The Identity of Andorite, Sundtite and Webnerite.

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I. Historical and Introductory.

On November 14th, 1892, Prof. J. A. Krenner[1] read before the Hungarian Academy of Sciences an account of a new silver ore from Felsőbánya, to which he gave the name of Andorite. It was described as orthorhombic with $a : b : c = 0{\cdot}97756 : 1 : 0{\cdot}86995$, and as having the chemical composition $2PbS.Ag_2S.3Sb_2S_3$.

At a meeting of the Scientific Society of Christiania, held on December 9th of the same year, Prof. W. C. Brögger[2] gave a description, under the name of Sundtite, of a mineral from Oruro, Bolivia. An analysis by G. Thesen gave to it the formula $(Ag_2,Cu_2,Fe)S.Sb_2S_5$, while crystallographic measurements showed it to be orthorhombic with

$$a : b : c = 0{\cdot}677107 : 1 : 0{\cdot}445786.$$

The angular measurements agree completely with those of Krenner for Andorite; but, not being aware of this, Brögger chose different para-

[1] "Andorit, uj hazai ezüstérez." *Mathematikai és természettudományi Értesitő*, XI. 119-122, 1892. German abstracts of this paper ("Andorit, ein neues ungarisches Silbererz") are given by A. Schmidt in *Zeits. Kryst. Min.* XXIII. 497-499, 1894, and in *Földtani Közlöny*, XXV. 258-259, 1895.

[2] "Sundtit, et nyt mineral fra Oruro i Bolivia." *Forhandlinger i Videnskabs-Selskabet i Christiania*, for 1892, No. 18, 1893; and *Zeits. Kryst. Min.* XXI. 193-199, 1893.

meters. The exact locality in Oruro of Brögger's Sundtite has been given by Dr. R. Pöhlmann[1] of Santiago as the Itos mine.

In 1894 the late Prof. A. W. Stelzner,[2] of Freiberg in Saxony, gave the results of an examination which had been made in 1889 of a mineral from the same mine at Oruro. An analysis by Dr. P. J. Mann gave to this mineral the formula $2\frac{1}{2}(PbS.Sb_2S_3)+Ag_2S.Sb_2S_3$, and accordingly it was described as an argentiferous zinckenite, for which the variety name of Webnerite was proposed. The crystals at Stelzner's disposal were not suitable for crystallographic determination, and the publication of his results was therefore deferred in the hope of better material being obtained. It was only when struck by the similarity in some of the characters of "Sundtite," as described by Pöhlmann, and the mineral he himself had examined, that he was induced to publish his paper, and in it to throw out the suggestion that some of the "Sundtite" described by Pöhlmann might possibly be "Webnerite."

Krenner's paper on Andorite appears to have escaped the notice of Stelzner, otherwise he would have observed that "Webnerite" has essentially the same chemical composition as Andorite.

In the present paper it will be shown:

1. That Andorite, Sundtite and Webnerite, which have been independently described as distinct mineral species, are in fact identical.

2. That Krenner's determination is the correct one for the species.

3. That "Sundtite" was correctly described crystallographically, but wrongly chemically.

4. That "Webnerite," in being called an argentiferous zinckenite, was incorrectly placed crystallographically, though accurately determined chemically.

In such a case it is clear that the slightly older name Andorite is the only one that can be retained for the species.

The identity in the first place of "Sundtite" and "Webnerite" was suggested to us by the examination of a specimen "from Hungary" in the British Museum collection, which, on examination, was found to have the chemical composition of "Webnerite," but the crystallographic characters of "Sundtite." A re-examination, therefore, of the original material described by Brögger and Stelzner appeared to be necessary, and through the kindness of Prof. Brögger on the one hand, and Prof.

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[1] "Notizen über Sundtit von Oruro in Bolivia." *Zeits. Kryst. Min.* XXIV. 124-125, 1894.

[2] "Bemerkungen über Zinckenite von Oruro in Bolivia." *Zeits. Kryst. Min.* XXIV. 125-127, 1894.

Weisbach on the other, this was rendered possible. The result of our examination of these specimens was to show that both were identical with the specimen "from Hungary." It was not until we had completed this work that we happened to notice Krenner's paper, and saw that the mineral "from Hungary" was a specimen of Andorite, and that consequently Andorite, "Sundtite" and "Webnerite" were identical.

