Crystallised Stannite from Bolivia.

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(With Plate II.)

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Historical and Introductory.

VERY little is known of the crystalline form of the somewhat rare mineral stannite, since in the few localities in which it has been found it usually occurs only in the massive state. Several suggestions, summarised below, have been made as to the type of crystalline symmetry of the mineral, but hitherto no crystals have been completely examined.

(1) *Orthorhombic.* Haüy (1822)[1], from an examination of cleavage fragments from Cornwall, concluded that the primitive form might possibly be a right rhombic prism.

(2) *Cubic.* Haidinger (1825)[2] mentioned Cornish crystals, having apparently the form of regular cubes, but the dulness of the faces did not allow of any measurements. The massive material appeared to show cleavages in the directions of the faces of the cube and rhombic dodecahedron. (Crystals of Cornish stannite are further mentioned on p. 65 below.)

(3) *Tetrahedral-Cubic.* Stannite has often been assumed to be a stanniferous fahlerz, and consequently to have the same crystalline form. It appears to have been Breithaupt (1830)[3] who first placed stannite in this systematic position, and assigned to it this type of symmetry.

Later, Breithaupt (1866)[4] mentioned large triakistetrahedra from Peru,

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[1] Traité de Minéralogie, 2nd Edit. 1822, Vol. IV, p. 170.

[2] English translation of Mohs' Mineralogy, 1825, Vol. III, p. 163.

[3] Uibersicht des Mineral-Systems, 1830, p. 75. Vollständige Char. d. Mineral-Systems, 3rd Edit. 1832, p. 275.

[4] Berg- und hüttenmänn. Zeitung, 1866, XXV, 181; and Min. Studien, 1866, p. 102

but these have since been shown[1] to be only tetrahedrite. In 1884 vom Rath[2] mentioned a similar large crystal, also from Peru, as existing in the collection of Mr. C. S. Bement, of Philadelphia. While on a visit to London, in December, 1899, Mr. Bement informed me that this crystal is very indistinct, and that it is no longer considered to be stannite.

More recently Stelzner[3] has described crystallised stannite from Potosi, Bolivia. The crystals are 5 mm. across and show the cubic forms $+o\{111\}$ and $-o\{1\bar{1}1\}$, with subordinate $d\{110\}$, $a\{100\}$ and $\kappa\{hkk\}$, but goniometric measurements do not appear to have been made. The crystals gave the blowpipe reactions of stannite, and a quantitative chemical analysis was made of the accompanying massive material. These crystals, which are the most distinct yet described, are stated by Stelzner to be frequently built up of sub-individuals: this suggests that they are probably only pseudo-cubic, and like the crystals to be described in the present paper.

(4) *Scalenohedral-Tetragonal.* Kenngott (1849)[4] considered stannite to be a stanniferous copper-pyrites, and remarked that Haidinger's cubes could equally well be considered to be tetragonal with the same symmetry as copper-pyrites. This view was supported by Delafosse.[5]

Of these types of symmetry the third—tetrahedral-cubic—is the one now generally accepted for the mineral. It will, however, be shown below that the crystals really belong to the fourth type, namely scalenohedral-tetragonal, but that by twinning the symmetry becomes pseudo-tetrahedral-cubic.

The specimen (Brit. Mus. No. 84686) which supplied crystals for the present investigation is from the San José Mine at Oruro, Bolivia; it was obtained by Sir W. Martin Conway, while on his Bolivian Expedition in 1898, and was, with several other Bolivian specimens,[6] presented by

[1] A. W. Stelzner, Zeits. Deutsch. geol. Ges. 1897, XLIX, 75; and Dana's System of Mineralogy, 6th Edit. 1892, p. 83.

[2] Verh. Ver. Rheinl. Bonn, 1884, XLI, 296; Compare A. W. Stelzner, Zeits. Deutsch. geol. Ges. 1897, XLIX, 75.

