

# Feinglosite, a new mineral related to brackebuschite, from Tsumeb, Namibia

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## Abstract

Feinglosite, the zinc analogue of arsenbrackebuschite, was found lining a cavity in a sample of massive chalcocite from Tsumeb, Namibia. In this cavity it is associated with wulfenite, anglesite and goethite. The mean of seven electron-microprobe analyses (wt.%) is: PbO 61.4, ZnO 7.3, FeO 1.8, As<sub>2</sub>O<sub>5</sub> 22.1, SO<sub>3</sub> 5.3, H<sub>2</sub>O (by difference) [2.1], total = [100.00]%, leading to the ideal formula: Pb<sub>2</sub>(Zn,Fe)[(As,S)O<sub>4</sub>]-H<sub>2</sub>O. Feinglosite is monoclinic, space group *P2*<sub>1</sub> or *P2*<sub>1</sub>/*m*, *a* 8.973(6), *b* 5.955(3), *c* 7.766(6) Å, β 112.20(6)°, with *Z* = 2. The strongest five reflections of the X-ray powder diffraction pattern are [*d* in Å (*I*) (*hkl*)]: 4.85 (50) (110), 3.246 (100) (112), 2.988 (60) (301), 2.769 (60) (300/211), 2.107 (50) (321). The mineral is pale olive-green, transparent, sectile, and has a white streak and adamantine lustre. It overgrows clusters of goethite crystals and forms globular microcrystalline aggregates up to 0.5–0.75mm in size. The hardness on Mohs' scale is 4–5: the mean micro-indentation hardness is 263 at VHN<sub>100</sub>. Its calculated density is 6.52 g cm<sup>-3</sup>. The mineral is pale brownish grey in reflected light (when compared with goethite). Visible spectrum reflectance data are presented. Feinglosite is named for Mark N. Feinglos who first recognised the mineral on a specimen in his collection.

KEYWORDS: feinglosite, new mineral, brackebuschite group, lead-zinc arsenate hydrate, X-ray data, electron-microprobe data, reflectance data, Tsumeb, Namibia.

## Introduction

IN 1984 a piece of massive chalcocite, from the Tsumeb mine, Namibia, was left for examination at The Natural History Museum, London, by Mark N. Feinglos. The specimen aroused interest because a cavity, about 1.5 cm across at one end of the specimen, was lined with botryoidal clusters of pale olive-green crystals. Initially, we were uncertain of

the identity of these crystals: X-ray powder-diffraction studies suggested they were related to heyite, but electron-microprobe analyses proved the mineral to be a lead-zinc arsenate, and thus quite different from heyite. Subsequent investigation revealed that it is a member of the brackebuschite group, and the zinc analogue of arsenbrackebuschite. Feinglosite is named after Prof. Mark N. Feinglos (b. 1948) of the Duke Medical Center, Durham, North Carolina, USA, who first noticed the mineral on one of the specimens from Tsumeb in his collection. The mineral data, and name, have been approved by the Commission on New Mineral and Mineral Names of the International Mineralogical Association.

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### Occurrence

We have no information on the discovery of feinglosite at Tsumeb apart from the fact that the sample was collected sometime in the 1970s. Two specimens are known to exist (broken from one larger specimen); they were acquired in about 1982. One of them, the type specimen (BM 1984,943), is in the mineral collection of The Natural History Museum, London.

### Physical properties

Feinglosite occurs in a cavity about 2 cm in diameter in massive chalcocite. The mineral forms radiating globular masses, usually with a goethite core (Fig. 1). Individual crystal clusters are about 0.5 mm in diameter. Feinglosite is a pale olive green with white streak. It is sectile and has an adamantine lustre. The hardness on Mohs' scale is 4–5. Micro-indentation hardness measurements, with a VHN load of 100 g, gave values in the range 253–285 and a mean value of 263.

The density of feinglosite could not be measured directly since it cannot be separated from goethite. The calculated density is  $6.52 \text{ g cm}^{-3}$  for the empirical formula with  $Z = 2$ .

### Chemical data

Fragments of feinglosite were embedded in cold-setting epoxy resin and polished for analysis by electron microprobe. Cameca SX-50 instruments were used at the Geological Survey of Canada, Ottawa, and at The Natural History Museum, London. At the former institute, analyses were made on material later used for the X-ray study; at the latter, the analyses followed optical examination and measurement of reflectance. The analyses were carried out at an electron accelerating potential of 20 kV and beam current of 20 nA; the standards used were galena (Pb), sphalerite (Zn), löllingite (Fe and As) and tetrahedrite (S). Water was estimated by difference, following confirmation of its presence by infrared studies.