II. The British Museum Specimen of Andorite "from Hungary."

The small specimen on which the mineral was found consists of a fragment of argillaceous rock, veined with quartz and pyrites, and containing a few minute cubes of the latter mineral. On one side is a bed of white quartz with a crystallised surface, and on this are distributed a few small crystals of Andorite. Some of these crystals rest only on the apices of the quartz crystals with scarcely any point of attachment, in which case they are completely and symmetrically developed on all sides, while others are more firmly attached and intergrown in the matrix. On the free surface of the specimen the following crystallised minerals were also found, but only in very small amount. Fluorite in minute colourless cubes with small $m\{311\}$ occurs in small groups with yellowish siderite. In one or two cavities are a few delicate hairs having the appearance of the plumosite variety of jamesonite. The fluorite contains a few black acicular enclosures, possibly of the same mineral. Mispickel is represented by one or two very minute prismatic crystals. A few specks of copper pyrites were found, in one case enclosed in Andorite. Lastly, a few minute hexagonal plates may possibly be referred to stephanite. All these minerals are of later formation than the Andorite, which is itself later than the quartz.

All the information we possess as to the locality of the specimen is that it was entered in the Museum register in 1861 as from Hungary; but this locality may possibly have been ascribed to it only because it was then thought to be freieslebenite.

The Andorite crystals are 1—3 mm. in length, have a dull black, often drusy surface, and are much striated and rounded, but are always symmetrically developed. All the crystals have the same short prismatic habit (fig. 1, p. 294), which closely resembles that of freieslebenite. Only rarely is seen a bright surface with a steel-grey colour and metallic lustre. The fracture is smooth and conchoidal, with a curious strong metallic lustre (rather like that sometimes shown by crystals of tetra-

hedrite and bournonite), and an iron-black or dark steel grey colour. There is no cleavage. The mineral is opaque, brittle, and easily crushed to powder. The streak is black and shining, but the fine powder is dull. The hardness is a little over 3, as the mineral scratches calcite with difficulty, and is itself easily abraded when rubbed on fluorite.

The density (weight of 1 cc.) is 5·33, at 19° C. as determined on 0·2152 gram of the material collected for analysis.

Crystallographic Characters (L.J.S.).—Orthorhombic,[1] with the forms :—

$a\{100\}$, $b\{010\}$, $n\{210\}$, $i\{430\}$, $m\{110\}$,
$l\{230\}$, $k\{120\}$, $y\{031\}$, $t\{091\}$.

Brögger's parameters and letters are here used. The following results were obtained from the measurement of 17 crystals and fragments with the δ eye-piece of the Fuess goniometer.

	Limits of measured angles.	No. of edges.	Mean.	Calculated (Brögger).	Measured (Krenner).
$ba = 010 : 100$	88° – 92°	17	90° 6′	90° 0′	90°0′
$bn = 010 : 210$	69½° – 74°	36	72° 2½′	71°18′	—
$bi = 010 : 430$	61° – 67°	6	63°53′	63° 5′	—
$bm = 010 : 110$	55°13′ – 59°11′	35	56°13′	55°54′	55°32′
$bl = 010 : 230$	42¾° – 46°54′	37	45° 0½′	44°33′	44°21′
$bk = 010 : 120$	34°54′ – 37°58′	12	36° 8½′	36°27′	36°28′
$by = 010 : 031$	35° – 41°	29	37°58½′	36°47½′	36°58′
$yy' = 031 : 03\bar{1}$	75°26′ – 77°	9	75°59′	73°35′	—
$bt = 010 : 091$	13°16′ – 15°26′	4	14° 8′	14° 0′	—
$ya = 031 : 100$	90° about	3	90° 0′	90° 0′	—
$yn = 031 : 210$	75° – 76°	8	75°30′	75° 7′	—
$ym = 031 : 110$	62½° – 64°40′	5	63°23′	63°19′	—
$yl = 031 : 230$	55° – 56½°	4	55°30′	55°12′	—
$yk = 031 : 120$	49½° – 49°33′	2	49°31′	49°53½′	—

The faces of the crystals are so rough that only approximate measurements could be obtained. The macropinacoid and prisms are rounded and very deeply striated parallel to the vertical axis, so that between k (120) and $k(1\bar{2}0)$ there is a continuous band of images, with brighter portions at the positions of $a\ n\ i\ m\ l\ k$; between k and b there are no images.

