*Canadian Mineralogist*
Vol. 17, pp. 87-92 (1979)

# PROSPERITE, $HCaZn_2(AsO_4)_2(OH)$, A NEW MINERAL FROM TSUMEB, SOUTH WEST AFRICA (NAMIBIA)

ROBERT I. GAIT AND B. DARKO STURMAN
*Department of Mineralogy and Geology, Royal Ontario Museum,*
*100 Queen's Park, Toronto, Ontario M5S 2C6*

PETE J. DUNN
*Department of Mineral Sciences, National Museum of Natural History, Smithsonian Institution,*
*Washington, D.C. 20560, U.S.A.*

## ABSTRACT

Prosperite occurs as radiating groups of white to colorless, slender crystals up to 10 mm in length and 1 mm in diameter. The crystals have a brilliant vitreous to silky lustre and are found in cavities in partly altered massive chalcocite from the mine at Tsumeb, South West Africa (Namibia). They are monoclinic, space group *C*2/*c* or *Cc* with *a* 19.252(4), *b* 7.737(2), *c* 9.765(2) Å, $\beta$ 104°32(1)′, Z = 8. The strongest X-ray powder diffraction lines are: 3.87(5)(020), 3.78(7) ($\bar{3}$12,112), 3.37(6)(510), 3.11(8)(600), 2.992(9)($\bar{1}$13), 2.788(5)(113), 2.723(10)(222, $\bar{4}$22, 421), and 2.614(6)($\bar{5}$13); Å, I, (*hkl*). The crystals are elongate [001], and the forms in order of decreasing importance are: {100}, {$\bar{1}$01}, {110}, {$\bar{1}$11}, {421}, {540}, {210}, {310}, {301} and {$\bar{1}$12}. No cleavage was observed. Hardness = 4½ (Mohs), $D_{obs}$ = 4.31 g/cm³, $D_{calc}$ = 4.40 g/cm³. Prosperite is biaxial positive, $n_\alpha$ 1.746, $n_\beta$ 1.748, $n_\gamma$ 1.768, $2V_{obs}$ 34°, $2V_{calc}$ 36°, $r >> v$, *Y* is parallel to *b* and $Z \Lambda c$ = 27° in the acute angle between *a* and *c*. The mineral does not fluoresce in either long- or short-wave ultraviolet radiation. Electron-microprobe analyses gave CaO 13.02, CuO 1.35, ZnO 33.22, $As_2O_5$ 47.92 ($H_2O$ = 4.0 wt. %, by TGA), total 99.51 wt. %, yielding the formula $H_{1.04}Ca_{1.09}(Zn_{1.91}Cu_{0.08})_{\Sigma 1.99}As_{1.95}O_{7.96}(OH)_{1.04}$ or ideally $HCaZn_2(AsO_4)_2(OH)$. The presence of OH was indicated by infrared spectra, which also confirmed arsenic as $AsO_4$. The name honors Mr. Prosper J. Williams, a noted mineral dealer from Toronto.