Following ZAF correction of the raw intensities, the mean of seven analyses gave PbO 61.4, ZnO 7.3,

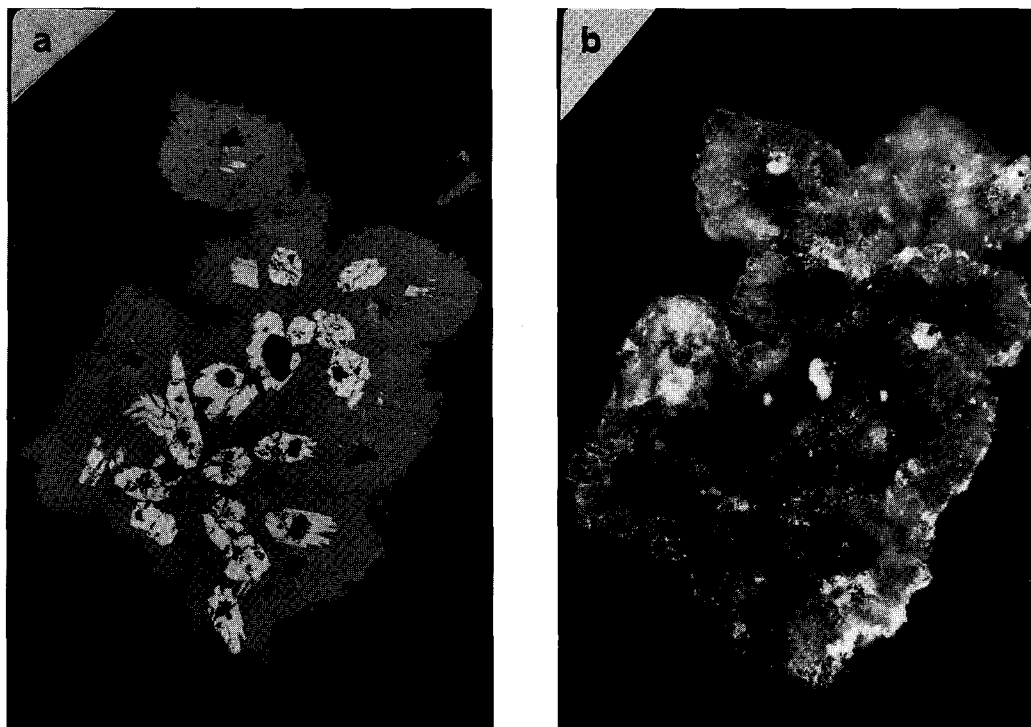
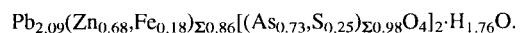


FIG. 1. Photomicrograph of feinglosite in polished section: (a) in plane-polarised light and (b) between crossed polars. In (a) note the inclusions of goethite (white) in the grey feinglosite (the black areas are holes). In (b) note the white to grey clusters of internally reflecting feinglosite surrounding the black, nearly opaque, crystals of goethite. Scale width for both photomicrographs is 1 mm.

FeO 1.8, As<sub>2</sub>O<sub>5</sub> 22.1, SO<sub>3</sub> 5.3, H<sub>2</sub>O (calc.) [2.1], total [100.0] wt.%. Recalculating this analysis on the basis of eight oxygens (by analogy with arsenbrackebuschite, Abraham *et al.*, 1978) resulted in the empirical formula



The ideal formula is therefore  $\text{Pb}_2(\text{Zn}, \text{Fe})[(\text{As}, \text{S})\text{O}_4]_2 \cdot \text{H}_2\text{O}$  and feinglosite is the zinc analogue of arsenbrackebuschite,  $\text{Pb}_2(\text{Fe}, \text{Zn})(\text{AsO}_4)_2 \cdot \text{H}_2\text{O}$ . The type specimen is a ferroan sulfatian variety.

