

Jentschite (TlPbAs₂SbS₆) — a new sulphosalt mineral from Lengenbach, Binntal (Switzerland)

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Abstract

Jentschite, TlPbAs₂SbS₆, is a new sulphosalt mineral from the famous Lengenbach locality (Binntal, Switzerland). It was discovered in association with numerous other Tl-As-sulphosalts such as hutchinsonite, wallisite-hatchite, edenharterite, bernardite, abundant realgar and orpiment in small cavities in a dolomitic rock of Triassic age which forms part of the Penninic Monte-Leone-nappe. The first specimens consisted of extremely small polysynthetically twinned crystals; a later find yielded less complicated twinned crystals in sizes up to 2 mm length. Single crystal X-ray diffraction studies gave a monoclinic cell with $a = 8.121(3)$, $b = 23.969(9)$, $c = 5.847(3)$ Å, $\beta = 107.68(3)^\circ$, $V = 1084.3(5)$ Å³, $Z = 4$, space group $P2_1/n$. The strongest lines in the X-ray powder diagram are (d_{obs} in Å, I_{obs} , hkl): 2.823 (100)(116), 3.587 (86)(221), 2.778 (84)(260), 3.998 (74)(060), 2.670 (58)(301), 3.816 (54)(210). Chemical composition (electron microprobe, mean of 15 analyses, wt.%) is: Tl 23.92, Pb 21.44, As 19.16, Sb 12.53, S 22.42, total 99.47 wt.% from which a simplified formula TlPbAs₂Sb₁S₆ can be derived. This formula is very close to that of the (orthorhombic) mineral edenharterite TlPbAs₃S₆. From structural and chemical data it was interpreted as the ordered structure of an Sb-bearing relative of edenharterite, a postulation that meanwhile could be confirmed by the complete structure determinations of both, edenharterite and jentschite (Berlepsch, 1996). Jentschite occurs in prismatic crystals up to 2 mm length; it is opaque with a black metallic to submetallic luster, red translucent in thin fragments. Fracture is uneven to conchoidal, the mineral is extremely brittle, the cleavage along $(\bar{1}01)$ is perfect; the streak is dark red (darker than that of edenharterite). Mohs hardness is 2–2½, according to a microhardness VHN (10 g load) of 38–51 kg/mm². The calculated density yields $D_{\text{calc}} = 5.24$ g/cm³.

The name is for Franz Jentsch (1868–1908) from Binn, a local 'Strahler' and for several years head of an early Lengenbach syndicate that exploited the rare Lengenbach sulphosalt minerals at the beginning of this century.

KEYWORDS: jentschite, Tl-Pb-As-Sb-sulphosalt, new mineral, crystal data, microprobe analyses, Lengenbach, Switzerland.

Introduction

It was in 1904, that the name 'jentschite' was used for the first time to describe an unknown sulphosalt species from Lengenbach in Binntal (Koechlin, 1904). Yet, shortly afterwards, the famous English mineralogist R.H.Solly, the leading expert on

Lengenbach minerals at that time, stated that this 'jentschite' was identical with a mineral described by himself as a new species under the name lengenbachite (Solly, 1905). According to the rules of the Commission on New Minerals and Mineral Names, I.M.A., the name of a mineral that was named erroneously may be used again after a lapse of at

least 50 years since its first mention. Taking account of the fact that the name 'jentschite' was never used to officially describe a new mineral species, and that its first mention was claimed by Solly to be erroneous already in 1905, we did not hesitate to use the name again in order to honour the great merits of the local expert of Lengenbach minerals, Franz Jentsch (1868-1908). As head of a 'Lengenbach syndicate' that exploited the Lengenbach sulphosalt mineralisation in the period around 1900, he provided the numerous mineralogists who were investigating the spectacular sulphosalt occurrence with carefully selected mineral specimens, and many of the new mineral species described from Lengenbach at that time were primarily discovered by him.

The first samples with the new mineral jentschite were detected among material of the ordinary exploitation collected for the 'Arbeitsgemeinschaft Lengenbach' by Toni Imhof and his team in 1987. Through this material an unmistakably new sulphosalt phase was recognized, yet, the polysynthetically twinned crystals did not allow an unequivocal determination of space group symmetry or of the cell parameters. It was some years later, in 1992, that additional material was discovered that enabled a thorough investigation of the new mineral which, however, fully confirmed all previous determinations carried out on the mineral.