## SOMMAIRE

On trouve la prospérite en groupements radiaires de cristaux allongés, blancs à incolores, longs de 10 mm et d'un mm de diamètre. Les cristaux, d'un éclat brillant vitreux à soyeux, se trouvent dans des cavités dans la chalcocite massive partiellement altérée de la mine de Tsumeb, en Namibie. Ils sont monocliniques, de groupe spatial *C*2/*c* ou *Cc*; *a* 19.252(4), *b* 7.737(2), *c* 9.765(2)Å, $\beta$ 104°32(1)′, *Z* = 8. Les huit raies les plus intenses du cliché de poudre (Å, I, *hkl*) sont: 3.87(5)(020), 3.78(7)($\bar{3}$12,112), 3.37(6)(510), 3.11(8)(600), 2.992(9)($\bar{1}$13), 2.788(5)(113), 2.723(10)(222,$\bar{4}$22,421) et 2.614(6)($\bar{5}$13). Les cristaux, allongés suivant [001], montrent les formes suivantes, en ordre d'importance décroissante: {100}, {$\bar{1}$01}, {110}, {$\bar{1}$11}, {421}, {540}, {210}, {310}, {301} et {$\bar{1}$12}. Aucun clivage n'a été observé. Dureté 4½ (Mohs): densité 4.31 (obs.), 4.40 (calc.). La prospérite est biaxe positive, $n_\alpha$ 1.746, $n_\beta$ 1.748, $n_\gamma$ 1.768, 2*V* 34° (obs.), 36° (calc.), $r >> v$, *Y* // *b*, $Z \Lambda c$ = 27° dans l'angle aigu entre *a* et *c*. Nulle fluorescence n'a été observée dans l'ultra-violet, ni aux longues, ni aux courtes longueurs d'onde. La microsonde donne CaO 13.02, CuO 1.35, ZnO 33.22, $As_2O_5$ 47.92 ($H_2O$ 4.0%, par ATG), total 99.51% (poids), d'où la formule $H_{1.04}Ca_{1.09}(Zn_{1.91}Cu_{0.08})_{\Sigma 1.99}As_{1.95}O_{7.96}(OH)_{1.04}$; idéalement, $HCaZn_2(AsO_4)_2(OH)$. La présence d'hydroxyle et de groupements $AsO_4$ a été confirmée par spectroscopie infrarouge. Le minéral est dédié à M. Prosper J. Williams, marchand de minéraux bien connu de Toronto.

(Traduit par la Rédaction)

## INTRODUCTION

The mine at Tsumeb, South West Africa (Namibia) is famous for its wealth of beautiful, rare and unusual mineral species. Specimens of Tsumeb minerals are the pride of many public and private collections because of their brilliant crystals and spectacular colors. Bartelke (1976) notes that about 150 species have been identified; of these approximately 35 were first described from Tsumeb. Söhnge (1964) described the general geological setting, the structure of the orebody, the ore distribution, and its genesis and paragenesis. A review of Tsumeb mineralogy is given in Wilson (1977); relevant chapters include an outline of the paragenetic relationships (Keller 1977) and a review of the literature pertaining to Tsumeb minerals (Weber 1977).

The new mineral described here was brought to the Royal Ontario Museum for identification by Prosper J. Williams in 1976. It is a hydroxyl-bearing hydrogen calcium zinc arsenate, ideally $HCaZn_2(AsO_4)_2(OH)$. We are delighted to name it prosperite (PRŎS-PÖRAIT) in honor of Mr. Williams, a noted mineral dealer from Toronto, whose efforts have enriched the Tsumeb collections of many museums, universities and private collectors throughout the world. The species and the name have received approval from the International Mineralogical Association Commission on New Minerals and Mineral Names.

Type material is preserved at the Royal Ontario Museum, Toronto (numbers *M* 35388, *M* 35389 and *M* 35391), at the United States National Museum of Natural History (Smithsonian Institution), Washington, D.C., U.S.A. (numbers *NMNH* 143732 and 143733) and at the British Museum (Natural History), London, England (number *B.M.* 1978, 19).

## ASSOCIATED MINERALS

Prosperite is a secondary mineral occurring in vugs in partly altered massive sulfide ore. A polished section of the altered sulfide matrix (R.O.M. #*M*35392) indicates that the dominant sulfide is chalcocite and that it encloses minute blebs of silver containing about 20 – 25 wt. % mercury (L. J. Cabri, pers. comm.). Part of the chalcocite is altered to massive, waxy, emerald-green conichalcite. Cuprite was also identified, closely associated with the chalcocite.

Two types of vugs were distinguished. One type is lined with druses of minute crystals of brilliant grass-green to olive-green conichalcite. These vugs contain prosperite and pale, blue-green rosettes of bladed adamite crystals. Vugs of the other type are lined with dull, pale green druses of cuprian austinite; these also contain prosperite and adamite crystals. The austinite contains approximately 40 mol % of the conichalcite end-member.

