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## **Namibite, a new Copper-Bismuth-Vanadium Mineral from Namibia**

by *Oleg v. Knorring* \* and *Th. G. Sahama* \*\*

### **Abstract**

A new copper-bismuth-vanadium mineral is described from a polyminerallie, hydrothermal quartz-vein deposit in northwestern Namibia. The mineral is named namibite after the Namib Desert.

The dominant habit of a namibite crystal is platy, parallel to {100}, with narrow forms {101} and {111}. Interpenetration twinning on (011) is common, often polysynthetic. Good cleavage is parallel to (100).

The mineral is easily soluble in dilute cold acids. Its composition corresponds to the formula  $\text{CuBi}_2\text{VO}_6$  with  $Z = 2$ . Calculated density 6.76 compared with 6.86 measured.

Single crystal X-ray precession photographs indicate a monoclinic symmetry with the space group  $C2/m$ ,  $Cm$  or  $C2$ . The unit cell parameters are:  $a = 11.864 \text{ \AA}$ ,  $b = 3.696 \text{ \AA}$ ,  $c = 7.491 \text{ \AA}$ ,  $\beta = 109^\circ 42'$ ,  $V = 309 \text{ \AA}^3$ . The three strongest powder lines are: 111:  $d = 3.018$ ,  $I = 100$ ; 202:  $d = 3.574$ ,  $I = 75$ ; 200:  $d = 5.58$ ,  $I = 70$ .

The mineral is not fluorescent. Hardness, 4.5-5 in the Mohs' scale. Color, dark green; streak, pistachio green. Refractive indices well above 2.10.  $b||\gamma$ ,  $a \wedge \alpha = 12^\circ$  in the acute angle  $\beta$ .  $2V_\alpha$  moderate for red and very small for blue. Slightly pleochroic with different shades of green, absorption  $\gamma > \beta > \alpha$ .

### **DISCOVERY**

In 1969 a drusy, mineralized quartz specimen containing various copper and bismuth minerals was obtained for examination from Mr. E. W. KAPLAN of Swakopmund, Namibia. The specimen came from a copper occurrence in the vicinity of Khorixas (formerly Welwitschia) in the northwestern part of Namibia. In this general area there are a number of small, abandoned copper mines where the mineralization is associated with hydrothermal quartz veins. In this particular specimen, however, the major mineral was beyerite, forming a canary-yellow incrustation in cavities lined with quartz crystals, calcite and

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some malachite. A closer examination of the specimen revealed a few minute, dark green specks of an unknown mineral (v. Knorring, 1971), set in the spherulitic beyerite matrix.

In Oktober, 1980, the occurrence was visited by the first author and some additional material was collected from the mine dumps for further investigation.

The new mineral is named namibite after the Namib Desert. The name has been approved by the Commission on New Minerals and Mineral Names of the International Mineralogical Association. Very small amounts of the type material are stored at both Departments of the authors.

#### OCCURRENCE

The quartz veins are drusy in character containing smaller and larger vugs, lined with quartz crystals and frequently filled with a variety of copper and bismuth minerals and often calcite too, partly replacing the quartz. In addition, numerous fractures in the quartz are also mineralized in the same manner.

Although copper is the main mineralizing agent a large amount of bismuth, tungsten and some lead, vanadium and silver are also present, indicating that this occurrence is a complex polymetallic deposit.

To date, the following minerals have been observed:

Native copper. Cuprite. Chalcocite. Malachite. Azurite. Chrysocolla. Planchite. A very rare black mineral with a spinel type structure corresponding to the synthetic  $\text{CuFeMnO}_4$  (Powder Diffraction File 20-358). A yellowish green mineral close to calciovolborthite.

Native bismuth. Bismite. Bismutite. Beyerite. Clinobisvanite (pseudomorphic after pucherite).

The new mineral namibite.

Galena. Scheelite. Cuprotungstite.

Iodargyrite. Embolite.

In addition, large amounts of hematite and goethite and some rutile, aragonite and gypsum have been noted.

