG. 1. Stibnite.

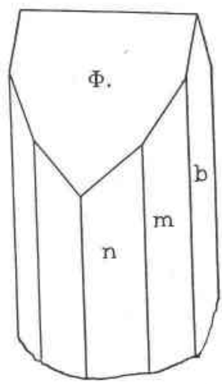

FIG. 2. Stibnite.

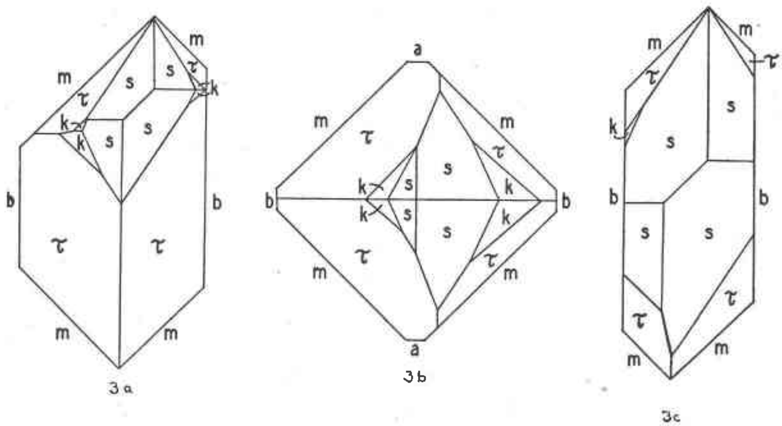

FIG. 3. Stibnite.

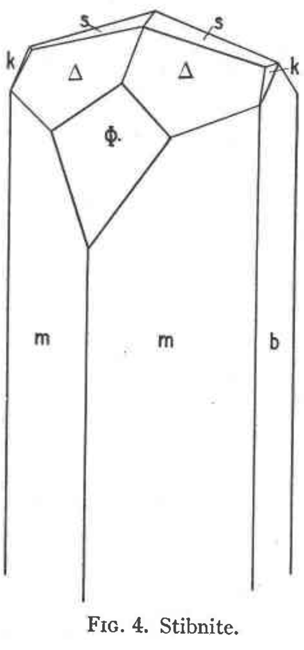

FIG. 4. Stibnite.

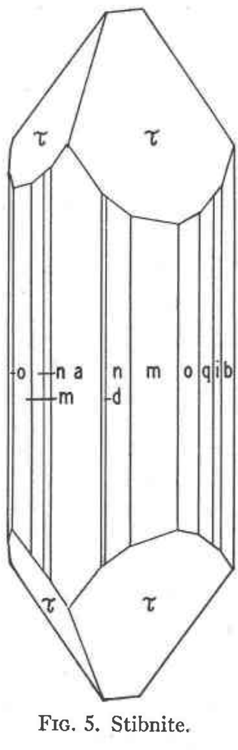

FIG. 5. Stibnite.

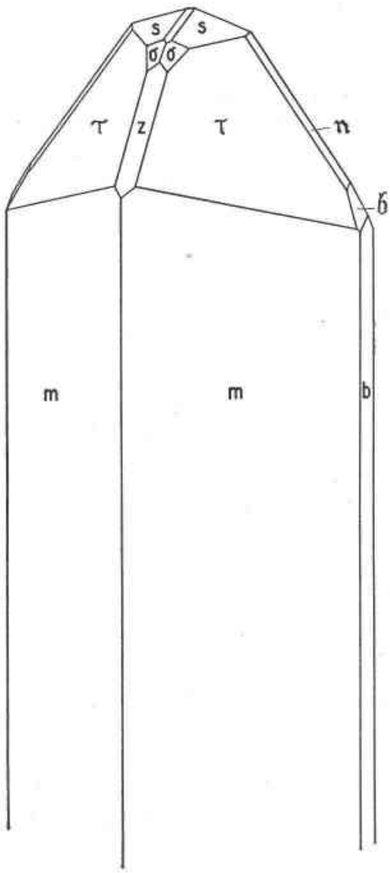

FIG. 6. Stibnite.

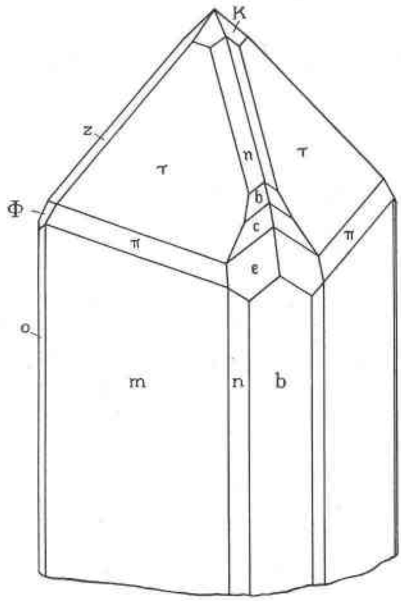

FIG. 7. Stibnite. Drawn with side pinacoid in front.