It is not possible at present to make any definite statements regarding the formation or genesis of prosperite because only two specimens are available for study; however, it does seem to be one of the last minerals to crystallize. The minerals associated with prosperite suggest a similar sequence to Keller's type II/4 (1977). The most likely sequence seems to be: primary sulfides → conichalcite $CaCu(AsO_4)(OH)$ and austinite $Ca(Zn,Cu)(AsO_4)(OH)$ → adamite $Zn_2(AsO_4)(OH)$ → prosperite $HCaZn_2(AsO_4)_2(OH)$.

Subsequent to the completion of our investigation, Dr. Paul Keller informed us that he had found prosperite during his study of an arsenate assemblage from Tsumeb. He has given us permission to describe the sequence of deposition of the minerals in this specimen. The secondary minerals have formed on an impure chalcocite in the following order: chalcocite, light brown adamite (0.3 mm thick), green cuprian adamite (0.3 mm thick), colorless radiating crystals of prosperite up to 4 mm long, and stout prismatic prosperite crystals up to 0.5 mm thick; these are followed by several other new minerals presently being described by Dr. Keller, one of which is koritnigite (Keller *et al.* in press).

Until more specimens of prosperite become available the paragenetic sequence must remain in doubt.

## PHYSICAL AND OPTICAL PROPERTIES

Prosperite is white to colorless with a brilliant vitreous to silky lustre; it occurs as radiating groups of slender crystals. Dense aggregates of crystals show a very faint blue tint. Prosperite has a white streak; its hardness is 4½ (Mohs scale); no cleavage was detected. The density is 4.31(1) g/cm³, measured on a Berman microbalance on crystals weighing 10 to 15 mg; the calculated density is 4.40 g/cm³. The lower measured density may reflect the fact that the material used consisted of aggregates of crystals which probably had some spaces between them.

The mineral is biaxial positive with refractive indices $n_\alpha$ 1.746(2), $n_\beta$ 1.748(2) and $n_\gamma$ 1.768(2) for sodium light. The $2V_z$ (measured) is 34° ± 2°, comparing favorably with a calculated value of 36°. The dispersion of the optic axes is $r \gg v$. The optical orientation is as follows: $Y$ parallel to $b$, $Z\Lambda c$ is 27° in the acute angle between $a$ and $c$. The calculated Gladstone–Dale constant (Mandarino 1976) for $HCaZn_2(AsO_4)_2(OH)$ is 0.173, comparing favorably with $K = 0.174$ obtained from the calculated density and measured refractive indices. The mineral does not fluoresce in either long- or short-wave ultraviolet radiation.

## CRYSTALLOGRAPHY

### *Morphology*

Prosperite occurs as radiating sprays of prismatic crystals up to 10 mm long and 1 mm in diameter (Fig. 1) and also as subparallel aggregates in sheaf-like arrangements. Some

FIG. 1. Prosperite: the main crystal is 5 mm long.

of the larger acicular prisms are composed of several smaller crystals in parallel orientation. The crystals are elongate parallel to [001]; in order of decreasing importance, the forms are: *a* {100}, *d* {$\bar{1}$01}, *m* {110}, *p* {$\bar{1}$11}, *z* {421}, *n* {540}, *k* {210}, *l* {310}, *o* {301} and *x* {$\bar{1}$12}. Figure 2 shows two views of a crystal with these forms developed; some of these forms may also be seen in the scanning electron microscope photographs in Figure 3. Table 1 contains the interfacial angles for prosperite. It was not possible to make a definite distinction between crystal classes 2/*m* and *m* from the observed data because the forms parallel to *c* were not completely developed all around any one crystal; the other forms were only observed on singly-terminated crystals. However, the evidence favors class 2/*m*.

It has been pointed out that the form {530} should be expected rather than {540}; however, all the *hk*0 faces observed on the crystals have corresponding reflections on the zero-level Weissenberg taken parallel to *c*. A weak reflection was noted for (10.8.0), equivalent to (540), but none was observed for (530) or (10.6.0). Another ambiguity arose concerning the face (301) that gave a poor signal ranging from $\rho = 61 - 64°$, with the signal being strongest at 64°. This latter figure is closer to (702), $\rho_{calc} = 64°25'$. However, on the precession X-ray photographs, the (602) reflection is much stronger than (14.0.4), indicating that (301), $\rho_{calc} = 61°21'$ should be assigned to this face.