[3] Zeits. Deutsch. geol. Ges. 1897, XLIX, pp. 97, 131; abstract Min. Mag. 1898, XII, 46. Stelzner's crystals were first mentioned in Zeits. Deutsch. geol. Ges. 1892, XLIV, 531; abstract Min. Mag. 1893, X, 261.

[4] Min. Untersuchungen, 1849, I, p. 41; Kenngott's Uebersicht (1844-9), 1852, p. 237.

[5] Nouveau Cours de Minéralogie, 1860, II, 416.

[6] An account of this collection will be published as an Appendix to Sir Martin Conway's book, "Bolivian Andes."

him to the British Museum. This specimen consists of radiating groups of prismatic crystals of mispickel, on which are a few bright crystals of andorite and pyrites. Encrusting all these minerals is the stannite, which occurs abundantly as crystalline crusts and as isolated crystals. As a later encrustation are minute white globules of an undetermined mineral.

The occurrence of crystallised stannite at Oruro has been previously mentioned by d'Orbigny [1] but the only information given by him is: "On n'exploite à Oruro qu'un riche filon d'étain du sommet de la montagne; filon composé d'étain sulfuré presque pure, souvent cristallisé."

Crystallography.

The crystals average 1—1·5 mm. across; the largest is 3 mm. Many of them are irregularly aggregated in crusts and partly embedded, and are consequently difficult to decipher, but those which are more isolated show very distinctly the form illustrated in Fig. 3, Plate II. They have the appearance of cubic crystals, but on closer examination they are at once seen to be composite. The faces are usually striated and rough, and on the goniometer they give several scattered images. A first series of approximate measurements was not good enough to distinguish the angles from those of a cubic crystal, but at the same time it was observed that the striations and characters of the faces agree only with scalenohedral-tetragonal symmetry. A second series of measurements carefully made on the best crystals, however, showed that the angles also agree with tetragonal and not with cubic symmetry.

The inclined hemihedral (scalenohedral) character is not a striking feature, and was not at first noticed,[2] but when the crystals are examined closely the differences in adjacent octants may easily be seen (Figs. 1—4). In one set of (positive) octants the planes of $p\{111\}$ and $n\{211\}$ are bright and smooth and the edges sharp, while in the adjacent (negative) octants p and n are represented by rather larger faces, which are here rough. The faces of n being larger cause the pits (Fig. 3) in the negative octants to be shallower, owing to the exclusion in many cases of the faces of $c\{001\}$.

[1] Voyage dans l'Amérique méridionale, 1826—1833, Tome III, 3e Partie, Géologie, p. 129, 1842. Stelzner (*loc. cit.* p. 86) has doubted this occurrence, but without sufficient reason.

[2] The figures prepared for the preliminary account in Sir Martin Conway's book, "Bolivian Andes," represent the crystals as holohedral.

The forms[1] noticed on the crystals measured are given below; with the exception of *a d t u* they are well developed on all crystals.

c{001}. Bright and smooth. On crystals which are in part simple it is present as a rather large face (Fig. 1), but in the twinned groups it is only present as small faces, forming the deep pits (Fig. 3).

a{100}. Usually only represented by striæ on *z*{201}, but on crystals from one specimen (described on p. 64 below) it is present as a bright narrow face on the edge [*zz*].

m{110}. Bright, but usually deeply striated, owing to its oscillation with $+p\{111\}$ and $-p\{1\bar{1}1\}$. The twinning makes this the most prominent face on the crystals.

e{101}. Bright; striated horizontally.

z{201}. Deeply striated horizontally, the striæ reflecting light with *e*{101} and *a*{100}.

$+d\{114\}$. Very narrow planes on the edge between $+n$ and *c*; deeply striated parallel to this edge. Other reflections from striæ were obtained near the positions of {229} and {223} also in the positive octants.

$+n\{112\}$. Bright and smooth; small.