The new mineral namibite is usually associated with beyerite. The following concentric sequence of mineralization is commonly seen outwards: native bismuth  $\rightarrow$  bismite  $\rightarrow$  bismutite  $\rightarrow$  namibite  $\rightarrow$  beyerite. In most cases namibite is seen in the form of rounded specks with radiating dendritic veinlets set in a matrix of spheroidal beyerite. Occasionally minute, platy crystals of namibite (up to 2 mm in size) are observed in the quartz crystals lining the cavity or in the spheroidal beyerite.

Some of the quartz specimens contain a large amount of scheelite which is almost invariably replaced by cuprotungstite. The rare silver minerals, iodargyrite and embolite, have been formed very late in the mineralization sequence. The former is found in minute, stout prismatic, yellowish crystals in small quartz vugs and embolite occurs as a waxy, greenish yellow coating on fractures in quartz. Most of the minerals are supergene in origin, frequently formed by concentric replacement of earlier low-temperature minerals.

### PROPERTIES

*Crystal morphology.* The available crystals are not suitable for accurate goniometer measurement. A typical habit is platy, parallel to  $\{100\}$ , with the narrow forms  $\{101\}$  and  $\{111\}$  (Fig. 1). In addition, some small and poorly developed faces are present in a few crystals. Because their indexing is uncertain, they have been neglected in the drawing. The interpenetration twinning on  $(011)$  is common, often in a polysynthetic manner. The cleavage parallel to  $(100)$  is fairly good.

*Chemistry.* The mineral is easily soluble in cold dilute acids without effervescence. A separate microprobe test (JEOL JCXA-733 instrument) showed no fluorine and an infrared absorption spectrum did not disclose any notable  $\text{H}_2\text{O}$  or OH. The amount of material available did not allow a chemical analysis to be made. A microprobe analysis (automated GEOSCAN of the Cambridge In-

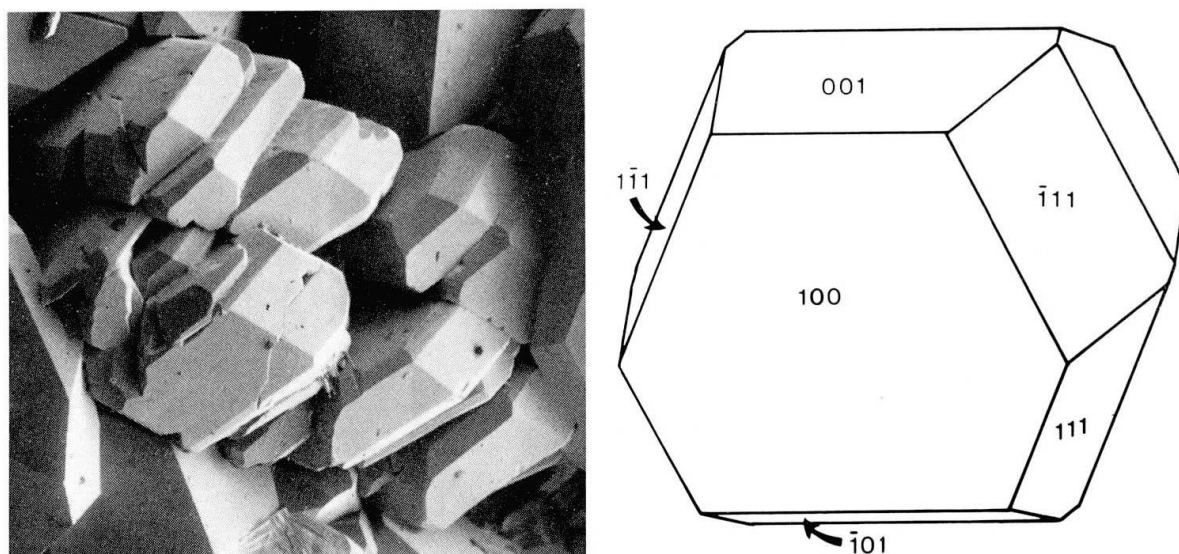


Fig. 1 Crystal morphology of namibite. A: Group of exceptionally well formed crystals, scanning electron micrograph. Diameter of the group is 1 mm. B: Idealized crystal habit.