Jentschite, like other new TI-As-sulphosalts such as edenhartherite $\text{TiPbAs}_3\text{S}_6$ (Graeser and Schwander, 1992), ernigglite $\text{Ti}_2\text{SnAs}_2\text{S}_6$ (Graeser *et al.*, 1992), and stalderite $\text{TiCu}(\text{Zn,Fe,Hg})_2\text{As}_2\text{S}_6$ (Graeser *et al.*, 1995), does not originate from the old classical Lengenbach site which was abandoned in 1987 because of dangerous exploitation and unattractive material, but from a new level that was inaugurated in 1988, located farther to the North-East and about 25 m above the old quarry.

The proposal for the new mineral and its name was submitted to the Commission on New Minerals and Mineral Names, I.M.A., for consideration (93-025). They accepted the new mineral unanimously, though with some critical remarks regarding the name. Type specimens are preserved at the Natural History Museum Basel, and at the Mineralogical Institute, University of Basel.

Description

Physical and optical properties. A first sample containing jentschite was found in 1987, the first year that the new Lengenbach site came into operation. The appearance of the mineral was very similar to that of edenhartherite; the platy habit of the crystals, however, pointed to a different mineral. From the subsequent study of the unknown mineral, the close relationship in particular to edenhartherite but also to

other TI-sulphosalts was recognized. The similarity of these minerals in appearance, morphology and optical properties makes it practically impossible to distinguish exactly the various Lengenbach TI-sulphosalts from each other without X-ray diffraction methods. Among the three most similar minerals jentschite, edenhartherite, hutchinsonite, the first has the highest density, the darkest streak colour and the lowest hardness. In polished section jentschite yields the highest reflectivity values and the most distinct anisotropy effects (see Table 1). Different from the other minerals in this group, jentschite shows a perfect cleavage across the prismatic *c*-axis (along $(\bar{1}01)$). If trying to break one of the acicular crystals, it always produces a clean cut along $(\bar{1}01)$ forming an angle of about 108° with the *c*-axis.

Regarding the fact that jentschite is a completely new Lengenbach mineral, the crystals achieve a remarkable size (≤ 2 mm length). Like other TI-minerals (ernigglite, stalderite) from Lengenbach, jentschite has remained an extremely rare species: since its first discovery in 1987 (exhausted for investigation), one additional find of five samples in 1992 was made, though with numerous excellent crystals. On the other hand, it may be pointed out that the closely related mineral edenhartherite has been discovered on far more than 100 samples in the meantime.

X-ray diffraction study. The powder diagram of jentschite contains numerous characteristic diffraction lines which allow a quick and unequivocal distinction from other closely related TI-Pb-As-sulphosalts. The single-crystal study (Weissenberg and Precession cameras) was very complicated for the preliminary material from 1987 because all crystals were polysynthetically twinned along (010) (albite twins). Finally, new excellent samples found in 1992 provided better material. These crystals, too, were all twinned but most of them appeared as contact twins along (100) (gypsum twins, see Fig. 2) from which single-crystal fragments could be separated, though they strongly preferred to break along the perfect cleavage parallel to $(\bar{1}01)$ than between the two twins. The results of the renewed study, however, fully confirmed the previously collected data (Table 2).

In the course of the single-crystal study a strange fact became obvious: photographs of the reciprocal lattice along the planes *ab*, and *b/c*, respectively, were practically identical with the corresponding planes of edenhartherite; only the third section along *a/c* was different, though in this case, too, a close relation between the two structures was easily recognizable.

Perhaps it should be mentioned that, compared with the original proposal for jentschite to the Commission on New Minerals and Mineral Names,

TABLE 1. Physical and optical properties of some Tl-As-sulphosalts from Lengenbach

| | Jentschite ¹ | Edenharterite ² | Hutchinsonite ³ |
|--|---|--|---------------------------------------|
| Shape: | long prismatic, platy to acicular | short prismatic to isometric | long prismatic, platy |
| Twins: | (010) albite twin (100) gypsum twin | not observed | not observed |
| Colour: | brilliant black, red internal reflections | brown to black, red internal reflections | dark red to black, red translucent |
| Streak: | dark red | raspberry red | orange |
| Cleavage: | ($\bar{1}01$) perfect | (100) distinct | (010) imperfect |
| Hardness: | 2–2½ | 2½–3 | 3½–4 |
| Density: | 5.24 g/cm ³ | 5.09 g/cm ³ | 4.6–4.7 g/cm ³ |
| Ore Microscopy (LEITZ MPV-compact microscope) | | | |
| Reflectivity (measured in air, WTiC standard): | | | |
| 470 nm: | 29.7–35.4 | 28.5–30.5 | – |
| 543 nm: | 28.8–33.1 | 28.5–31.5 | 30.0–31.0 |
| 587 nm: | 26.7–30.3 | 27.0–28.5 | – |
| 657 nm: | 26.6–29.9 | 27.0–29 | – |
| Microhardness: | 38–51 (10g) | 95–101 (10g) | 170–171 (100g) |
| Anisotropy: | clearly visible | weak | distinct |