$+p\{111\}$. Bright and smooth; small. This and $+n$ are faintly striated parallel to their mutual intersection.

$+t\{221\}$. Observed only once as a very narrow striation on the edge $[+p,m]$.

$-n\{1\bar{1}2\}$. Dull and rough; rather larger than $+n$.

$-p\{1\bar{1}1\}$. Dull and rough; usually rather larger than $-p$, but sometimes quite small.

$+u\{423\}$. Minute bright faces in the zone [201, 111, 021]. On two crystals.

About a dozen crystals were measured on the goniometer, but reliable measurements could be obtained from only a few. Only portions of simple crystals can be observed, and it is not always easy to separate the reflections belonging to each individual. Even portions of crystals, which

[1] The letters adopted for the forms are those used in Dana's Mineralogy (6th Ed. 1892) for copper-pyrites. For these forms to be strictly analogous with those of copper-pyrites + and — would probably have to be interchanged.

are at first sight apparently simple, were usually found on more careful examination to show twin-lamellæ. The results of the measurements are:

	Measured.	Limits.	No. of edges.	Calculated.	Copper-pyrites (Haidinger).	Corresponding Cubic angles.
$ce = 001 : 101$	*44° 30′	42°24′ — 44°38′	10	—	44° 34⅓′	45° 0′
$cz = 001 : 201$	63 8	62 57 — 63 15	7	63° 2′	63 5½	63 26
$cd = 001 : 114$	19 9	18 — 20	8	19 9½	19 12½	19 28
$cn = 001 : 112$	34 44	34 16 — 35 4	9	34 48	34 52	35 16
$cp = 001 : 111$	54 15	54 1 — 54 38	19	54 16	54 20	54 44
$cm = 001 : 110$	89 57	89 54 — 90 2	9	90 0	90 0	90 0
$tp = 221 : 111$	16	—	1	15 57	15 55½	15 47¼
$en = 101 : 112$	29 46	29 41 — 29 52	4	29 42½	29 45	30 0
$ce' = 101 : 011$	59 35	59 30 — 59 40	2	59 25	59 30	60 0
$em = 101 : 110$	60 7	60 5 — 60 8	4	60 17½	60 15	60 0
$pu = 111 : 423$	15 11	15 0 — 15 18	3	15 8½	15 9	15 13½
$mm' = 110 : 110$	90 0	89 58 — 90 5	5	90 0	90 0	90 0

Twinning.—The most interesting feature of the crystals is the twinning, which gives rise to pseudo-cubic forms, and is invariably present. The two twin-laws are :—

(i) Interpenetrant symmetric twins with $e(101)$ as twin-plane, the two individuals being symmetrical to each other with respect to this plane.

(ii) Interpenetrant twins with the twin-axis perpendicular to $p(111)$ Also juxtaposed twins (Fig. 4) with the same twin-axis and $p(111)$ for the plane of combination.

The first law, on which every crystal is twinned, is illustrated by Figs. 2 and 3, and the stereographic projection, Fig. 5. The ideal simple crystal (Fig. 1), when reflected across the plane (011), gives the interpenetrating doublet shown in Fig. 2, and when also reflected across the homologous plane (101) the three interpenetrating individuals produce a figure closely resembling a regular rhombic dodecahedron in appearance (Fig. 3). In each octant three planes of the tetragonal sphenoid $p\{111\}$ come together, and correspond to the regular tetrahedron; these faces bound the edges of deep triangular pits formed by three faces of $n\{112\}$ and three faces of the basal planes $c\{001\}$, the latter being in the twinned position approximately parallel to the three faces of the cube. The prism