(c) short crystals with more or less complex pyramidal terminations. These are very similar in habit to the average crystals from Ichinokawa, Japan. They are shown in figures 3, 5, 6, and 7.

Thirty-three crystals were measured, some of them by both authors, and revealed a very complex form series with three well established new forms. Since the crystallography of stibnite has been very carefully studied recently by Neff[3] there seemed to be no occasion for a general discussion of the form series here. A list of the forms observed is given in the following table together with a table of combinations.

1. Table of the Forms of Stibnite from Manhattan, Nevada.

List of Forms:

Letter	Symbol	Frequency	Letter	Symbol	Frequency
b	(010)	Every crystal	p	(111)	2 crystals
a	(100)	3 crystals	s	(113)	20 crystals
d.	(12.1.0)	4 “	μ	(114)	1 “
h	(310)	1 “	v	(227)	1 “
n	(210)	14 “	𝔥	(116)	3 “
ι	(320)	4 “	K	(233)	24 “
k	(430)	1 “	λ	(313)	1 “
m	(110)	Every crystal	τ	(343)	21 “
d	(230)	7 “	η	(353)	1 “
o	(120)	12 “	σ	(213)	10 “
q	(130)	14 “	𝔫	(243)	13 “
i	(140)	6 “	𝔟	(253)	14 “
θ	(160)	1 “	𝔱	(263)	4 “
Θ	(170)	1 “	𝔠	(273)	10 “
l.	(180)	1 “	𝔢	(283)	2 “
N	(023)	3 “	x.	(293)	3 “
L	(103)	3 “	ψ	(146)	1 “
z	(101)	10 “	e	(123)	10 “
*Φ.	(503)	22 “	M	(413)	1 “
			Ξ	(5.11.3)	1 “
			𝔪	(5.10.3)	3 “
			T	(521)	1 “
			φ.	(4.10.3)	1 “
			𝔞	(9.10.3)	4 “
			*Π.	(673)	7 “
			*Δ.	(425)	6 “

* indicates new form.

2. Table of Combinations.

1. b, m, s, τ. Slender needles. Figure 1.
2. b, n, m, Φ.. Figure 2.
3. $b, m, \tau, \mathfrak{b}$.
4. b, m, s, K, τ. Figure 3, a, b, c.
5. $b, m, \Phi., s$.
6. $b, m, \Phi., s, K, \Delta$. . Figure 4.
7. $b, m, \Phi., s, K, \tau, \sigma$.
8. $b, n, \iota, m, \Phi., s, K, \Pi$. .
9. $b, d., n, \iota, k, m, q, \tau$.
10. $b, m, \Phi., s, K, \tau, e$.
11. $b, a, d., n, m, o, q, i, \tau$. Figure 5.
12. $b, m, d, o, q, K, \tau, \mathfrak{b}$.
13. $b, m, \Phi., K, \sigma, \mathfrak{n}, \mathfrak{b}, \mathfrak{c}$.
14. $b, m, L, z, s, \tau, \sigma, \mathfrak{n}, \mathfrak{b}$. Figure 6 approximately.
15. $b, n, \iota, m, z, \Phi., K, \tau, s, \sigma, \mathfrak{n}, \mathfrak{t}, \mathfrak{e}, \mathfrak{b}, m$.
16. $b, n, m, o, q, z, \Phi., K, \tau, \mathfrak{n}, T, M, \mathfrak{e}, \mathfrak{a}, \mathfrak{b}, \Pi., \mathfrak{c}$.
17. $b, a, d., n, m, o, q, i, \tau, \mathfrak{n}, \mathfrak{c}$.
18. $b, m, q, i, \theta, \Theta, z, p, K, \tau, \mathfrak{n}, \mathfrak{b}, \mathfrak{t}, \mathfrak{c}, x., m$.
19. $b, m, d, o, q, L, z, \Phi., N, s, \mu, v, \mathfrak{h}, K, \sigma, \mathfrak{n}, \mathfrak{b}, \mathfrak{c}, x., e, \Pi$. .
20. $b, n, m, d, o, q, i, z, \Phi., s, k, \tau, \sigma, \mathfrak{n}, \mathfrak{b}, \mathfrak{t}, \mathfrak{e}, \mathfrak{a}, \Pi$. .
21. $b, m, d, o, q, z, \Phi. K, \tau, \mathfrak{n}, \mathfrak{b}, \mathfrak{c}, x., e, \mathfrak{a}, \Pi$.
22. $b, a. d., n, \iota, m, d, o, q, i, l., N, p, s, K, \lambda, \tau, \eta, \mathfrak{n}, \mathfrak{b}, \mathfrak{c}, x., \psi, e, \phi$. . .
23. $b, n, m, q, L, z, \Phi., N, s, \mathfrak{h}, K, \tau, \sigma, \mathfrak{n}, \mathfrak{b}, \mathfrak{t}, \mathfrak{c}, \phi. \Pi$.