The form {311} was recognized only as a tiny face on one crystal and is not shown in the drawing (Fig. 2). The crystals were slightly bent and twisted, and so the accuracy of the

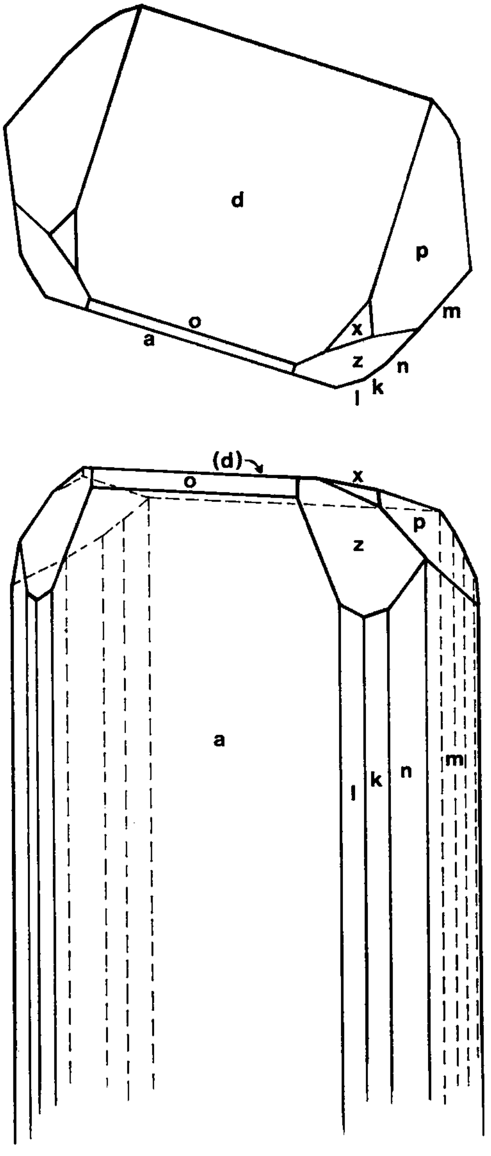

FIG. 2. Crystal drawings of prosperite.

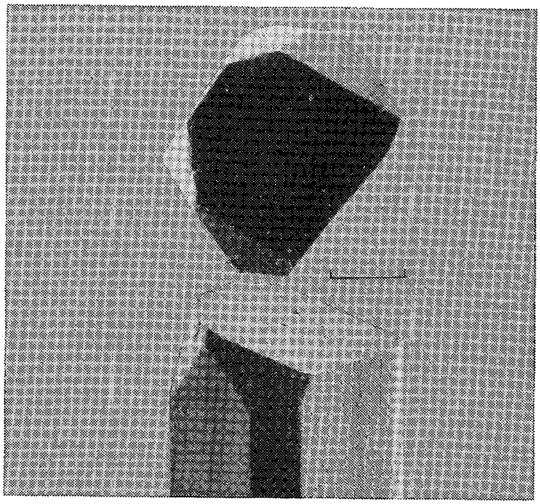

FIG. 3. Two SEM views of a prosperite crystal. Bar represents 0.05 mm.

measurements in Table 1 was lower than generally obtained with the optical goniometer.

### *X-ray diffraction data*

Single-crystal X-ray data were obtained from Weissenberg and precession methods. The mineral is monoclinic, space group *C2/c* or *Cc*. The refined cell dimensions were obtained from a least-squares refinement using the X-ray powder diffraction data and selected known indices from the precession photographs. The cell constants are *a* 19.252(4), *b* 7.737(2), *c* 9.765(2)Å, $\beta$ 104° 32(1)′. The cell volume is 1408.1Å$^3$; $Z = 8$ formula units.