faces $m\{110\}$ of the simple crystals form the faces of the pseudo-dodecahedron, the edges of which are replaced by V-shaped grooves formed by the faces of $e\{101\}$. Owing to a frequent oscillation between $e\{101\}$ and $z\{201\}$, these grooves gradually widen out towards the pseudo-tetrad axes. Each pseudo-dodecahedral face m is very nearly parallel to four portions of two e faces in the opposite sides of the four grooves adjacent to it. The striations on these planes m and e, which are nearly parallel, and sometimes in the actual crystals nearly co-planar, are approximately at right-angles (really 90°42½′); and it was this character which suggested in the first place that the crystals could not be parallel groupings of cubic sub-individuals. Doublets resembling Fig. 2 are rarely present on the specimen, and there are always indications of a third individual. Crystals like Fig. 3 are common, and are often as symmetrically and regularly developed as shown in the drawing; in some cases they are developed on nearly all sides, one crystal showing six of the eight possible triangular pits. From the projection (Fig. 5)[1] it will be seen that in the two opposite octants XYZ and $\overline{X}\overline{Y}\overline{Z}$ the sphenoidal planes $p\{111\}$ of the three individuals are coincident, while in the two octants $\overline{X}\overline{Y}Z$ and $XY\overline{Z}$ all three planes of $p\{111\}$ are separate; in each of the remaining four octants two sphenoidal planes coincide and the third is separate. Each pole m of the pseudo-dodecahedron nearly coincides with two poles e, except in the positions (101) and (011) where there is only one pole e. Although approximating to cubic symmetry, it will be seen from the projection that there is only one plane of symmetry to the whole group of three crystals.

The following (p. 60) are the observed and calculated (from $ce = 44°30'$) angles, when the crystals are twinned on $e(101)$ and (011).

These measured and calculated angles are not in close agreement. The images were often scattered, and not very good; further, it was not always possible to distinguish to which individuals the various reflections belonged, especially when the crystals are further complicated by twinning on the second law.

It was not possible to distinguish between $c\bar{c}$ (or cc) and $\underline{c}\underline{\bar{c}}$, or between $\underline{p}\underline{p}$ (or $\underline{p}p$) and $p\underline{\bar{p}}$. Only on one crystal could more than one of the

[1] The angle ce in the projection has been taken as 43½°, instead of 44½°, in order to separate more distinctly the poles which nearly coincide. The poles of the crystal in the normal position are indicated by unbarred letters, those of the crystal twinned about (101) are indicated as $\bar{c}\,\bar{e}$, etc., and those twinned about (011) as $\underline{c}\,\underline{e}$, etc. The parallel planes beneath the plane of projection are omitted.

	Calculated.	Measured.
$p\bar{p}=p\underline{p}$	1° 38¼′	1°29′, 1°29′, 1°24′, 1°10′, 1°10′, 1°6′, 1°5′, 53′, 35′.
$p\underline{p}$	1 37½	
$c\bar{c}=c\underline{c}$	89 0	Numerous readings between the limits 89°11′ and 90°33′.
	91 0	
$c\underline{\bar{c}}$	89 59	
$m\underline{e}=\bar{m}\underline{e}=$etc.	0 52	
$e\underline{\bar{e}}=e\underline{e}$	2 0	
$\underline{e}\,\bar{e}$	1 25½	1°27′.

angles $p\bar{p}$, etc., in the same octant be fairly accurately measured: the results were 1°10′ and 1°6′. In the same pit the angles between the three planes of $c\{001\}$ were measured as 90°33′, 90°30′, 90°22′, and in another pit as 90°32′, 90°26′, 90°12′. The portions of the planes of $c\{001\}$ in adjacent octants are never quite parallel, the angles 43′, 25′, 20′, etc. being measured; even apparently single c planes in the same octant sometimes give two sharp images measured at 21′, 22′, etc. apart.

Twinning on the second law, in which the twin-axis is (111), though common, is not invariably present, as is twinning on the first law. The pseudo-dodecahedra (Fig. 3) described above give rise to the juxtaposed twin shown in Fig. 4, or two interpenetrate.[1] Twin lamellæ may also often be seen running through the crystals. As shown in Fig. 4, these are not symmetric twins as in the first law.