[1] Before the idea of the identity of the mineral with Sundtite and Andorite had been entertained, the axial ratios were deduced from the angles $bn = 72°2\frac{1}{2}'$ and $by = 37°58\frac{1}{2}'$, as $a : b : c = 0·324 : 1 : 1·281$.

The faces of the form $y\{031\}$ are very rough, having a pitted and drusy surface, so that generally only maximum light readings could be obtained. The faces of the form $b\{010\}$ are often brighter, but are striated and rounded horizontally; they are sometimes represented by two or more distinct planes forming a very obtuse salient or re-entrant angle, and several images were seen at 3° to 9° from the true position of b in the zone [100]; this could not be made to agree with any twinning on the assumption that the crystals were monosymmetric.

The habit of the crystals, which is remarkably constant and symmetrical, is shown in fig. 1 (p. 294). In the figure the prisms have been drawn as distinct faces, but on the actual crystals this is only sometimes the case, and then only with k and l. Not infrequently two crystals are intergrown, but no twin law could be discovered.

Chemical Composition (G. T. P.).—As the total amount of material on the single specimen was very limited, only 0·2073 gram was available for analysis. This consisted for the most part of measured crystals, from which the drusy material on the y (031) faces was scraped off as far as possible.[1] The mineral is easily fusible, and is decomposed by hydrochloric acid.

In the quantitative analysis, the finely powdered mineral, dried at 100° C., was weighed into a porcelain boat, and decomposed in a current of chlorine. Only a gentle heat, with a spirit lamp alone, was applied, so that no volatilisation of lead chloride or ferric chloride occurred. After the decomposition in chlorine, the non-volatile chlorides were transferred to a porcelain dish and digested with boiling water, to which a little nitric acid was added. The silver chloride was filtered off, and the filtrate was evaporated down with sulphuric acid; alcohol was then added, and the lead weighed as lead sulphate. In the filtrate the copper was precipitated by sulphuretted hydrogen, and then the iron, after oxidising with bromine water, with ammonia.

The volatile chlorides were absorbed by water containing hydrochloric and tartaric acids. The solution was transferred to a beaker and warmed gently for some time to expel the chlorine. The sulphur was then precipitated as barium sulphate. The filtrate was evaporated down to expel excess of acid and the slight precipitate obtained on dilution added to the rest of the barium sulphate, which was afterwards purified by digestion in hydrochloric acid in the usual manner. In the filtrate the excess of

[1] This drusy material sometimes showed hexagonal outlines under the microscope, and it is possibly the same mineral as that referred to stephanite above.

barium was removed by means of sulphuric acid. The antimony was then precipitated by sulphuretted hydrogen, and, after washing with alcohol and carbon bisulphide and heating to 260°-270° in a current of carbon dioxide, was weighed as trisulphide. The filtrate from the sulphide of antimony contained scarcely a trace of iron.

The mineral was tested for arsenic by the Fresenius-Babo method, but with negative result.

The results of this analysis, given in Column I below, agree with the formula $2PbS.Ag_2S.3Sb_2S_3$ (see IX p. 298).

		I.	II.		III.
Pb	...	21·81	0·923		22·07
Ag	...	11·73	0·943	1·042	11·31
Cu	...	0·73	0·099		0·69
Fe	...	1·45	0·022		0·70
Sb	...	41·76	3·002		41·91
S	...	22·19	6·000		23·32
Insoluble	...	—			0·04
		99·67			100·04

I. The present analysis of Andorite "from Hungary," made on 0·2073 gram.

II. The atomic ratios of the same with S=6.

III. J. Loczka's analysis of Krenner's Andorite from Felsőbánya, Hungary. The 0·70 per cent. of iron includes some zinc and manganese.

The close agreement in the measured angles and in the chemical composition shows the identity of our mineral with Krenner's Andorite.

The above description was written before we had read Krenner's paper. We have preferred to leave it in its original form, since the locality of our specimen is somewhat doubtful, and the associated minerals are not the same as those on Krenner's material.

III. Krenner's Andorite.

Krenner's description of the characters of Andorite is in close agreement with the preceding description of the British Museum specimen.