Prosperite gives a sharp, distinctive X-ray powder diffraction pattern. Table 2 shows the observed data from two methods, Guinier-de Wolff and Gandolfi (using a powder-ball mount), compared with the calculated spacings from the refined cell parameters. The X-ray powder

TABLE 1. ANGLE TABLE FOR PROSPERITE

Monoclinic, *a* = 19.252(4), *b* = 7.737(2), *c* = 9.765(2)Å, $\beta$ = 104°32(1)'

| Form | Measured | | Calculated | |
|---|---|---|---|---|
| | $\phi$ | $\rho$ | $\phi$ | $\rho$ |
| *a* 100 | 90° | 90° | 90°00' | 90°00' |
| *m* 110 | 22°47' | 90° | 22°33' | 90°00' |
| *n* 540 | 27°43' | 90° | 27°25' | 90°00' |
| *k* 210 | 39°16' | 90° | 39°42' | 90°00' |
| *l* 310 | 52°02' | 90° | 51°14' | 90°00' |
| *o* 301 | 90° | 61°-64° | 90°00' | 61°21' |
| *d* $\bar{1}01$ | -90° | 15°29' | -90°00' | 14°50' |
| *p* $\bar{1}11$ | -11°50' | 52°18' | -11°51' | 52°12' |
| *x* $\bar{1}12$ | - 1°02' | 33°22' | - 0°15' | 32°15' |
| *z* 421 | 45½° | 72½° | 43°01' | 73°50' |
| *y* $\bar{3}11$* | -45°40' | 60°20' | 46°07' | 61°13' |