Single analyses wt. % of the metals					Average	Oxides wt. %		Unit cell content O = 6	
Cu	10.4	10.2	10.0	10.1	10.2 ± 0.1	Cu <sub>2</sub> O	11.5	Cu	1.01
	10.2	10.2	10.2	10.1					
Bi	67.0	65.9	66.2	66.5	66.5 ± 0.5	Bi <sub>2</sub> O <sub>3</sub>	74.1	Bi	2.00
	65.8	66.8	66.7	66.9					
V	8.2	8.1	8.1	8.1	8.1 ± 0.1	V <sub>2</sub> O <sub>5</sub>	14.5	V	1.00
	8.1	8.0	8.2	8.0					
Total						100.1			

Table I Microprobe analysis of namibite.

strument Co.) is reproduced in Table I. No other constituents except those mentioned in this table were detected, and its copper-bismuth-vanadium composition is unique. Metal standards and EMPADR VII data reduction program by J. RUCKLIDGE and E. L. GASPARRINI were used. The composition of the mineral corresponds to the formula  $\text{CuBi}_2\text{VO}_6$  with  $Z = 2$ . The density, calculated from the analysis and unit cell volume, is 6.76 compared with the value of  $6.86 \pm 0.03$  measured with a Berman balance on a sample of 11.9 mg.

*X-ray crystallograph.* Single crystal precession photographs indicate a monoclinic symmetry with systematic extinctions corresponding to the space groups  $C2/m$ ,  $Cm$  and  $C2$ . The X-ray powder pattern, taken with a Philips wide angle goniometer with filtered copper radiation and using quartz as an internal standard, is reproduced in Table II. A few faint lines could not be accurately measured and are not included in the table. The measurement of the poor lines beyond 020 was found meaningless for the purpose of indexing. Wherever possible, the intensities of the powder lines were checked on the single crystal photographs. The unit cell dimensions, calculated from the powder pattern and checked on the precession photographs, are:

$$\begin{aligned}
 a &= 11.864 \pm 0.008 \text{ \AA} \\
 b &= 3.696 \pm 0.004 \\
 c &= 7.491 \pm 0.005 \\
 \beta &= 109^\circ 42' \pm 06' \\
 V &= 309 \text{ \AA}^3
 \end{aligned}$$

*Physical and optical data.* The mineral is not fluorescent. The Vickers microindentation hardness number, with 100 g and 200 g loads respectively, was found to be 473, corresponding to 4.5–5 in the Mohs' scale. The streak of the mineral is pistachio green.

<i>I</i>	<i>hkl</i>	<i>d</i> <sub>obs.</sub>	<i>d</i> <sub>calc.</sub>
30	001	7.05	7.05
70	200	5.58	5.58
10	-201	5.34	5.34
5	201	3.80	3.80
75	-202	3.574	3.575
40	002	3.525	3.526
50	-111	3.284	3.283
100	111	3.018	3.017
20	-401	2.960	2.960
30	400	2.792	2.792
60	-402	2.672	2.671
5sh	{ -112 310 }	2.628	{ 2.630 2.623 }
35	202	2.611	2.610
16	-203	2.486	2.487
15	-312	2.394	2.395
15	112	2.364	2.365
13	311	2.288	2.287
5	-403	2.200	2.201
20	-113	2.056	2.056
13b	{ -313 -511 }	1.999	{ 2.003 1.996 }
18	-602	1.9377	1.9380
8	600	1.8612	1.8615
15	020	1.8481	1.8480

sh = shoulder      b = broad

Table II X-ray powder pattern of namibite.

The extremely high refractive indices (well above 2.10), the intimate twinning and the scarcity of the material make it difficult to obtain complete optical data. The following properties can be presented: optical orientation  $b \parallel \gamma$ ,  $a \wedge \alpha = \text{ca. } 12^\circ$  in the acute crystallographic angle  $\beta$ . The optic axial angle  $2V_\alpha$  is moderate for red and very small for blue. Pleochroic scheme,  $\alpha$  slightly yellowish green,  $\beta$  pistachio green,  $\gamma$  dark green, absorption  $\gamma > \beta > \alpha$ .

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