The only important difference is the good cleavage parallel to $b(010)$[1]

[1] $=a(100)$ of Krenner.

noted by him. We have not seen the material described by Krenner, but no cleavage is shown by any of the Andorite ("Sundtite" and "Webnerite") specimens which we have examined. It may, however, be mentioned that while measuring our crystals, indistinct images were sometimes obtained from small points or irregular fractures in approximately the positions of $c\{001\}$ and $b\{010\}$, which may indicate the existence of imperfect cleavages in these directions. Krenner gives the fracture as uneven, and does not mention the characteristic conchoidal fracture. The specific gravity in the original paper is stated to be 5·541, but in the abstracts by Schmidt it is given as 5·341, which is very close to the value obtained by us. The analysis published by Krenner is quoted in Column III above.

With Brögger's position of the crystals and parametral plane, Krenner's[1] measured angles $bl = 44°21'0''$ and $bx = 66°0'46''$ give the axial ratios $a : b : c = 0{\cdot}68197 : 1 : 0{\cdot}44496$, and his forms will then be—

$a\{100\}$, $b\{010\}$, $m\{110\}$, $l\{230\}$, $k\{120\}$, $u\{130\}$
$\{x011\}$, $\gamma\{021\}$, $y\{031\}$, $q\{221\}$, $r\{121\}$, $\beta\{131\}$.

Of these forms, $u\{130\}$ [$=n\{210\}$ of Krenner] is not elsewhere recorded.

Brögger's parameters and letters for the forms are the ones here adopted, since his measurements are the more accurate.

IV. Brögger's "Sundtite."

In presenting to the Museum, and thus with great liberality placing at our disposal, about half of the original crystallised material, Prof. Brögger states that Thesen's analysis was not made on the actual material which was measured, and that it is therefore possible that the crystals have not the composition assigned to them by that analysis.

The four small fragments which we have examined consist of an aggregate of bright, well-developed crystals of Andorite and pyrites, the latter being mostly of earlier formation. Scattered over both of these, and partly embedded in them, are small crystals of pyrites; and later still are minute globules of a yellow incrusting mineral, which sometimes completely coats the surfaces of the crystals.[2] There are also a few small aggregates of an

[1] Krenner interchanges $a\{100\}$ and $b\{010\}$; his parametral plane would be (463), which is not an observed form.

[2] The amount of this was too small to make a satisfactory determination of the chemical composition possible. Pöhlmann mentions antimony oxide as a yellow powder dusted over the crystals.

orange-red coloured mineral, and a few black needles with a metallic lustre; similar needles are called stibnite by Brögger, jamesonite by Pöhlmann, and zinckenite by Stelzner, whose determination is based on an analysis. The larger and earlier crystals of pyrites are octahedral in habit, with small cube, $a\{100\}$, and pyritohedral, $\pi e\{210\}$, planes, and are of interest as apparently showing, in addition to the direct form, $é\{210\}$, the inverse form, $e\{120\}$, together with what is apparently the rhombic dodecahedron, $d\{110\}$; but when the crystals are placed on the goniometer, these are seen to be due to frequent oscillations between $a(100)$ and $é(210)$. The smaller crystals of pyrites have a rather different habit, being cubes or cubo-octahedra with small $\pi e\{210\}$.

The Andorite crystals are, as described by Brögger, very bright and rich in faces. The habit is somewhat varied; some of the crystals are thick-tabular parallel to the orthopinacoid $a(100)$, as in Brögger's figure, others are of the same habit as the Hungarian crystals (fig. 1, p. 294), and some have the pyramids in the zone [110, 001] largely developed, as shown in fig. 2. The basal plane is comparatively rare, and, when present, is usually quite small, so that the habit shown in fig. 2 is rather exceptional. The mineral has a steel-grey colour with bright metallic lustre; the powder is black and dull. It is very brittle, and has a smooth conchoidal fracture; it scratches calcite with difficulty. The density (weight of 1 cc.), determined on 0·4778 gram of the material used for analysis, was found to be 5·377 at 20° C.

The following crystallographic determinations were made on the material which was collected for the analysis; most of the fragments which showed crystal faces being measured in order to make certain of the identification of the mineral. The best crystals were not measured, but left intact on the specimens to represent the mineral in the collection; it is therefore probable, as pointed out by Brögger, who measured two crystals, that future measurements will add considerably to the list of forms. On the 15 crystals and fragments so measured the following 37 forms were detected:—

Pinacoids.	Prisms.	Macrodomes.	Brachydomes.	Pyramids.	
a 100	ϕ 610	h 102	x 011	v 112	δ 364
b 010	ψ 510	θ 305	ν 043	χ 223	r 121
c 001	n 210	σ 203	π 032	p 111	ε 362
	o 320	κ 405	γ 021	z 332	ω 132
	m 110	f 101	y 031	q 221	β 131
	l 230	e 302		ρ 331	a 162
	k 120	λ 301			ζ 2.21.7
		μ 902			s 211

Brögger's $g\{250\}$ and $d\{601\}$, and the Hungarian forms $i\{430\}$, $n\{130\}$ and $l\{091\}$ were not observed on these crystals. With these the total number of forms which have been observed on Andorite is 42.