*Not shown in Figure 2

TABLE 2. X-RAY POWDER DIFFRACTION DATA FOR PROSPERITE

| Monoclinic, *C2/c* or *Cc*<br>*a* = 19.252(4), *b* = 7.737(2),<br>*c* = 9.765(2)Å; $\beta$ = 104°32(1)' | | Guinier de Wolff | | Gandolfi 114.6 mm (powder ball mount) | |
|---|---|---|---|---|---|
| *hkl* | $d_{calc}$Å | $d_{meas}$Å | $I_{est}$ | $d_{meas}$Å | $I_{est}$ |
| 200* | 9.32 | 9.26 | 3 | 9.34 | 4 |
| 110* | 7.14 | 7.11 | 2 | 7.17 | 3 |
| $\bar{1}11$ | 5.98 | 5.96 | ½ | 5.91 | ½ |
| 310 | 4.84 | 4.82 | ½ | | |
| 002* | 4.73 | 4.72 | 2 | 4.69 | 2 |
| $\bar{1}12$* | 4.13 | 4.10 | ½ | | |
| 311 | 4.00 | 3.99 | ½ | 3.97 | ½ |
| 020* | 3.869 | 3.86(6) | 5 | 3.86(3) | 5 |
| 112 | 3.779 | 3.78(0) | 7 | 3.77(3) | 5 |
| $\bar{3}12$ | 3.772 | | | | |
| 021 | 3.580 | 3.57(1) | ½ | 3.57(0) | 1 |
| 220 | 3.573 | | | | |
| $\bar{5}11$ | 3.417 | 3.42(1) | ½ | | |
| 510* | 3.358 | 3.36(5) | 6 | 3.35(3) | 5 |
| 221 | 3.241 | 3.25(0) | 1 | | |
| 600* | 3.106 | 3.11(1) | 8 | 3.10(8) | 8 |
| $\bar{1}13$* | 2.991 | 2.992 | 9 | 2.991 | 9 |
| 511* | 2.960 | 2.959 | 1 | | |
| $\bar{3}13$ | 2.914 | 2.919 | ½ | | |
| 113* | 2.786 | 2.788 | 5 | 2.788 | 2 |
| 222 | 2.726 | 2.723 | 10 | 2.722 | 10 |
| $\bar{4}22$ | 2.723 | | | | |
| 421 | 2.717 | | | | |
| $\bar{5}13$* | 2.611 | 2.614 | 6 | 2.611 | 5 |
| $\bar{7}11$ | 2.590 | 2.594 | 1 | | |
| 130 | 2.555 | 2.550 | ½ | | |
| $\bar{1}31$ | 2.488 | 2.483 | 4 | 2.488 | 2 |
| 512 | 2.485 | | | | |
| $\bar{2}23$ | 2.485 | | | | |
| 131 | 2.445 | 2.442 | 3 | 2.442 | 1 |
| 023 | 2.443 | | | | |
| $\bar{2}04$ | 2.441 | | | | |
| 620* | 2.422 | 2.419 | 3 | 2.424 | 1 |
| 004* | 2.363 | 2.362 | 4 | 2.360 | 2 |
| 422 | 2.354 | 2.349 | ½ | | |
| $\bar{6}22$ | 2.350 | | | | |
| $\bar{8}02$ | 2.335 | 2.332 | ½ | | |
| $\bar{1}14$ | 2.311 | 2.310 | ½ | | |
| $\bar{3}14$ | 2.310 | | | | |
| $\bar{1}32$ | 2.280 | 2.276 | ½ | | |
| $\bar{7}13$ | 2.244 | 2.232 | ½ | | |
| 621 | 2.243 | | | | |
| $\bar{5}14$ | 2.178 | 2.177 | 1 | | |
| 204 | 2.165 | 2.173 | 1 | 2.168 | ½ |
| $\bar{6}02$ | 2.160 | | | | |
| $\bar{5}31$ | 2.136 | 2.131 | 2 | 2.132 | 1 |
| $\bar{6}23$ | 2.132 | | | | |
| 513 | 2.076 | 2.080 | ½ | | |
| $\bar{9}11$ | 2.061 | 2.062 | ½ | 2.058 | ½ |
| $\bar{8}21$ | 2.043 | 2.039 | ½ | 2.032 | 1 |
| 712 | 2.031 | | | | |
| $\bar{9}12$ | 2.027 | 2.023 | 2 | | |
| 531 | 2.009(0) | 2.009 | ½ | 2.006 | ½ |
| 423 | 2.008(9) | | | | |
| $\bar{8}22$ | 1.999 | 1.993 | ½ | | |
| 820 | 1.996 | | | | |
| $\bar{3}33$ | 1.995 | | | | |
| 314 | 1.977 | 1.970 | ½ | 1.975 | 1 |
| $\bar{7}14$ | 1.972 | | | | |
| 040 | 1.934 | 1.931 | ½ | | |
| 404 | 1.922 | 1.920 | 1 | | |
| $\bar{9}13$ | 1.911 | 1.907 | 2 | 1.910 | 1 |
| 224 | 1.889 | 1.889 | 3 | 1.889 | 1 |
| $\bar{5}33$ | 1.888(8) | | | | |
| $\bar{6}24$ | 1.886 | | | | |
| $\bar{7}31$ | 1.881 | 1.878 | ½ | | |
| $\bar{8}23$ | 1.878 | | | | |
| 821 | 1.872(9) | 1.870 | ½ | | |
| $\bar{1}15$ | 1.872(8) | | | | |
| $\bar{5}15$ | 1.834 | 1.835 | 1 | 1.835 | ½ |
| $\bar{2}42$ | 1.790 | 1.784 | 2 | 1.788 | 1 |
| $\bar{4}41$ | 1.787 | | | | |
| 440 | 1.786 | | | | |
| 115 | 1.785(8) | | | | |
| 514 | 1.755 | 1.754 | ½ | 1.756 | ½ |
| 242 | 1.728 | 1.724 | 2 | 1.726 | 2 |
| $\bar{4}42$ | 1.727 | | | | |
| $\bar{4}25$ | 1.726 | | | | |

Plus many additional lines to 0.7774Å

*Indexed from precession photographs

CuK$_\alpha$ radiation

diffraction data were recorded using Cu*Kα* radiation. The intensities were estimated visually.

The parallel and sub-parallel aggregation of the crystals gives them an appearance suggestive of lamellar twinning. However, no evidence of twinning was found in the single-crystal X-ray study or during the examination of the crystals with the petrographic microscope and the universal stage.

## Chemical Composition

Crystals of prosperite were analyzed using an ARL–SEMQ electron microprobe with an operating voltage of 15 kV and a beam current, measured with a beam-current monitor, of 0.15 μA. The results were corrected for background, backscatter, fluorescence and absorption.