¹Jentschite TlPbAs₂SbS₆, Lengenbach (this paper)

²Edenharterite TlPbAs₃S₆, Lengenbach (Graeser and Schwander, 1992)

³Hutchinsonite TlPbAs₃S₉, Lengenbach (Graeser, 1965)

the monoclinic cell has been changed and a cell with a smaller angle β has been chosen ($001 \rightarrow \bar{1}01$) in agreement with the structure determination (Berlepsch, 1996).

Chemical composition. From preliminary EDS investigations on the SEM the qualitative composition of the mineral as a Tl-Pb-As-Sb-S-sulphosalt could be derived. Quantitative analyses were carried out on an ARL microprobe (Table 3), from which the formula for jentschite could be calculated as TlPbAs₂Sb₁S₆. The analyses were performed on two individual crystals, partly as twins, partly as random intergrowth. Though the variation between the numerous analyses appears relatively small, it must be pointed out that, compared with the theoretical formula, the values for Pb and Sb are always too low and that for As too high.

Edenharterite and jentschite. In 1992 we described the new Tl-mineral edenharterite from the Lengen-

bach quarry (Graeser and Schwander, 1992). The single-crystal diffraction study (see above) of jentschite revealed a conspicuous relationship between the structures of the two minerals, that was additionally confirmed by the chemical analyses and the mineral formula derived from them. The respective data for the two mineral species are compiled in Table 4. From these data arose the question on the nature of the relationship, an essential problem before submitting the proposal to the Commission on New Minerals and Mineral Names, I.M.A., for consideration. From the fact that both minerals have an identical general formula but clearly different crystal symmetry, it becomes obvious that they cannot represent members of a solid-solution series (otherwise the new phase would represent merely an Sb-bearing edenharterite within a hypothetical solid-solution series between edenharterite and a hitherto unknown Sb-edenharterite). The

TABLE 2. X-ray powder diffraction data of jentschite from Lengenschbach

| <i>h k l</i> | <i>d</i> _{calc} | <i>d</i> _{obs} | <i>I</i> / <i>I</i> ₁ | <i>h k l</i> | <i>d</i> _{calc} | <i>d</i> _{obs} | <i>I</i> / <i>I</i> ₁ |
|--------------|--------------------------|-------------------------|----------------------------------|--------------|--------------------------|-------------------------|----------------------------------|
| 0 2 0 | 11.984 | 11.947 | <10 | 0 5 2 | 2.338 | 2.338 | 17 |
| 1 1 0 | 7.365 | 7.377 | <10 | 3 7 1 | 2.106 | 2.106 | 14 |
| 0 1 1 | 5.426 | 5.430 | <10 | 3 7 0 | 2.060 | 2.059 | <10 |
| 1 0 1 | 5.358 | 5.346 | 32 | 3 8 1 | 1.993 | 1.994 | <10 |
| 0 2 1 | 5.052 | 5.042 | 12 | | | 1.960 | <10 |
| 1 4 0 | 4.738 | 4.738 | 19 | | | 1.923 | <10 |
| 0 4 1 | 4.080 | 4.090 | 26 | | | 1.899 | <10 |
| 0 6 0 | 3.995 | 3.998 | 74 | | | 1.861 | <10 |
| 2 1 0 | 3.819 | 3.816 | 54 | | | 1.816 | <10 |
| 2 1 1 | 3.712 | 3.715 | <10 | | | 1.790 | <10 |
| 2 2 1 | 3.585 | 3.587 | 86 | | | 1.752 | <10 |
| 1 4 1 | 3.317 | 3.322 | 19 | | | 1.724 | <10 |
| 2 4 0 | 3.250 | 3.252 | <10 | | | 1.695 | 12 |
| 1 6 1 | 3.203 | 3.201 | <10 | | | 1.641 | <10 |
| 2 5 0 | 3.011 | 3.008 | 11 | | | 1.566 | <10 |
| 0 7 1 | 2.917 | 2.916 | 21 | | | 1.539 | <10 |
| 1 1 6 | 2.821 | 2.823 | 100 | | | 1.505 | <10 |
| 2 6 0 | 2.779 | 2.778 | 84 | | | 1.485 | <10 |
| 3 0 1 | 2.670 | 2.670 | 58 | | | 1.462 | <10 |
| 2 3 1 | 2.645 | 2.647 | <10 | | | 1.448 | <10 |
| 0 4 2 | 2.526 | 2.527 | <10 | | | 1.342 | <10 |
| 2 5 1 | 2.420 | 2.418 | 22 | | | 1.231 | <10 |