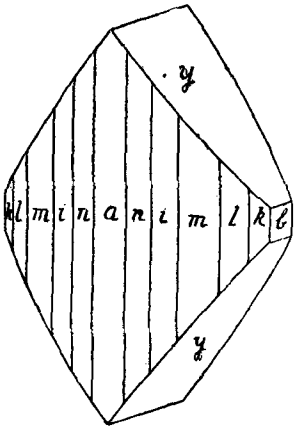

FIG. 1.

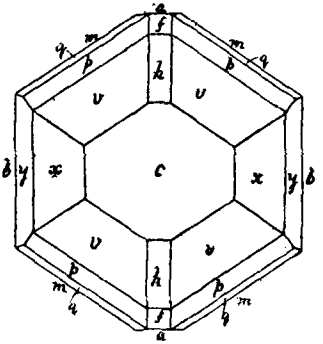

FIG. 2.

The individual crystals showed the following forms:—

1. abc, $nmlk$, hf, $x\gamma y$, vqp, $r\omega\beta a$. A rough, unsymmetrical crystal; the basal plane is a mere point.

2. bc, $h\theta\sigma f$, $x\pi\gamma y$, $v\chi pq$, $\delta r\varepsilon\omega\beta\zeta$. This crystal is represented in fig. 2; it is only a fragment off the top of a small crystal.

3. ab, $nmlk$, $x\pi\gamma y$, and small pyramidal planes: habit as in fig. 1.

4. a, nml, fe, $x\gamma y$, $v\chi pq$, rs. An unsymmetrical crystal with a large r plane.

5. ab, nml, $x\nu\pi y$, and pyramids.

6. ab, nml, $x\pi y$, pzq.

7. ab, nml, $h\sigma\kappa fe\lambda\mu$, xy, vpq, $\delta r\omega\beta s$. Like fig. 2 without the basal plane.

8. ab, ψnom, $h\sigma fe\lambda\mu$, and pyramids.

9. c, m, he, y, $vpqp$, ωs, &c. Like fig. 2, but with the basal plane very small.

10. ab, ϕnm, y, and pyramids.

11 and 12. ab, $nmlk$, and brachydomes. Fig. 1.

13. ab, nml. 14. a, nm. 15. a, n.

The measured angles establishing the new forms are:—

	Calculated (Brögger).	Measured (L. J. Spencer).
$a : \phi(610)$	6° 26′	6°51′. A narrow plane on crystal No. 10.
$a : \psi(510)$	7 43	7°35′. Narrow plane on No. 8.
$a : o(320)$	24 17½	23°, 24°. Striæ on No. 8.
$a : \theta(305)$	68 27	[21°26′], [22°]. Very small on No. 2.
$a : \sigma(203)$	66 18	66°42′, 67°, [23°]. Narrow plane and striæ on Nos. 2, 7 and 8.
$a : \kappa(405)$	62 13½	61°59′. Narrow plane on No. 7.
$a : \lambda(301)$	26 51	27°10′, 26°54′, 27°. Narrow planes on Nos. 7 and 8.
$a : \mu(902)$	18 29	18°35′, 18½°. Narrow plane and striæ on Nos. 7 and 8.
$b : \nu(043)$	59 16½	59°30′. Striæ on No. 5.
$b : \pi(032)$	56 14	56°14′, 57°, [33°19′], [33½°]. Striæ on Nos. 2, 3, 5 and 6.
$c : \chi(223)$	27 55½	27°45′. Narrow planes on Nos. 2 and 4.
$m : \rho(331)$	22 45	22°52′, 22½°. Narrow planes and spots on Nos. 1 and 9.
$c : \delta(364)$	39 44	39°26′, 40°. $\pi\delta = 22°17′, 22¼°$ (calculated 22°16′). On Nos. 2 and 7.
$c : \varepsilon(362)$	58 58	59°5′. $y\varepsilon = 30°37′$ (calculated 30°31′). On No. 2.
$h : a(162)$	51 47½	51°49′. On No. 1.
$y : \zeta$ (2.21.7)	6 26	6°23′. A narrow plane between $\beta(131)$ and $y(031)$. On No. 2.