The standards used in the first series of analyses were: synthetic olivenite for Cu and As, synthetic ZnO for Zn, fluorapatite for Ca, P and F, and hornblende for Fe, Mg and Mn. Of these elements, only Ca, Zn, Cu and As are present in significant amounts. Fe is present as a trace and P, F, Mg and Mn are either absent or present only as traces. A microprobe wavelength-dispersive scan at 20 kV indicated the absence of any other elements with atomic number above 9. Separate analyses using other standards confirmed these analytical results. Four crystals were analyzed using the above methods and standards, with an average of 10 or more sample points on each crystal. Scans were made at 10 μ intervals across the crystals, but no compositional zoning was detected. The crystals were found to be very similar in composition, with only minor variation in the Zn:Cu ratio. There is a sympathetic variation between Zn and Cu from sample point to sample point. The Cu content varies as much as ± 50% of the amount shown in Table 3 (1.35 wt.%); this variation seems random and not crystallographically controlled. The final electron microprobe analysis is given in Table 3 and was obtained using the following standards: adamite for Zn and As, synthetic olivenite for Cu, and hornblende for Ca.

TABLE 3. ELECTRON MICROPROBE ANALYSIS OF PROSPERITE

| | Analytical | | | | | Theoretical | | |
|---|---|---|---|---|---|---|---|---|
| | Wt. % | No. of Atoms | | | | Wt. % | No. of Atoms | |
| Ca | 13.02 | Ca | 1.09 | | | 12.02 | Ca | 1.00 |
| ZnO | 33.22 | Zn | 1.91 | 1.99 | | 34.87 | Zn | 2.00 |
| CuO | 1.35 | Cu | 0.08 | | | - | - | - |
| $As_2O_5$ | 47.92 | As | 1.95 | | | 49.25 | As | 2.00 |
| $H_2O$* | 4.0 | $H_2O$ | 1.04 | | | 3.86 | $H_2O$ | 1.00 |
| Total | 99.51 | | | | Total | 100.00 | | |

*TGA

Empirical formula, calculated on the basis of 9 oxygen atoms:

$$H_{1.04}Ca_{1.09}(Zn_{1.91},Cu_{0.08})_{\Sigma 1.99}As_{1.95}O_{7.96}(OH)_{1.04}$$

Ideal formula: $HCaZn_2(AsO_4)_2(OH)$

Accuracy of data: ± 3% of the amount shown for Ca, Zn and As
±50% of the amount shown for Cu

The differential thermal analysis and the thermogravimetric measurements were performed on a Mettler Thermoanalyzer using an 11 mg sample of the mineral. The sample was coarse-ground to between 200 and 100 mesh in acetone and only the coarse material used for the analyses. This was done to minimize the loss of (OH), to be expected if the sample is too finely ground. The sample was pre-dried in a high vacuum. The reference substance was α–$Al_2O_3$, the crucibles were composed of $Al_2O_3$, the heating rate was 8°C per minute in a dynamic nitrogen atmosphere up to 1000°C. The DTA and TGA curves for prosperite are shown in Figure 4. The prominent endothermic peak at 655°C is related to a 4.0 wt. % loss occurring between 469° and 682°C with the main loss between 641° and 665°C. The infrared spectra indicate that this weight loss is due to (OH); the remaining H is expressed as hydrogen in the chemical formula. Additional endothermic peaks at 927° and 965°C are related to fusion of the sample.

Infrared analyses were performed on two samples by Mr. D. M. Farrell of CANMET, Ottawa. One sample had been heated to 680°C in dry nitrogen and the other was the natural, unheated material. The spectra of the mineral

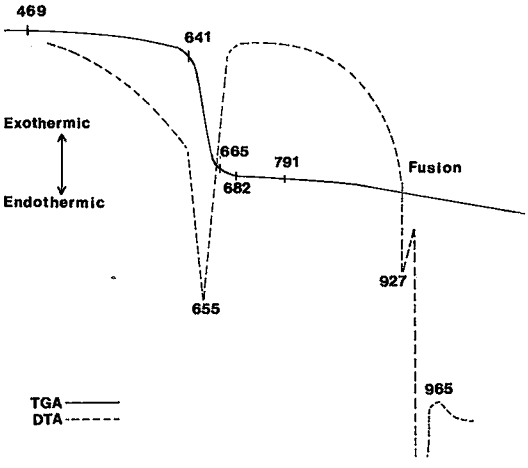

FIG. 4. DTA/TGA curves for prosperite.