Debye-Scherrer camera, 114.60 mm, Fe-K α radiation

Single-crystal data:

Space group $P2_1/n$

$$a = 8.121(3) \text{ \AA}$$

$$b = 23.969(9) \quad \beta = 107.68(3)^\circ$$

$$c = 5.847(3)$$

$$V = 1084.3(5) \text{ \AA}^3$$

Lattice constants refined from the powder data
 I / I ₁ were determined densitometrically

single-crystal data, on the other hand, exclude the possibility of it being a polytypic mineral to edenharterite. Hence the minerals were interpreted as homeotypes, in which the amount of Sb might be responsible for the formation of the respective mineral; small Sb-contents remain randomly distributed in a structure of orthorhombic symmetry yet, when exceeding a special threshold value, Sb occupies a site of its own in an ordered monoclinic structure. A comprehensive crystal-chemical and structural investigation by Berlepsch (1996) clearly supported this assumption.

On a Lengenschbach sample sent to us for determination just recently, one small crystal (0.5 mm length) was investigated because of its uncommon appearance. During a Gandolfi study, the diffraction pattern of the whole crystal was recorded, which, to our great surprise, showed the characteristic diffraction lines of both minerals, edenharterite and jentschite. Therefore

the whole crystal was checked by single-crystal methods, yet the result was not very helpful; the X-ray films yielded exclusively the reflections of the orthorhombic phase edenharterite. As the crystal must not be destroyed, it was subject to a SEM study. Using the EDS device, the chemical composition, in particular the As/Sb ratio, was determined by point-analyses. All determinations were carried out on the flat (010) face in order to get highly reproducible values. The analyses prove that the crystal is not homogeneous with respect to the As-Sb-contents, the extreme values reaching from TIPbAs_{2.65}Sb_{0.35} to TIPbAs_{2.5}Sb_{0.5} which is quite close to the formula of jentschite (Table 3). Presumably the composition of this crystal corresponds almost exactly to some threshold value between edenharterite and jentschite, provided that the transition from edenharterite to jentschite is controlled by nothing other than the As/Sb-ratio.

TABLE 3. Chemical composition of jentschite (wt.%)

| | I | II | III | IV |
|--|-------|-------|---------------------|--------|
| Tl | 23.90 | 23.76 | 23.92 (23.47–23.98) | 23.34 |
| Pb | 21.52 | 21.16 | 21.44 (20.67–21.48) | 23.66 |
| As | 19.30 | 19.44 | 19.16 (17.91–20.88) | 17.11 |
| Sb | 12.40 | 12.21 | 12.53 (10.66–14.94) | 13.91 |
| S | 22.53 | 22.63 | 22.42 (21.87–22.83) | 21.97 |
| Total | 99.65 | 99.20 | 99.47 | 100.00 |
| Structural formula (based on 11 atoms) | | | | |
| Tl | 1.00 | 1.00 | 1.01 | 1.00 |
| Pb | 0.89 | 0.87 | 0.89 | 1.00 |
| As | 2.21 | 2.22 | 2.20 | 2.00 |
| Sb | 0.87 | 0.87 | 0.89 | 1.00 |
| S | 6.03 | 6.03 | 6.02 | 6.00 |

I, II mean of 3 analyses on individual crystals

III mean of 15 analyses (with ranges)

IV theoretical composition for $\text{TlPbAs}_2\text{Sb}_1\text{S}_6$

ARL microprobe (20 kV, 20 nA)

Standards: TlAsS_2 (Tl,As,S), galena (Pb,S), stibnite (Sb)