The calculation of the angles of crystals twinned on the second law is much simplified if it is assumed that the three twin-planes (101), (011) and (111) all have positive indices[2]; the twin-plane (111) will then be exactly coincident for all three simple individuals, and the twin-axis will be strictly parallel to the zone-axis of the pseudo-hexagonal zone formed by six m planes. Several planes of $e\{101\}$ will be slightly out of this pseudo-hexagonal zone, and when twinned on (111) they will form with each other across this zone angles of 1°38¼′; the corresponding measured values were 1°13′ and 1°10′. The prominent striations on the m faces make, in the twin crystals (Fig. 4), an angle of 108°31½′. It was not, however, possible to prove that the four twin-planes all have positive

[1] Compare the interpenetrating dodecahedra of argyrodite figured in Min. Mag. 1898, XII, 7.

[2] In Fig. 4 the twin-plane is $(\bar{1}11)$.

indices, and it is quite possible that another combination of homologous planes might account for the irregularities between the measured and calculated angles noted above.

The pseudo-cubic groups described above remind one of the pseudo-dodecahedra of phillipsite, and also of the several cubic minerals exhibiting optical anomalies; but in these cases the groupings are usually more complex than the twinning together of three tetragonal individuals.[1]

Physical Characters.

The colour of the stannite crystals is iron-black, with a bright metallic to sub-adamantine lustre, somewhat resembling black blende. On one specimen (described below) the crystals have a bronze-coloured tarnish on the surface. The mineral is opaque. The streak is black and dull. The crystals are not very brittle; H = 3½. The fracture is sub-conchoidal to uneven; no cleavage was observed.[2] Specific gravity 4·45.[3]

Chemical Composition.

The material collected for analysis consisted mainly of well-developed crystals projecting from the surface of the specimen, but some of the underlying crystalline material was also collected in the belief that it was all stannite; the latter, however, contained some andorite, as suggested by the results of the analysis, and as actually seen to be the case upon a further and more careful examination of the specimen.

The results of the analyses by Mr. G. T. Prior are given below under columns I-V. Analysis I was made on 0·3678 gram of material, which was decomposed with nitric acid; in II, 0·4215 gram was fused with sodium carbonate and sulphur, and the tin obtained in solution as sodium sulpho-stannate; for the sulphur determination (III) 0·2233 gram was fused with sodium carbonate and potassium nitrate. The mean of these analyses is given under IV. Germanium was tested for, but found to be absent:—

	I.	II.	III.	IV(Mean).	Atomic ratios.
Cu ...	28·58	28·54		28·56	·453
Fe ...	10·95	10·90		10·93	·197
Sn ...	25·52	24·90		25·21	·213
Sb ..	3·54	3·88		3·71	·031
Pb ...	2·02	2·09		2·06	·010
Ag ...	0·94	0·82		0·88	·008
S ...	—	—	27·83	27·83	·874
				99·18	

[1] Compare the pseudo-cubic crystals of iodyrite described in this number of the Magazine, p. 46.

[2] Crystals of Cornish stannite appear to possess cleavages, see pp. 54, 65.

[3] Calculated from the specific gravity of the material analysed (4·52) by deducting 8·58 per cent. of andorite (sp. gr. 5·35).

The atomic ratios of Sb, Pb and Ag are approximately those required by he andorite formula $PbAgSb_3S_6$; and the atomic ratios of Cu : Fe : Sn : remaining S = ·453 : ·197 : ·213 : ·814, agree approximately with the formula Cu_2FeSnS_4 for stannite. Under column V below is given the percentage composition of the stannite after deducting Sb_2S_3, PbS and Ag_2S. Column VI gives the calculated percentage composition required by the formula Cu_2FeSnS_4:—

		V.		VI(Cu_2FeSnS_4).
Cu	...	31·52	...	29·54
Fe	...	12·06	...	13·01
Sn	...	27·83	...	27·65
S	...	28·59	...	29·80
		100·00		100·00

This analysis, which is the first that has been made on crystallised stannite, therefore supports the empirical formula usually given for the mineral, namely Cu_2FeSnS_4.

