

## Claringbullite, a new hydrated copper chloride

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**SUMMARY.** Claringbullite,  $\text{Cu}_4\text{Cl}(\text{OH})_7 \cdot n\text{H}_2\text{O}$  where  $n$  is about 0.5, a new mineral, is reported as soft blue plates in cuprite from Nchanga open pit, Zambia and Kambowe, Mina M'sesa, Katanga. The mineral is hexagonal  $a$  6.6708,  $c$  9.183 Å,  $Z = 2$ . Optically, claringbullite is uniaxial negative with  $\omega = 1.782$  and  $\epsilon = 1.780$ . Indexed powder data are given together with five electron-probe analyses of the mineral.

IN 1973 a specimen of cuprite said to have come from the Nchanga open pit,<sup>1</sup> Zambia, with tiny blue platy crystals on one corner, was brought to the Museum for identification by Mr. N. Wilson. The blue crystals were thought to be gerhardite,  $\text{Cu}_2\text{NO}_3(\text{OH})_3$ , but their X-ray powder pattern did not correspond to this, or any other known mineral. A match was obtained, however, with a blue mineral from Bisbee, Arizona, belonging to Dr. S. A. Williams. A few days later a blue mineral from the M'sesa mine, Kambowe, Katanga, on loan from the Sorbonne, Paris, and believed to be a new species, was X-rayed and its powder pattern found to be identical with that of the Zambian and Arizonan mineral.

The Zambian and Katangan specimens form the type specimens of claringbullite,  $\text{Cu}_4\text{Cl}(\text{OH})_7 \cdot n\text{H}_2\text{O}$  where  $n$  is about 0.5. The mineral is named for Sir Frank Claringbull, former director of the British Museum (Natural History) and Keeper of Mineralogy. The data that follow and the name have been approved prior to publication by the Commission on New Minerals and Mineral Names, I.M.A.

*Physical and optical properties.* Claringbullite from Nchanga occurs as a slightly divergent group of blue plates filling a cavity in quartz and malachite on cuprite. Yellow-stained quartz crystals also occur on the specimen. The Katangan occurrence consists of slightly divergent groups of soft blue plates up to 1 mm across, with pearly lustre, in a vug in cuprite, associated with acicular and tabular crystals of brochantite. Malachite and copper occur elsewhere on the specimen. The claringbullite plates are flattened on  $\{0001\}$ ; cleavage is perfect on  $\{0001\}$ ; distinct on  $\{10\bar{1}0\}$  and  $\{11\bar{2}0\}$ . Fragments from the Katangan specimen were used for the optical investigation and consist of micaceous, thin, delicate laminae with maximum dimensions from 0.05 to 0.28 mm. The mineral is uniaxial negative. In transmitted light it is pale blue with no noticeable pleochroism and  $\omega_{\text{Na}}$  is 1.782 for sodium light. All cleavage flakes remained dark between crossed polars.

A cleavage flake of size  $0.28 \times 0.17 \times 0.015$  mm was mounted on a stage rotation apparatus. When viewed edgewise it remained pale blue for the principal vibration directions, but it was not possible to determine the refractive index for the extraordinary ray using the immersion method because of the micaceous nature of the fragment. Between crossed polars the edge-on flake showed straight extinction and abnormal interference colours of dark blue rising to yellowish-green. The yellowish-green interference colour was obtained when the 0.17 mm dimensions of the cleavage flake was parallel to the axis of the microscope and was judged to be first-order

<sup>1</sup> S. Korowski, personal communication, believes that the specimen comes from the Nchanga deep mine, not the open pit.

yellow masked by the blue body-colour of the mineral. From the relative retardation of 275–400  $m\mu$  the birefringence was calculated as 0.002 ( $\pm 0.0004$ ). Claringbullite is thus uniaxial negative  $\omega = 1.782$ ,  $\varepsilon = 1.780$ . Because of its low birefringence and the thinness of the plates, satisfactory interference figures could not be obtained.

By immersing a grain of Katangan claringbullite in dilute Clerici solution, its density was estimated to be close to  $3.9 \text{ g.cm}^{-3}$ .