There are doubtless other particular combinations of the many forms present. It will be noted that the prism series is very rich in forms. The new orthodome (503) is present on two-thirds of the measured crystals and gave excellent readings in good position. The two new pyramids, although not so constant in position, were present on so many crystals that they are regarded as well established. The measurements for the new forms are as follows:

	Calculated		Measured		No. of		Limits	
	ϕ	ρ	ϕ	ρ	Faces	Crystals	ϕ	ρ
(503)	90°00′	59°40′	90°00′	59°40′	15	10		59°36′–59°47′
(673)	40°48′	72°19′	40°53′	72°24′	11	7	40°35′–41°11′	72°05′–72°40′
(425)	63°36′	42°29′	63°36′	42°13′	11	5	62°37′–62°25′	41°31′–42°39′

Of the many pyramids the most prominent is τ (343) which appears in all the drawings and is present on two-thirds of the crystals. As this form is also the dominant form on the stibnite of Japan, there is a striking similarity between the crystals from the two localities. Indeed the whole form series of the Manhattan stibnite shows a distinct parallelism to that of Japan. Had the more complex crystals been drawn, such as combinations 18 to 23, the similarity would be still more striking. In view of the many crystal figures of the Japanese stibnite now available it was regarded as a waste of labor to draw all of these crystals, only one of which, No. 16, has been attempted.

Figure 3 was drawn to show how various may be the appearance of crystals of stibnite on which identical forms occur but with varying and unequal development of their faces. It is impossible to recognize the forms except by measurement.

In addition to the forms regarded as typical, almost every more complex crystal had single faces to which more or less definite and simple indices could be assigned but as they were quite sporadic the data is not presented.

It appears that the stibnite crystals from Manhattan may be placed along with those from Felsöbanya and Japan as representing this mineral at the maximum of crystal development.

Orpiment

Orpiment occurs very abundantly at the White Caps Mine, chiefly in massive form or replacing realgar. It was found very rarely in vugs of calcite in the form of isolated crystals. These were in some cases slender needles of a clear golden yellow color and in others in stout crystals with definite terminations. As is usually the case with this mineral, most of the crystals were bent and bruised but a small number of uninjured crystals was removed and measured. As they add definite proof to that already advanced that orpiment is monoclinic, the data are presented. Furthermore an angle table is given for orpiment, regarded as monoclinic, since none for two-circle measurements has hitherto been printed.

The only modern descriptions of orpiment crystals are those of Stevanovic[4] and Farrington.[5] Both authors regarded the mineral as monoclinic and gave figures. In some respects the crystals from Mercur are similar to those here studied.

Ten crystals were measured, most of them fragmentary or so intergrown with other individuals that only a part of their faces were accessible. The perfect pinacoidal cleavage and the excellent development of the prism zone made orientation always definitely possible. In some cases the measurements were made by orienting the crystal with (010) as pole. In these cases only interfacial angles

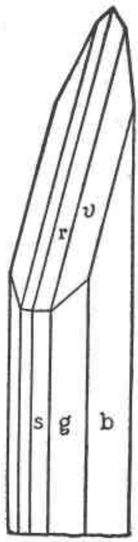

FIG. 8. Orpiment, Manhattan, Nevada, drawn from back.

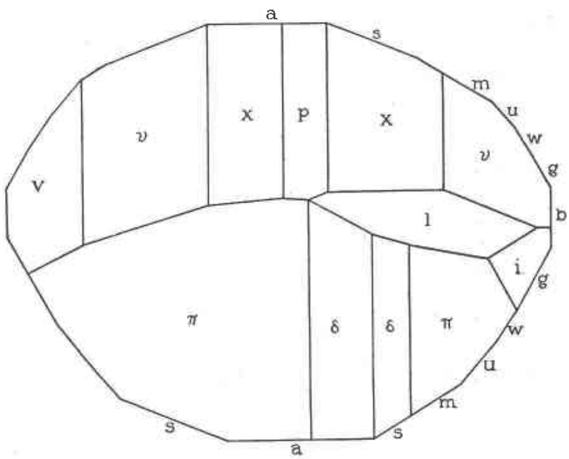

FIG. 9. Orpiment.

were obtained and although these sufficed to identify the forms they are not included in the angles tabulated below. There are three striated zones on the crystals more or less well developed.