This formula has been written by various authors in many different ways, of which only the following two need be mentioned here:—$Cu_4SnS_4 + Fe_2SnS_4$ represents an orthostannate, and $CuFeS_2 + CuSnS_2$ shows a possible relation to copper pyrites ($CuFeS_2$).

Relation between Stannite and Copper-pyrites.

The remarkably close crystallographic relation existing between stannite and copper-pyrites may now be pointed out. The type of symmetry—scalenohedral-tetragonal—is the same for both, and the angles are almost identical. The angular element (*ce*, 001 : 101 = 44°30′) given above for stannite lies between the usually accepted value for copper-pyrites, namely 44°34½′ (Haidinger), and that obtained by Mr. Fletcher[1] on crystals from Freiberg, Saxony, namely 44°22′. The crystal forms[2] and character of the faces are also similar. Further, the twin-laws[3] are the same, including the remarkable symmetric twins, of which very few examples are known among minerals. Pseudo-cubic crystals, as the

[1] Phil. Mag. 1882 [v], XIV, 287; Proc. Cryst. Soc. 1882, p. 126; Zeits. Kryst. Min. 1883, VII, 331.

[2] For the stannite forms to be strictly analogous with those of copper-pyrites + and — as given above, would probably have to be interchanged; if this is done all the stannite forms, with the exception of $-n\{1\bar{1}2\}$, have been noted on copper-pyrites.

[3] A third, but very rare, twin-law of copper-pyrites is represented by the complementary interpenetrant twins with $m(110)$ as twin-plane; this has not been observed on the stannite crystals.

result of twinning, have long ago been figured by Haidinger[1] for copper-pyrites, and one of his figures represents a pseudo-cubic crystal again twinned on $p(111)$ as in Fig. 4 above.

As far as crystallographic characters are concerned stannite and copper-pyrites are therefore practically identical; and, as pointed out above, a possible chemical relation is suggested when the formula of stannite is written in the form $CuFeS_2 + CuSnS_2$ (that of copper-pyrites being $CuFeS_2$). There is absolutely no evidence to support the possible suggestion that the crystals described in the present paper may be pseudomorphs of stannite after copper-pyrites: the implanted crystals are quite sharp and homogeneous, and not a trace of copper-pyrites was seen on any of the Bolivian specimens.

The supposed relation (p. 54) between stannite and fahlerz receives some support in the fact that the composite twinned crystals of stannite simulate the symmetry of fahlerz.

Other Specimens of Crystallised Stannite.

Oruro, Bolivia.—Besides the specimen described above there are three others, brought by Sir Martin Conway from Oruro, on which are crystals of stannite. As the characters of the stannite and the associated minerals are somewhat different in each of these a brief description is now given.

The largest specimen (Brit. Mus. No. 84687) consists of a matrix of massive quartz, pyrites and tetrahedrite, with the free surface, measuring about 28×23 cm., covered with good crystals of augelite,[2] mispickel, quartz and pyrites, together with some powdery kaolinite and minute yellow globules of cervantite (?). On this surface are abundant drusy black crusts of stannite, but the form of the minute crystals cannot, as a rule, be made out even under the microscope. On parts of the specimen, however, where the stannite is more coarsely crystallised, the characteristic twinning described above can sometimes be distinguished. Small cavities at the back of the specimen contain good crystals of wolfsbergite,[3] andorite and stannite, the last like Fig. 3.

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[1] Memoirs Wernerian Nat. Hist. Soc. Edinburgh, 1822, Vol. IV. p 17, Figs. 37-41; Edinb. J. Sci. 1825, Vol. III, Plate III, Figs. 29, 32, 34. Two of Haidinger's figures are reproduced in Mr. Fletcher's paper (*loc. cit.*).