Morphology. The first find of jentschite in 1987 provided one almost perfect crystal (Fig. 1) of about 0.4 mm length which, besides X-ray diffraction work, was subject to a measurement on the optical goniometer. As can be seen from the SEM picture, the crystal is polysynthetically twinned along {010} (albite twins). Though the small size of the crystal was quite cumbersome for this purpose, the measured values permitted an unequivocal indexing of the faces (Fig. 2). Whereas in the case of jentschite isolated crystals are quite common, the mineral

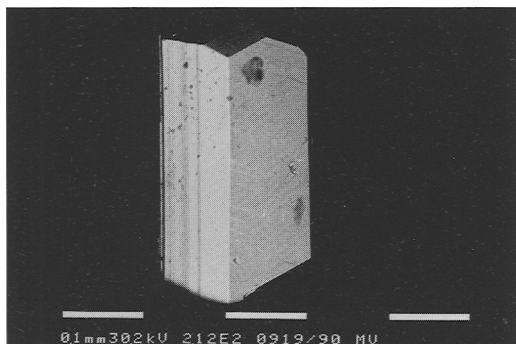


FIG. 1. SEM picture of jentschite: the polysynthetic twinning of the crystal is clearly visible. The cleavage along {101} is indicated by striations parallel to this face.

edenharterite occurs only in aggregates composed of extremely small single crystals, of mostly less than 0.2 mm, that were not suitable for goniometric measurements. Actually, the crystal of Sb-bearing edenharterite described above represents a unique isolated edenharterite crystal known so far. Therefore this crystal, too, was measured goniometrically and drawn by the SHAPE program. Comparison of the two crystal drawings clearly shows the close morphological relationship between jentschite and edenharterite.

Occurrence. Jentschite is one of the numerous members of sulphosalts occurring in small rounded cavities (druses) of the Triassic dolomite at Lengenbach in Binnental (Fig. 3). Moreover, it belongs to the group of Tl-sulphosalts like edenharterite, stalderrite, erniggliite, hatchite, wallisite, hutchinsonite, and some additional species at this time not yet clearly identified, that obviously became enriched within the uppermost part of the dolomite outcrop. They are unequivocally products of hydrothermal activity during a last stage of the formation of minerals in the Binnental dolomite. Tl and As originate from a tectonically underlying series of gneisses and were remobilised by either Alpine metamorphism (Graeser, 1965), or by an earlier event (Knill, 1995).

Acknowledgements

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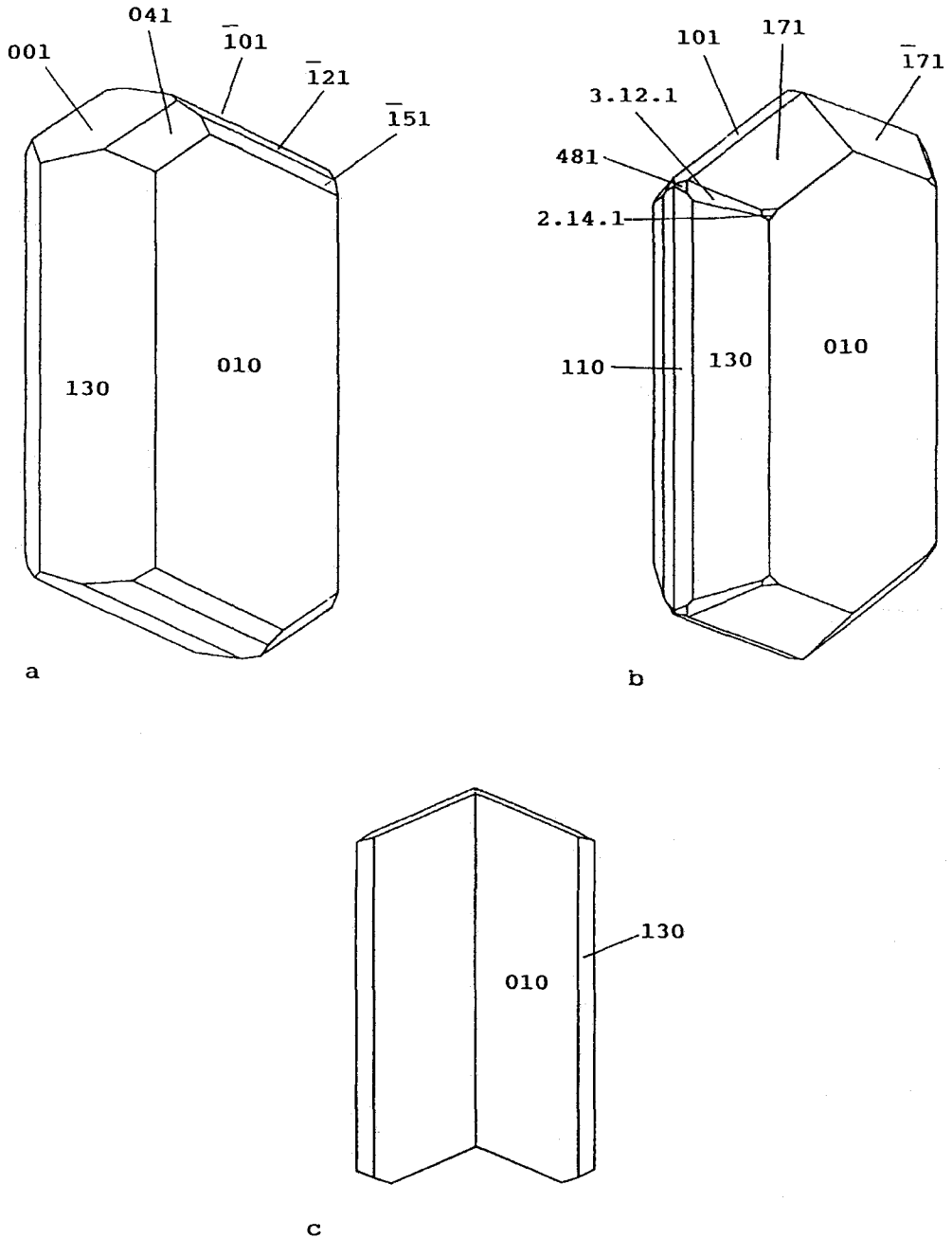