### Optical properties

In plane-polarised reflected light feinglosite is a very pale brownish grey and significantly lower reflecting than the goethite with which it is intergrown (Fig. 1). It consists of a compact mass of very small crystallites ( $\sim 5\text{--}10\ \mu\text{m}$ ). Internal reflections are abundant, and are colourless except where the mineral encloses goethite; here they are a very pale yellow. Pleochroism is absent. The mineral is not noticeably anisotropic. Its bireflectance is very weak but is measurable: reflectance measurements could not be made on areas of the mineral entirely free from internal reflections, nor at positions of extinction, hence the reflectance percentages

TABLE 1. Reflectance spectra of feinglosite

$\lambda_{\text{nm}}$	$R_I$	$R_2$	${}^{im}R_I$	${}^{im}R_2$
400	12.2	12.3	2.19	2.40
420	11.8	12.0	2.09	2.29
440	11.6	11.8	2.03	2.22
460	11.4	11.6	2.00	2.13
470	11.2	11.5	1.98	2.11
480	11.2	11.4	1.96	2.09
500	11.1	11.2	1.91	2.04
520	10.9	11.1	1.87	2.01
540	10.8	11.0	1.84	2.00
546	10.8	10.9	1.84	2.00
560	10.8	10.9	1.83	1.98
580	10.7	10.8	1.82	1.97
589	10.7	10.8	1.82	1.97
600	10.7	10.8	1.82	1.97
620	10.7	10.8	1.82	1.96
640	10.7	10.8	1.82	1.96
650	10.7	10.8	1.82	1.96
660	10.7	10.8	1.82	1.95
680	10.7	10.7	1.83	1.95
700	10.6	10.7	1.84	1.95

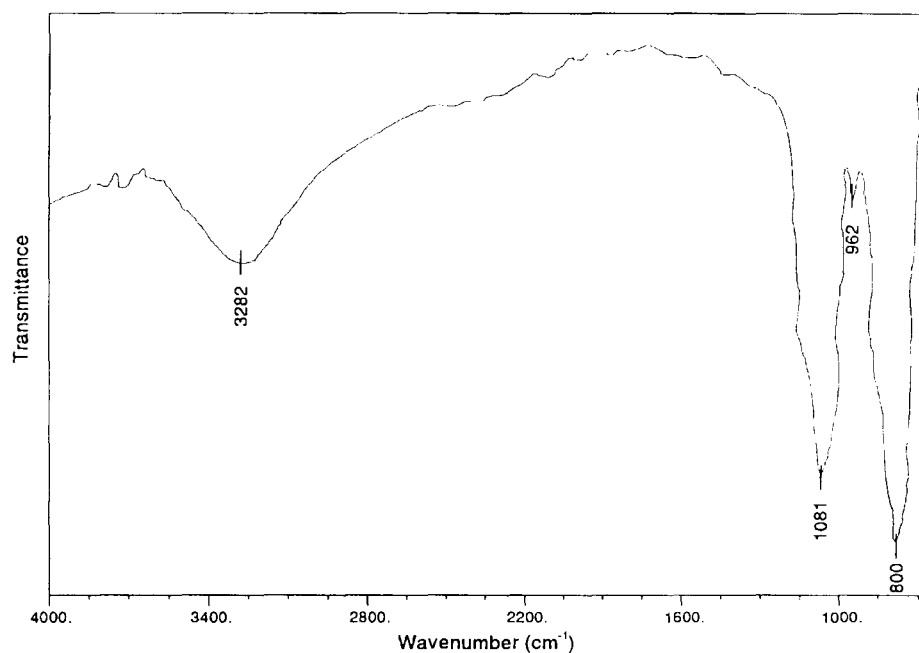


FIG. 2. Infrared-absorption spectrum of feinglosite.

TABLE 2. X-ray powder diffraction data for feinglosite

$I_{\text{est}}$	$d_{\text{meas}} \text{ \AA}$	$d_{\text{calc}} \text{ \AA}$	$hkl$	$I_{\text{est}}$	$d_{\text{meas}} \text{ \AA}$	$d_{\text{calc}} \text{ \AA}$	$hkl$
20	8.36	8.31	100	50	2.107	2.110	$\bar{3}21$
5	7.14	7.19	001	3	2.060	2.058	$\bar{4}12$
50	4.85	4.84	110			2.028	$\bar{3}20$
10	4.48	4.50	$\bar{1}11$	15	2.024	2.022	$\bar{3}22$
20	4.16	4.15	200			1.984	$\bar{4}03$
20	3.88	3.88	$\bar{1}02$	15	1.984	1.981	113
30	3.659	3.659	111	20	1.960	1.961	410
5	3.534	3.531	$\bar{2}11$			1.907	$\bar{1}31$
25	3.430	3.436	$\bar{2}02$	30	1.889	1.882	$\bar{4}13$
100	3.246	3.249	$\bar{1}12$			1.867	023
10	3.126	3.122	201	15	1.865	1.863	$\bar{3}04$
10	3.074	3.078	012	3	1.844	1.843	$\bar{2}14$
60	2.988	2.991	$\bar{3}01$			1.825	131
20	2.797	2.803	120			1.824	321
60	2.769	2.769	300	20	1.823	1.821	$\bar{1}14$
		2.765	211			1.820	401
5	2.675	2.673	$\bar{3}11$	5	1.796	1.798	004
20	2.622	2.623	112			1.773	$\bar{5}01$
		2.511	310			1.767	$\bar{1}32$
10	2.507	2.506	121	10	1.770	1.766	$\bar{4}22$
5	2.462	2.463	$\bar{2}21$			1.741	411
5	2.419	2.420	220	5	1.742	1.721	014
10	2.398	2.397	003			1.719	$\bar{2}32$
5	2.359	2.361	$\bar{1}22$			1.718	$\bar{4}04$
		2.293	022	20	1.716	1.717	123
30	2.293	2.290	$\bar{3}03$			1.712	$\bar{5}12$
10	2.253	2.250	$\bar{2}22$	10	1.677	1.675	231
5	2.195	2.193	402	5	1.654	1.654	$\bar{3}31$
		2.155	221			1.624	$\bar{2}24$
5	2.152	2.152	311	15	1.624	1.624	