[2] This is the fourth locality at which the rare mineral augelite has been found. Compare Min. Mag. 1898, XII, p. 1.

[3] This is a new locality for the rare mineral, wolfsbergite (=chalcostibite). Compare Min. Mag. 1897, XI, 338. These occurrences are described in the Appendix to Sir Martin Conway's book, "Bolivian Andes."

Another specimen (No. 84689) consists of an aggregate of jamesonite needles encrusted with small crystals of pyrites and stannite, the latter showing the complex twinning.

On the fourth specimen (No. 84684) some of the stannite crystals are of quite a different type. This is from the San José mine, and is a large piece of massive tetrahedrite with massive quartz and pyrites. One cavity is almost completely lined with crystals of stannite, which have a bronze coloured tarnish on the surface; they are about a millimeter across, and are confusedly grown together forming a crust. The faces are bright, and smoother than those of the crystals described above. Two of the partially embedded crystals were measured on the goniometer; each showed one large plane of the form $m\{110\}$, surrounded at the edges by smaller faces of $z\{201\}$, $a\{100\}$, $e\{101\}$ and $n\{112\}$. They are twinned on $p(111)$, one crystal being twinned on two planes of this form: no twinning on the plane $e(101)$ was detected on these crystals. Other cavities in this specimen contain black crystals of stannite, like those figured above, together with crystals of wolfsbergite, andorite, quartz and pyrites.

Potosi, Bolivia.—A small specimen (No. 84075) from this locality was supplied to the Museum in 1898 by Messrs. G. L. English and Co. of New York. It consists of massive quartz, pyrites and tetrahedrite, with crystals of quartz, mispickel and stannite in cavities. The stannite crystals are black with a brilliant metallic to sub-adamantine lustre; they are very small and closely aggregated together. On the goniometer only approximate measurements could be obtained; all that could be determined was a triangular face bounded at the edges by three narrow planes at angles of about $35\frac{1}{4}^{\circ}$ with the triangular face. The triangular faces gave two, three or more images (one pair at 48′ apart), but no pits, as shown in Fig. 3, were seen. The crystals are too imperfect to show whether they are pseudo-cubic, or cubic with the forms $o\{111\}$ and $d\{110\}$.

The association of minerals on this specimen is the same as on the specimen from Potosi described by Stelzner (p. 55), but his crystals of stannite were larger and probably more distinct.

Tatasi, Bolivia.—This specimen (No. 84324) from the Carmen vein in the silver mine at Tatasi, prov. Sud-Chichas, dept. Potosi, was presented to the Museum by my friend Mr. Malcolm Roberts, A.R.S.M., Administrator of Mines to the Compañia Guadalupe de Bolivia The matrix is a white, altered volcanic tuff with blebs of quartz and numerous veins and specks of pyrites. On the free surface are crystals of quartz, pyrites and stannite, the last being in very indistinct rounded crystals or groups

of crystals, up to 3 mm. across, with a black drusy surface. The stannite encrusts pyrites, and sometimes there is only a shell of material enclosing pyrites. The most distinct crystal appears to be cubic with the form of a deltoid-dodecahedron $\kappa\{hhk\}$, and it further appears to show signs of being composite like the Oruro crystals described above.