and the standard, synthetic $As_2O_3$, were recorded in the infrared in the double-beam mode using a blank KBr disk for reference. All the spectra were recorded on a Beckman IR–12 spectrophotometer under standard operating conditions in the 0 – 100% $T$ mode. The results of these infrared analyses indicated that the weight loss of 4.0 wt. % should be attributed to (OH) and that the arsenic should be expressed in the chemical formula as $AsO_4$.

On the basis of this information, the empirical formula calculated from the final analysis may be given as $H_{1.04}Ca_{1.09}(Zn_{1.91}Cu_{0.08})_{\Sigma 1.99}$-$As_{1.95}O_{7.96}(OH)_{1.04}$ on the basis of 9 oxygen atoms. The ideal formula may be expressed as $HCaZn_2(AsO_4)_2(OH)$.

## Conclusion

Prosperite seems to be unique, and bears no chemical or structural analogies to other mineral species, or to synthetic compounds. Crystals have been supplied to Dr. J. D. Grice of the National Museum of Natural Sciences, Mineral Sciences Division, Ottawa for a structure determination.

## Acknowledgements

The authors are most grateful to Mr. D. M. Farrell of CANMET, Ottawa for performing the infrared analyses on prosperite. Dr. Louis J. Cabri kindly identified the main opaque minerals in a polished section of the matrix material. We thank Dr. Paul Keller of the University of Stuttgart, Federal Republic of Germany, for allowing us to use the description of his prosperite specimen. We also thank the following people at the Royal Ontario Museum for their contributions: Mrs. Cynthia Peat for doing most of the X-ray powder diffraction patterns, Mr. R. A. Ramik for performing the DTA and TGA studies, Drs. J. A. Mandarino and F. J. Wicks for their critical reading of the manuscript, Mrs. Violet Anderson for the photomicrograph, Miss Helen Driver for typing the manuscript, and Mrs. Josephine Galt for typing the tables; we thank the Department of Photography and the Art Department for their assistance in preparing the figures and drawings. Finally we thank Prosper J. Williams for bringing this mineral to our attention and for donating one of the specimens to the mineral collections of the Royal Ontario Museum.

## References

Bartelke, W. (1976): Die Erzlagerstätte von Tsumeb, Südwestafrika und ihre Mineralien. *Aufschluss* 27, 393-439.

Keller, P. (1977): Paragenesis: assemblages, sequences, associations. *In* Tsumeb. The World's Greatest Mineral Locality. (W. E. Wilson, ed.). *Mineral. Record* 8(3), 38-47.

————, Hess, H., Süsse, P., Schnorrer, G. & Dunn, P.J. (1979): Koritnigit, $Zn[H_2O|HOAsO_3]$, ein neues Mineral aus Tsumeb, Südwestafrika. *Tschermaks Mineral. Petrog. Mitt.* 26 (in press).

Mandarino, J. A. (1976): The Gladstone-Dale relationship — Part I: Derivation of new constants. *Can. Mineral.* 14, 498-502.

Söhnge, P. G. (1964): The geology of the Tsumeb mine. *In* The Geology of some Ore Deposits in Southern Africa. II. Deposits of some Minerals Outside the Witwatersrand Basin (S. H. Haughton, ed.), *Spec. Publ. Geol. Soc. S. Afr.*

Weber, D. (1977): Minerals: a review of the literature. *In* Tsumeb. The World's Greatest Mineral Locality (W. E. Wilson, ed.). *Mineral. Record* 8 (3), 101-110.

Wilson, W. E., ed. (1977): Tsumeb. The World's Greatest Mineral Locality. *Mineral. Record* 8, (3).

*Received August 1978; revised manuscript accepted September 1978.*