114.6 mm Debye-Scherrer powder camera employing Ni-filtered Cu radiation ( $\lambda_{\text{Cu-}k\alpha} = 1.54183 \text{ \AA}$ )

Intensities estimated visually

Indexed on  $a = 8.973$ ,  $b = 5.995$ ,  $c = 7.776 \text{ \AA}$ ,  $\beta = 112.20^\circ$

(Table 1) must be considered as semi-quantitative. They were obtained with a Zeiss MPM 03 microscope-spectrophotometer;  $\times 40$  objectives (effective numerical apertures 0.28); an SiC reflectance standard, and Zeiss immersion oil  $N_D = 1.515$ .

#### Infrared-absorption study

The equipment and procedures for acquiring the infrared-absorption spectrum for feinglosite are identical with those used to obtain the spectrum for mc Alpineite (Roberts *et al.*, 1994) and need not be repeated here. The spectrum (Fig. 2) clearly shows a broad band, centred on  $3282 \text{ cm}^{-1}$ , which is due to O-H stretching in the water molecules and validates our calculation of  $\text{H}_2\text{O}$  by difference.

#### X-ray studies

Repeated attempts to obtain decipherable single-crystal X-ray precession photographs using Mo radiation showed that even extremely small fragments of feinglosite are composed of multiple crystallites. Nodes on precession orientation films are weak, broad and fuzzy and are essentially uninterpretable. However, the X-ray powder diffraction pattern superficially resembles that of arsenbrackebuschite (PDF 29-1428), especially in the higher  $d$ -space region, and the feinglosite powder data could be successfully indexed by analogy and by trial-and-error indexing.

Feinglosite is thus monoclinic with space-group choices  $P2_1$  or  $P2_1/m$  (by analogy with arsenbracke-

buschite, Abraham *et al.*, 1978, and Hofmeister and Tillmanns, 1978) and diffraction aspect  $P2_1/*$ . A fully indexed powder pattern is presented in Table 2. The refined cell parameters,  $a$  8.973(6),  $b$  5.955(3),  $c$  7.766(6) Å,  $\beta$  112.20(6) $^\circ$ ,  $V$  384.2(4) Å $^3$ , and  $a:b:c = 1.5068:1:1.3041$ , are based on 23 reflections, between 4.16 and 1.624 Å, in the X-ray powder pattern for which unambiguous indexing was possible.

#### References

- Abraham, K., Kantz, K., Tillmanns, E. and Walenta, K. (1978) Arsenbrackebuschite,  $Pb_2(Fe,Zn)(OH,H_2O)[AsO_4]_2$ , a new arsenate mineral. *Neues Jahrb. Mineral., Mh.*, 193–6.
- Hofmeister, W. and Tillmanns, E. (1978) Strukturelle Untersuchungen an Arsenbrackebuschit. *Tschermaks Mineral. Petrog. Mitt.*, **25**, 153–63.
- Roberts, A.C., Ercit, T.S., Criddle, A.J., Jones, G.C., Cureton, F.F. II and Jensen, M.C. (1994) Mcalpineite,  $Cu_3TeO_6 \cdot H_2O$ , a new mineral from the McAlpine mine, Tuolumne County, California, and from the Centennial Eureka mine, Juab County, Utah. *Mineral. Mag.*, **58**, 417–24.

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