FIG. 2. Morphology of jentschite and edenharterite. (a) jentschite habit, usually twinned along (010) (albite twin); (b) edenharterite crystal; (c) jentschite twinned along (100) (gypsum twin).

Dr. J.A. Mandarino (now emeritus), for his helpful suggestions, especially regarding the naming of the mineral. Mr Ralph Cannon (Kassel, Germany) kindly

provided the unique sample with Sb-bearing edenharterite. We are greatly obliged to R. Guggenheim, D. Mathys, and M. Düggelin (SEM laboratory,

TABLE 4. Relations between edenharterite and jentschite

| | Edenharterite ¹ | Jentschite ² |
|-----------------|---|--|
| Formula | TlPbAs ₃ S ₆ | TlPbAs ₂ Sb ₁ S ₆ |
| Crystal system | orthorhombic | monoclinic |
| Space group | Fdd2 | P2 ₁ /n |
| Cell parameters | <i>a</i> = 15.465 Å | 8.121 Å |
| | <i>b</i> = 47.507 | 23.969 |
| | <i>c</i> = 5.843 | 5.847 |
| | β = 90° | 107.68° |
| | <i>a</i> : 1 : <i>c</i> = 0.326:1:0.123 | 0.339:1:0.244 (X-ray) |
| | 0.328:1:0.123 | 0.339:1:0.246 (goniom.) |
| Cell volume | V = 4292 Å ³ (= 4·1073) | 1084 Å ³ |
| Cell content | Z = 16 | 4 |

¹ Graeser and Schwander (1992)

² this paper

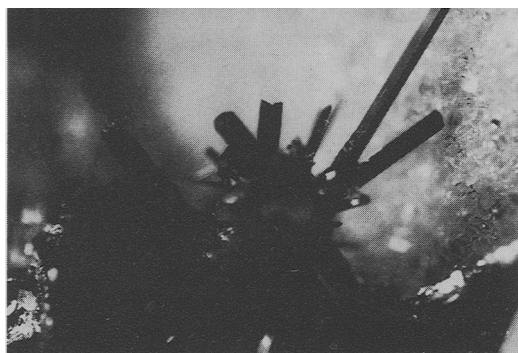


FIG. 3. Type specimen of jentschite with typical gypsum twinned crystal. The largest crystal has a length of 2 mm. Photograph by W. Gabriel.

University of Basel) for their help in performing SEM pictures and chemical analyses of the minerals (especially the Sb-bearing edenharterite). The Arbeitsgemeinschaft Lengenschbach, the syndicate exploiting the Lengenschbach minerals for scientific research, kindly put the required material at our disposal.

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