ON THE CRYSTAL FORM OF STERNBERGITE

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Summary

Remeasurement of crystals of sternbergite ($AgFe_2S_3$) from Joachimsthal, Bohemia, shows that the classical data (Haidinger, 1828) are inadequate. The crystals are orthorhombic, dipyramidal, giving the parameters, $a:b:c=0.5913:1:0.6250$ and the forms *c*(001), *b*(010), *a*(100), *m*(110) only as twin plane, *d*(032), *e*(101), *q*(332), *r*(221), *s*(331), *t*(131), of which *a d e r t* are new. Twinning on *m* is common. Crystals are tabular parallel to *c*. Cleavage, *c*, perfect. The morphology is similar to that of cubanite ($CuFe_2S_3$) but a close systematic relation between the two species is not regarded as proved.

Sternbergite ($AgFe_2S_3$) and cubanite ($CuFe_2S_3$) are both described as orthorhombic and pseudo-hexagonal, commonly twinned on (110). The accepted crystallographic elements of the two species do not, however, show the expected similarity:

Sternbergite $a:b:c=0.5832:1:0.8391$ Haidinger (1828)
Cubanite $a:b:c=0.5822:1:0.5611$ Hlawatsch (1910)

Since a study of excellent crystals of cubanite from a new find confirmed Hlawatsch's choice of parameters,[1] it seemed that a morphological similarity with sternbergite would be properly exhibited by reducing the *c*-axis of sternbergite by one-third of its length, to give the value 0.5594. The reduced vertical axis resulted, however, in somewhat unnatural form symbols. With promising crystals of sternbergite at hand, it was decided, therefore, to make new measurements in order to check the early work. The result was surprising. It was actually found that the form corresponding approximately to Haidinger's primitive pyramid (111) more naturally receives the symbol (332), producing the expected proportional change in the length of the *c*-axis; but at the same time the new measurements differ considerably from the old ones and consequently the final comparison of the elements of the two species is not very close.

The material studied was detached from a specimen from the type locality, Joachimsthal[2] in Bohemia; the specimen was recently acquired by the Harvard Mineralogical Museum in a collection of choice minerals bought from Dr. Techn. Ing. Hans R. von Karabacek of Vienna. The sternbergite occurs in packs of subparallel plates up to 4 mm. in diam-

[1] Hlawatsch's elements refer to "chalmersite," which is identical with cubanite (Peacock and Yatsevitch), *Am. Mineral.*, vol. **21**, pp. 55–62, 1936.

[2] In the original description of sternbergite, Haidinger (1828, p. 1) gives the following item of information which is perhaps not generally known: ". . . when, in the beginning of the sixteenth century, a larger kind of silver coin was introduced into Germany, it took the name of *Joachimsthaler*, from the place of its coinage, a name which was afterwards changed into *thaler*, *talaro*, and *dollar*."

eter, with the characteristic pinchbeck brown colour and occasional steel-blue tarnish. The plates are so soft and flexible, and so prone to separate along the perfect cleavage parallel to the plane of platy development, that single crystals can rarely be successfully detached for measurement; fair readings can, however, be obtained from smaller undeformed plates and blades projecting from aggregates separated from the main specimen.

The plates are bevelled by narrow faces in full orthorhombic symmetry, producing variously distorted subhexagonal outlines. The truncating faces are for the most part small and dull and sometimes slightly warped; consequently the measured angles, especially the polar distances range rather widely. The better measurements on five crystals from the new materials, and five crystals from an old specimen from Joachimsthal,[3] are given in Table 1; the co-ordinate angles refer to Haidinger's orientation of the orthorhombic axes, in which the broad plane of the plates is the base and the light striations on this plane follow the *b*-axis.

TABLE 1. STERNBERGITE. TWO-CIRCLE MEASUREMENTS ON TEN CRYSTALS FROM JOACHIMSTHAL

Forms	Faces	Measured range		Measured mean		Calculated	
		ϕ	ρ	ϕ	ρ	ϕ	ρ
c(001)	12	—	—	—	0°00′	—	0°00′
b(010)	1	—	—	−0°10′	90 00	0°00′	90 00
a(100)	1	—	—	90 13	90 00	90 00	90 00
d(032)	8	−0°10′– 0°21′	43°42′–44°30′	0 02	43 57	0 00	43 09
e(101)	8	90 00 –90 13	45 00 –47 52	90 04	46 47	90 00	46 35
q(332)	3	58 53 –59 43	62 00 –62 18	59 18	62 09	59 24½	61 30
r(221)	17	59 01 –60 04	66 55 –69 30	59 37	67 40	59 24½	67 50½
s(331)	8	59 09 –59 34	74 35 –75 16	59 23	74 56	59 24½	74 49
t(131)	18	29 06 –30 00	63 20 –67 00	29 24	64 59	29 24½	65 05