In the above list, the angles are enclosed in square brackets when the measured angle is the complement of the given calculated angle. The new pyramids $\delta\varepsilon a\zeta$ are represented by very small, bright, unstriated planes, giving sharp images, and several good measurements were obtained besides those given above; they lie in several zones on the crystals, e.g. [120, 001], [100, 032], [100, 031], [010, 102] etc., as is shown on the stereographic projection, fig. 3.[1]

[1] On this projection all the forms of Andorite, with the exception of $u\{130\}$, are represented.

Most of the forms noted by Brögger are present as well-developed planes, giving measured angles closely agreeing with the calculated values. Some of the best measurements obtained are—

	Calculated (Brögger).	Measured (Brögger).	Calculated (Krenner).	Measured (L. J. Spencer).
$vv' = 112 : 1\bar{1}2$	*23°54½′	*23°54½′	23°53′	23°56′, 23°59½′, 24°3′
$vv'' = 112 : \bar{1}\bar{1}2$	43 32	—	43 6	43 25
$hh' = 102 : \bar{1}02$	36 26½	36 28	36 8	36 33
$xx' = 011 : 0\bar{1}1$	48 3	48 1½	47 58½	48 1, 47°58′

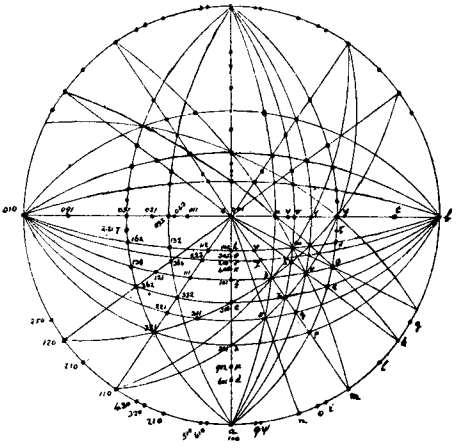

Fig. 3.

With the exception of Nos. 2 and 9, all the above crystals were used for the analysis, and in the collection of more material the characteristic bright conchoidal fracture of the mineral was relied upon. As far as could be seen the only impurities present in the material collected were minute crystals of iron pyrites, which were scattered like dust throughout the Andorite crystals, and so small that they were only visible under the microscope or with a high-power lens; two or three sharp bright cubo-octahedra of pyrites were large enough to be picked out. That this impurity could have been only small in amount is seen by the low per centage of iron shown in the analysis. The methods adopted in the analysis were the same as those described on p. 290. The results given in Column IV below agree closely with the formula $2PbS.Ag_2S.3Sb_2S_3$; thus proving the identity of "Sundtite" with the Hungarian mineral.

		IV.	V.		VI.
Pb	...	24·10	1·013		trace
Ag	...	10·94	0·879	0·975	11·81
Cu	...	0·68	0·096		1·49
Fe	...	0·30	0·043		6·58
Sb	...	41·81	2·990		45·03
S	...	22·06	6·000		35·89
		99·39			100·80

IV. The present analysis of Brögger's "Sundtite" from Oruro, made on 0·4956 gram (G. T. Prior). No trace of arsenic was detected by the Fresenius-Babo test.

V. The atomic ratios of the same with S = 6.

VI. G. Thesen's analysis, which was given by Brögger as representing the composition of "Sundtite." In the original paper no details are given as to the methods of analysis or of the material used; but, as stated above, Prof. Brögger has informed us that the analysis was not made on measured crystals, and that the material handed over for chemical investigation was all used up in the analysis. The specific gravity of 5·50 was determined on this material. Under these circumstances it is useless to criticise the results, but it may be suggested that the iron was present as pyrites.