Cornwall.—Only two of the several specimens of Cornish stannite in the British Museum show any signs of crystals; and these are similar to the imperfect crystals mentioned by Haidinger in 1825 (see p. 54 above). The specimens, which are labelled Cornwall (No. 19109) and Wheal Rock, St. Agnes (No. 33475), consist of compact granular stannite, showing in places indications of a poor cleavage; the colour is dark steel-grey, with a yellowish tinge owing to the presence of intermixed copper-pyrites. On the walls of cavities in the massive material are a few distorted cubes or short square prisms of stannite, which measure up to 2 mm. in cross-section; a few crystals are much elongated and measure $8 \times 1 \times 1$ mm. The faces of these crystals are very dull and uneven, and are encrusted with numerous minute crystals of copper-pyrites. Approximate measurements on the goniometer gave angles of about 90°. There appears to be a fair cleavage perpendicular to the length of the prism, and possibly another cleavage parallel to the faces of the prism. These crystals may therefore be tetragonal with the basal pinacoid and one prism. The colour of the crystals is the same as of the massive material, and the streak is dull black.

Crystals from all the specimens mentioned above were examined chemically by Mr. Prior, and in each case found to contain copper, iron, tin and sulphur.

EXPLANATION OF PLATE II.

Fig. 1.—An ideal simple, scalenohedral-tetragonal crystal of stannite, with the forms. $c\{001\}$, $m\{110\}$, $e\{101\}$, $z\{201\}$, $+p\{111\}$, $-p\{1\bar{1}1\}$, $+n\{112\}$, $-n\{1\bar{1}2\}$.

Fig. 2.—The same twinned on (011).

Fig. 3.—The same twinned on (011) and (101), producing a pseudo-cubic compound crystal.

Fig. 4.—A pseudo-cubic crystal, as in Fig. 3, further twinned on $p(\bar{1}11)$.

Fig. 5.—Stereographic projection of Fig. 3 (*see* footnote on p. 59).

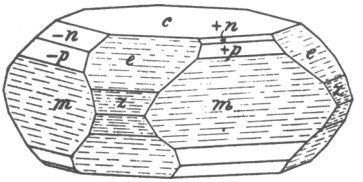


Fig. 1.

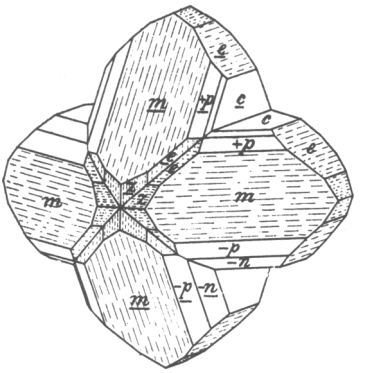


Fig. 2.

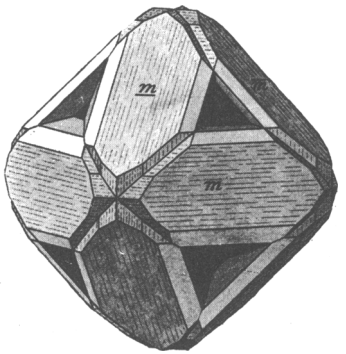


Fig. 3.

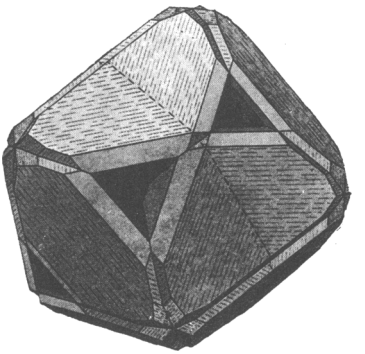
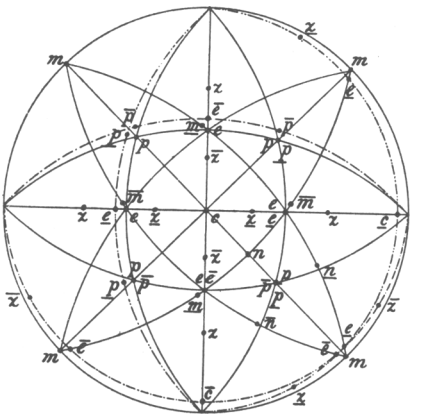


Fig. 4.



L. J. S., *del.*

Fig. 5.

L. J. SPENCER: STANNITE FROM BOLIVIA.