The proper choice of unit form is not at once apparent. Haidinger's orientation, which places the axis of hexagonal pseudo-symmetry vertical, is the natural one, but his parametral plane, which corresponds to *q*(332) in the adopted notation, is not acceptable as the unit form since it leads to unsatisfactory form symbols. On the whole it seems best to make *e* the unit macrodome with the twin plane as the unit prism, which choice leads to the symbols given and elements similar to those of cubanite. *X*-ray study might show that the relative length of the vertical edge

[3] The writer is obliged to Professor Charles Palache for these measurements, which were made many years ago and laid aside as they did not fit the existing crystal data on sternbergite.

of the unit cell is three times the adopted c-axis, in which case $s(331)$ would be the better primitive pyramid.

The pyramids in the principal zone $[\bar{1}10]$ are not satisfactory for the determination of the elements; and since Haidinger relied on two measurements between faces in this zone for his axial ratio, the poor agreement between his data and the present observations is easily understood. The numerous and fairly constant azimuth measurements on q, r, s, and the angles for e, t, which are occasionally present as good faces, lead to the following elements:

$$p_0:q_0:r_0 = 1.0570:0.6250:1$$
$$a:b:c = 0.5913:1:0.6250$$

Although stated as usual to four decimals, for the sake of internal consistency in the angle-table, the error in these elements may be as high as one per cent. Nevertheless, the parameters given are certainly nearer the truth than the classical values.

The calculated angles in Table 1 are based on the above elements; the agreement with the measured angles is as good as might be expected from the nature of the material. Table 2 gives a formal angle-table for sternbergite in the style recently proposed by the writer (1934). Table 3 correlates the form letters and symbols used for sternbergite by Haidinger (1828), Dana (1892), Victor Goldschmidt (1897, 1922), and the present writer. The transformation of elements and symbols is given by the formulas

Haidinger—Dana—Goldschmidt to Peacock:
$a:b:\frac{2}{3}c$; 300/030/002[4]

The transformation of the elements is only approximate since the angular position of Haidinger's unit form $f(111)$ departs considerably from that of $q(332)$ in the new notation:

		ϕ	ρ
$f(111)$	Haidinger	59°45′	59°00′
$q(332)$	Peacock	59 24½	61 30

In the nature of the case, Haidinger's forms not observed by the writer are neglected as unreliable. Dana's $w(301)$ appears to be a misinterpretation of Haidinger's $\frac{4}{3}$P$\bar{r}$-3 (h), a Mohs symbol equivalent to the Miller symbol (106).

Crystals of sternbergite are invariably thin basal plates with perfect and easy cleavage parallel to c. This plane is always lightly striated par-

[4] Using the convenient linear form of transformation formula described by Barker (*Systematic Crystallography*, p. 32, 1930).

Table 2. Sternbergite—$AgFe_2S_3$

Orthorhombic, dipyramidal

$a:b:c=0.5913:1:0.6250$; $p_0:q_0:r_0=1.0570:0.6250:1$

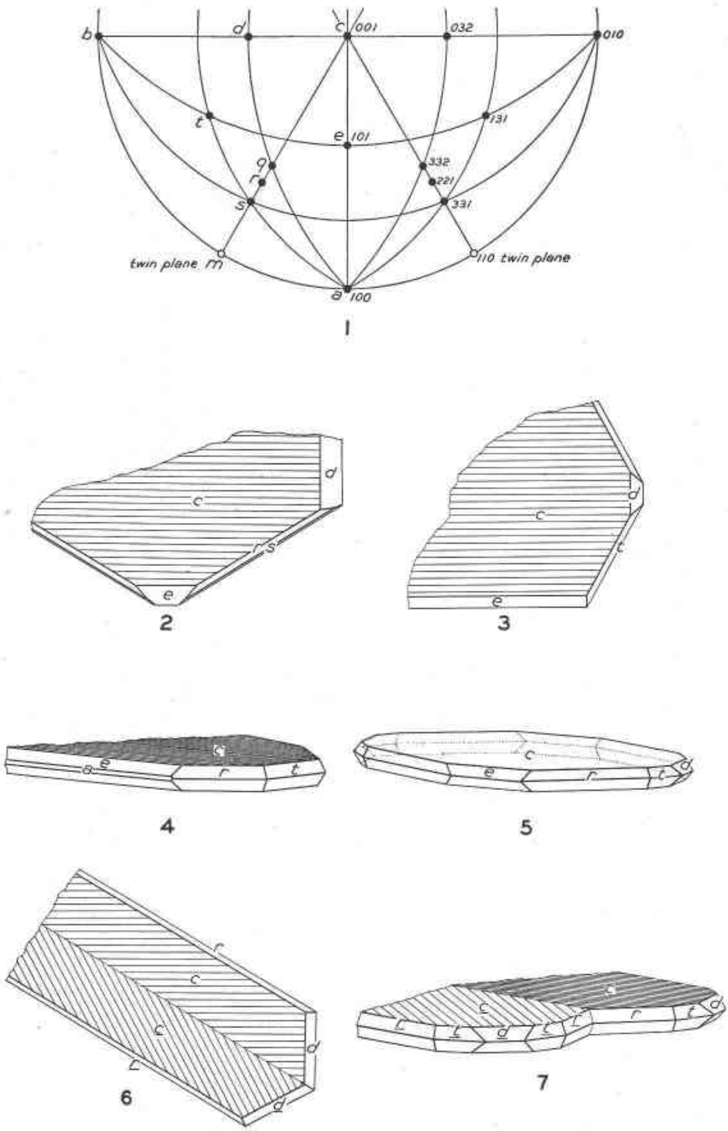
$q_1:r_1:p_1=0.5913:0.9461:1$; $r_2:p_2:q_2=1.6000:1.6912:1$