The distinction between these zones is not easy and it is largely this character that has given rise to the doubt as to whether orpiment is orthorhombic or monoclinic. It was found possible to distinguish them, however. The prism zone [001] has distinct plane faces with better lustre and surface than either of the others and striations are not deep. The zone of positive pyramids $[10\bar{1}]$ and of negative pyramids [101] are similar; both are deeply striated but the signals reflected from the front series $[10\bar{1}]$ were much less numerous than those from the back ones. In addition to these three zones the only faces on our crystals were the clinodome l(023) and the positive pyramid *i*(243). The measurements obtained were not sufficiently good to permit the calculation of reliable axial elements. The calculated angles given in the following table are therefore based on the elements of Stevanovic.

TABLE III
FORMS AND CALCULATED AND MEASURED ANGLES OF ORPIMENT FROM MANHATTAN

Letter	Symbol	Calculated		Measured				No. of measured		No. of crysts. on which seen
		ϕ	ρ	ϕ	Limits ϕ in minutes	ρ	Limits ρ in minutes	faces	cryst.	
b	(010)	0° 00′	90° 00′	0° 00′	0′ to −33′	90° 00′	—	6	4	10
a	(100)	90 00	90 00	90 20	0 to −42	90 00	—	3	2	4
s	(320)	68 19.	"	68 07	+12 to −12	"	—	3	2	6
m	(110)	59 12	"	59 16	+47 to −34	"	—	5	4	7
u	(120)	39 59	"	39 49	+26 to −28	"	—	9	5	8
**w*	(250)	33 51.	"	33 44	+ 1 to − 1	"	—	2	2	3
g	(130)	29 13	"	29 23	+ 4 to − 5	"	—	6	5	7
l	(023)	1 32	23 55.							1
**o*	(101)	90 00	48 25.	92 40		48 52		1	1	2
e	(103)	"	20 59.							
d	$(\bar{1}03)$	−90 00	19 48							
p	$(\bar{1}01)$	"	47 49	−89 40		47 49		1	1	2
q	$(\bar{4}49)$	−58 34	29 33							
r	$(\bar{2}12)$	−73 14	49 03.	−76 56		48 52		1	1	1
x	$(\bar{3}23)$	−68 07	49 56.	−68 22	+37 to −37	49 57	+16 to −14	5	3	6
ν	$(\bar{3}43)$	−51 13	54 46	−51 43	+71 to −98	55 08	+72 to −99	6	4	8
β	$(\bar{2}32)$	−47 53	56 05							
y	$(\bar{5}85)$	−46 03	56 53	−46 11		58 25		1	1	1
v	$(\bar{1}21)$	−39 41	59 57	−39 41		61 27		1	1	4
**f*	$(\bar{2}52)$	−33 34	63 23	−33 59		65 33		1	1	2
*α	$(\bar{1}31)$	−28 57	66 19	−32 14	+71 to −70	66 10	+10 to −11	2	2	2
*δ	(414)	81 37	48 44	82 23		48 56		1	1	3
*π	(313)	78 52	48 58	76 56	+13 to −17	48 32	+44 to −31	3	3	4
*μ	(212)	73 34	49 36	74 16	+39 to −56	49 22	+22 to −58	4	3	6
i	(243)	40 26	49 21	41 48		50 03		1	1	3
k	$(\bar{1}23)$	−39 04	29 44							
n	$(\bar{1}33)$	−28 25	37 06							
z	(523)	76 41	62 33							
κ	$(\bar{4}23)$	−73 16	57 01							

* Indicates new form.

The elements on which the angles were calculated are as follows:—

$$a:b:c = 0.5962:1:0.6650. \quad \beta = 90°41'$$
$$p_0 = 1.1154, \quad q_0 = 0.6650. \quad \mu = 89°19'$$

The agreement of calculated and measured angles is not good but it is at least as good for the forms indicated in the table as new as for those already established.

The two figures drawn give an inadequate representation of the crystals which are much distorted by unequal growth of the faces. Figure 8 shows a common habit—plates with an acute summit where prism zone meets negative pyramid zone. This crystal is drawn as seen from the back. Figure 9 is a basal projection of the largest crystal, measuring about 1 cm. in width and heighth. It was not completely bounded by the prism zone but the prisms found on it have been restored.

A further evidence of the monoclinic character of orpiment was obtained by carefully measuring the extinction direction in orientated cleavage plates. It was found that Y to c made an angle of from one to three degrees with an error of less than one-half degree, in the negative quadrant. The extinction was not parallel in any of the five cleavage flakes examined.

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