*Chemical investigation.* Electron-probe analyses of five grains of claringbullite, obtained with a Cambridge Geoscan, are given, after correction, in Table I. Analyses 1–3 are of grains from the Zambian specimen, 4 and 5 from the Katangan specimen, and 6 represents ideal  $\text{Cu}_4\text{Cl}(\text{OH})_7 \cdot \frac{1}{2}\text{H}_2\text{O}$ . The standards used were pure copper, sylvine (Cl), and anglesite (S). The Katangan and, to a lesser extent, the Zambian grains were unstable under the electron beam, so the analyses were obtained by using a defocused beam and moving the specimen after each count. The water figures were obtained by difference. However, in a direct determination, a

TABLE I. Electron probe analyses of claringbullite

	1	2	3	4	5	6
CuO	78.18	79.89	79.58	74.42	82.70	76.18
SO <sub>3</sub>	0.06	0.08	0.08	0.12	0.12	—
Cl	8.55	8.71	8.84	8.30	8.20	8.49
H <sub>2</sub> O*	[15.14]	[13.28]	[13.49]	[19.03]	[20.83]	17.26
Less						
O $\equiv$ Cl	1.93	1.96	1.99	1.87	1.85	1.93
Sum	100.00	100.00	100.00	100.00	100.00	100.00

1, 2, and 3. Nchanga open pit, Zambia.

4 and 5. Kambowe, Mina M'sesa, Katanga.

6. Theory for  $\text{Cu}_4\text{Cl}(\text{OH})_7 \cdot \frac{1}{2}\text{H}_2\text{O}$ .

\* By difference.

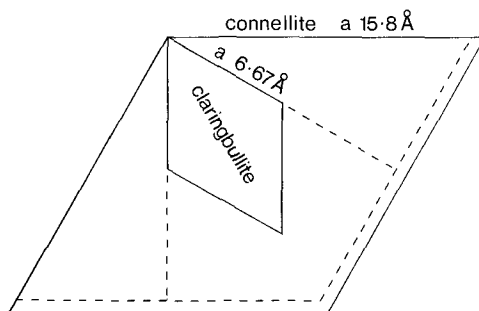


FIG. 1. Comparison of unit cells of connellite and claringbullite.

small sample ( $\sim 100 \mu\text{g}$ ) of the Katangan material gave a bound-water figure of 14.3% on a Perkin Elmer 240 elemental analyser. An infra-red absorption spectrum was obtained from a KBr disc. All the absorptions were very weak and those present were assigned to trace amounts of nitrate ( $1385, 1399 \text{ cm}^{-1}$ ) and sulphate ( $1070 \text{ cm}^{-1}$ ). Silicate, phosphate, arsenate, and carbonate anions were not detected. An absorption at  $1653 \text{ cm}^{-1}$  showed that some of the OH ( $3450 \text{ cm}^{-1}$ ) was present as  $\text{H}_2\text{O}$ . This water is thought to be zeolitic in nature, hence the introduction of  $n$  in the formula. Nitrogen was not detected when the water determination was made, establishing the  $\text{N}_2\text{O}_5$  content as less than 1%; it was not within the range of elements detectable in our electron probe. On the basis of eight copper atoms per formula unit, the formula derived from the mean of analyses 1–5 is  $\text{Cu}_{8.00}(\text{SO}_4)_{0.01}\text{Cl}_{1.99}(\text{OH})_{14.00} \cdot 0.68\text{H}_2\text{O}$ .

*X-ray investigation.* An apparently isotropic flake from the Zambian specimen was mounted vertically on a glass fibre;  $15^\circ$  oscillation and rotation photographs gave a layer line spacing of  $6.65 \text{ \AA}$  and some evidence of hexagonal symmetry. Using a Bunn chart for hexagonal crystals it was possible to index the first two dozen lines of an  $11.46 \text{ cm}$  powder pattern for  $\log c/a = 0.140$ ,  $c/a = 1.38$ . Referring to Donnay and Ondik (1973) some similarity to the connellite-buttenbachite group was shown, but the claringbullite powder patterns were different. A further photograph with a prolonged exposure time failed to reveal any intermediate layer lines. Zero and first-layer Weissenberg photographs around the same axis confirmed the hexagonal symmetry and gave a  $c$ -axis dimension of  $9.16 \text{ \AA}$ , very close to those of connellite and



*Type specimens.* The specimen of claringbullite from Zambia is registered in the British Museum (Natural History) collection as BM 1976, 109. The Katangan specimen is the property of the Sorbonne, Paris.

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