V. Stelzner's "Webnerite."

The specimen kindly presented to the British Museum by Prof. A. Weisbach consists of one of the indistinct crystals from Stelzner's original specimen in the collection of the Berg-Akademie at Freiberg. The smooth conchoidal fracture with strong metallic lustre, and the other characters which could be directly observed are in agreement with those of the Hungarian mineral. The striated zone of prisms gave a continuous band of images with brighter parts corresponding to the positions of $a(100)$, $n(210)$ and $i(430)$, as is shown by the following rough measurements:—

	Calculated.	Measured (L. J. S.).
$an = 100 : 210$	18°42′	$16\frac{1}{2}°$, 17°, 18°
$ai = 100 : 430$	26°55′	27°, 27°, $27\frac{1}{4}°$

Rough faces of the form $y\{031\}$ also seem to be present.

These crystallographic measurements, when considered in connection

with the chemical composition as quoted in Column VII below, are enough to show that "Webnerite" is identical with Brögger's "Sundtite" from the same locality, and with Andorite.

Stelzner gave to "Webnerite" the formula $2\frac{1}{2}(PbS.Sb_2S_3)+Ag_2S.Sb_2S_3$. But, as shown below, when the copper is taken as replacing silver, and when the iron is considered to be present as pyrites, the numbers obtained in the analysis agree just as closely with the simpler formula $2(PbS.Sb_2S_3)+Ag_2S.Sb_2S_3$.

		VII.	VIII.		IX.	X.
Pb	...	24·30	1·004		23·81	25·53
Ag	...	10·25	0·812	0·900	12·42	10·65
Cu	...	0·65	0·088		—	—
Fe	...	0·53	—		—	—
Sb	...	40·86	2·896		41·63	41·66
S		23·10	6·000		22·14	22·16
		99·69			100·00	100·00

VII. P. J. Mann's analysis of Stelzner's "Webnerite" from Itos mine, Oruro, Bolivia.

VIII. The atomic ratios of the same with S = 6, after deducting iron and the corresponding amount of sulphur, as pyrites, FeS_2.

IX. The calculated percentage composition of $2PbS.Ag_2S.3Sb_2S_3$.

X. The calculated percentage composition of $2\frac{1}{2}(PbS.Sb_2S_3)+Ag_2S.Sb_2S_3$.

VI. Other Specimens of Andorite from Oruro; Occurrence of Alunite.

In the British Museum are two other specimens of Andorite from Oruro, which may be described here. One of these is labelled "Sundtit, Mina Itos, Oruro," by T. Hohmann of Valparaiso, by whom it was sent to Europe, his authority for the locality being Pöhlmann's paper. This shows rather indistinct crystals of Andorite, of the habit represented in fig. 1, with cubo-octahedra of pyrites, on a matrix of decomposing massive pyrites and quartz. Some of the massive Andorite is mixed with pyrites, and does not seem to be very pure. There is a small radiated group of acicular crystals which may be jamesonite, zinckenite, or stibnite.

White crystalline *alunite* occurs, coating parts of this specimen. It consists generally of a loose aggregate of minute crystals, but in places

it is more compact. This occurrence of alunite is very similar to that recently described by E. B. Hurlburt[1] from the National Belle mine, Red Mountain, Ouray Co., Colorado. Under the microscope the material is seen to consist wholly of sharply developed crystals rather more than 0·01 mm. in diameter. Each crystal consists of a rhombohedron truncated by the basal planes as in Hurlburt's figure, but here the basal planes are always triangles and the outlines of the crystals are hexagons. When the crystals rest on a basal plane they are isotropic, but they are too small to give an interference figure in convergent polarised light. The chemical reactions were in agreement with alunite, which is a hydrated basic sulphate of aluminium and potassium. The mineral gave a good potassium flame which was not masked by sodium, as would be the case with the Red Mountain material in which half the potassium is replaced by sodium. Coating some of these crystals, as well as other parts of the specimen, is a cherry-red powder, which, as it contains iron, is probably turgite. It was possibly formed, together with the alunite, by the decomposition of the pyrites.

The second specimen is labelled "Zinckenit,[2] Socavon de la Virgen, Oruro." In a cavity at the back of the specimen is a small amount of Andorite, as shown by qualitative chemical analysis and the measurement of crystal fragments. Besides pyrites and quartz, there are also crystals of kaolin, cassiterite, both massive and in minute crystals of a pale yellowish colour, and a little alunite. No tetrahedrite was seen on this specimen. The prismatic crystals of cassiterite are about ¼ mm. in length, and show the forms $m\{110\}$ and $s\{111\}$; the measured angles varied only slightly from the mean value $ms^3 = 46°48'$. The massive cassiterite was tested for germanium, but with negative results. The minute alunite crystals are similar to those described above, but here the basal planes are smaller, so that the crystals have the appearance of cubes; the forms present are therefore $r(100)$ and $c(111)$. The most striking mineral on this specimen is the coarsely acicular "zinckenite;" with it is a more finely acicular mineral with the felted appearance of "feather ore."