Forms	ϕ	$\rho=C$	ϕ_1	$\rho_1=A$	ϕ_2	$\rho_2=B$
c(001)	—	0°00′	0°00′	90°00′	90°00′	90°00′
b(010)	0°00′	90 00	90 00	90 00	—	0 00
**a*(100)	90 00	90 00	—	0 00	0 00	90 00
***m*(110)	59 24½	90 00	90 00	30 35½	0 00	59 24½
**d*(032)	0 00	43 09	43 09	90 00	90 00	46 51
**e*(101)	90 00	46 35	0 00	43 25	43 25	90 00
q(332)	59 24½	61 30	43 09	40 50½	32 14½	63 25½
**r*(221)	59 24½	67 50½	51 20½	37 08	25 19	61 52½
s(331)	59 24½	74 49	61 55½	33 49½	17 30	60 35
**l*(131)	29 24½	65 05	61 55½	63 33	43 25	37 49

* New form. ** Only as twin plane.

Table 3. Sternbergite. Correlation of Letters and Symbols

Haidinger (1928)	Dana (1892)	Goldschmidt (1897) (1922)	Peacock
a(001)	*c*	*c*	*c*(001)
i(010)	*b*	*a b*	*b*(010)
—(100)	—	—	*a*(100)
—(011)	—	—	*d*(032)
b(021)	*e*	*e*	—(031)
c(0.10.1)	*u*	*u*	—(0.15.1)
h(106)	—	*w*	—(104)
—(203)	—	—	*e*(101)
—(301)	*w*	—	—(902)
f(111)	*s*	*s*	*q*(332)
—(443)	—	—	*r*(221)
g(221)	*v*	*v*	*s*(331)
d(121)	*d*	*d*	—(362)
—(263)	—	—	*l*(131)
m(110)	*m*	*m*	*m*(110) twin plane



FIGS. 1–7. Sternbergite. Stereographic projection of the accepted forms and typical crystals from Joachimsthal, Bohemia.

allel [010], rarely also parallel [100]. The forms, *a*, *b*, are quite insignificant, each having been observed only once as a line face. The prism *m* never appears as an external plane. The forms, *d*, *e*, are present on most of the crystals, *d* usually small (Fig. 3), *e* sometimes elongated (Figs. 3, 4). The form of some of the plates is determined mainly by pyramids in the zone [$\bar{1}$10], in which *q* is quite unimportant, *r* common, *s* less frequent. Occasionally *t* is the only pyramid (Fig. 3); often *r* and *t* occur together (Figs. 4, 5, 7). Many of the plates are twinned by reflection in (110), which is also the composition plane about which the striations on the common basal planes are in symmetrical feathered arrangement. In some of the twins there is no visible re-entrant angle (Fig. 6); in others the terminations of the two individuals are clearly separated (Fig. 7).

The revised elements of sternbergite and cubanite show the following similarity:

Sternbergite $a:b:c=0.5913:1:0.6250$

Cubanite $a:b:c=0.5822:1:0.5611$

Both are orthorhombic, pseudo-hexagonal, frequently twinned on the unit prism, and striated on the base parallel to the *b*-axis. On the other hand the two minerals differ in typical habit, hardness and cleavage. Whether the two species should be regarded as closely related or not, can be decided only by röntgenographic investigation.

References

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