This occurrence of Andorite at the Socavon de la Virgen (= Virgin level) shows that the Itos mine is not the only mine at Oruro in which the mineral is found. It is therefore not absolutely certain that Brögger's specimen came from the Itos mine, as stated by Pöhlmann.

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[1] *Amer. Journ. Sci.* 1894, XLVIII. p. 130.

[2] This may possibly be jamesonite.

[3] Dana gives $ms = 46°26\frac{2}{3}'$, and Miller 46°26'.

The silver mines of Oruro have been described by H. Reck,[1] A. Webner,[2] formerly of the Itos mine, Weiner,[3] and A. W. Stelzner.[4] They form a group of mines in the hill on the west side of the town of Oruro, which is the capital of the department Oruro. It would seem that Andorite is one of the principal silver ores of these lodes, which are some of the most important in South America, and were worked by the Indians previous to their discovery by the Spaniards in the sixteenth century.

VII. The Systematic Position and the Characters of Andorite.

The formula of Andorite ($2PbS.Ag_2S.3Sb_2S_3$) resembles that of zinckenite ($PbS.Sb_2S_3$) in representing a metasulph-antimonite, and as both zinckenite and Andorite are orthorhombic, it might be expected that there would be some crystallographic relationship between them. The only angles, however, which can be compared are not at all close. In the elongated and striated zones there is an approach to angles of 60°, but this is shown by Penfield[5] to be the case with many sulpho-salts.

Sundtite.		Zinckenite.	
$am = 100 : 110$	34° 6′	$c\varepsilon = 001 : 102$	29°40½′
$ch = 001 : 102$	18°13¼′	$hk = 010 : 061$	14°42′

As there is also no crystallographic relation between Andorite and the monosymmetric miargyrite ($Ag_2S.Sb_2S_3$), it may be concluded that in Andorite the lead and silver do not isomorphously replace each other, but that we have here a definite double salt with the composition $2(PbS.Sb_2S_3)+Ag_2S.Sb_2S_3$. The cubic brongniartite ($Ag_2S.PbS.Sb_2S_3$) also seems to be a double salt which is related in a similar manner to the orthorhombic jamesonite ($2PbS.Sb_2S_3$), though there is here nothing to correspond to miargyrite. Amongst well-determined minerals, other double salts are freieslebenite and diaphorite, bournonite and aikinite: and in the whole range of the sulpho-salts, with the exception of tetrahedrite-tennantite and polybasite-pearceite, isomorphous replacement seems to

[1] *Petermann's Geograph. Mitth.* 1867, p. 319.

[2] *Berg- und Hüttenm. Zeit.* 1887, p. 157; 1888, pp. 241 and 263.

[3] *Annales des Mines* 1894, Ser. 9, V. Mem. p. 511, with map.

[4] *Zeits. deutsch. geol. Ges.* 1897, XLIX. pp. 82, 126. See also F. de Castelnau, *Expédition Amerique du Sud*, 1851, III. 358.

[5] *Amer. Journ. Sci.* 1896, [4] II. p. 28; and *Zeits. Kryst. Min.* 1896, XXVII. p. 76.

take place only to a limited extent, and when two bases occur together in larger quantity double salts are formed.

Summary of the Characters of Andorite.

Orthorhombic.—$a : b : c = 0{\cdot}6771 : 1 : 0{\cdot}4458$.

$100 : 110 = 34°6'$, $001 : 101 = 33°21\frac{1}{2}'$, $001 : 011 = 24°1\frac{1}{2}'$.

A list of forms is given on pp. 293-4.

Colour, dark steel-grey ; brilliant metallic lustre ; opaque.

Streak, black and shining ; powder dull.

No cleavage ; fracture smooth and conchoidal. Brittle.

Specific gravity 5·35. Hardness $3\frac{1}{4}$.

Composition, $2PbS.Ag_2S.3Sb_2S_3 = PbAgSb_3S_6$.

Localities : Felsőbanya, Hungary ; the silver-tin mines at Oruro, Dept. Oruro, Bolivia.