

Buttgenbachite **$\text{Cu}_{36}(\text{NO}_3)_2\text{Cl}_8(\text{OH})_{62} \cdot 4\text{--}10\text{H}_2\text{O}$**

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Crystal Data: Hexagonal. *Point Group:* $6/m\ 2/m\ 2/m$. Crystals are hexagonal, acicular and striated $\parallel [0001]$, terminated by $\{20\bar{2}1\}$, to 1 mm; as isolated crystals, radiating groups and felted crystal aggregates.

Physical Properties: Hardness = 3 $D(\text{meas.}) = 3.36\text{--}3.42$ $D(\text{calc.}) = 3.23\text{--}3.25$

Optical Properties: Translucent. *Color:* Deep azure-blue; blue in transmitted light.

Streak: Pale greenish blue. *Luster:* Vitreous.

Optical Class: Uniaxial (+). $\omega = 1.738$ $\epsilon = 1.752$

Cell Data: *Space Group:* $P6_3/mmc$. $a = 15.739\text{--}15.750$ $c = 9.127\text{--}9.161$ $Z = 1$

X-ray Powder Pattern: Likasi, Congo; close to connellite.

13.70 (vvs), 7.95 (vvs), 2.75 (vvs), 2.30 (vvs), 1.621 (vs), 3.27 (s), 2.51 (s)

Chemistry:

	(1)	(5)
SO_3	0.00	
N_2O_5	5.40	2.75
CuO	71.56	72.87
Cl	6.02	7.22
H_2O	17.34	18.79
$-\text{O} = \text{Cl}_2$	[1.36]	1.63
Total	[98.96]	100.00

(1) Likasi, Congo; original total given as 99.04%; corresponds to $\text{Cu}_{36.00}(\text{NO}_3)_{4.00}\text{Cl}_{6.80}(\text{OH})_{61.20} \cdot 7.92\text{H}_2\text{O}$. (2) Do.; crystal-structure analysis yields $\text{Cu}_{36.0}(\text{NO}_3)_{2.6}\text{Cl}_{6.6}(\text{OH})_{62.8} \cdot 2.1\text{H}_2\text{O}$. (3) Tombstone, Arizona, USA; crystal-structure analysis yields $\text{Cu}_{36.0}(\text{NO}_3)_{1.1}\text{Cl}_{7.9}(\text{OH})_{63} \cdot 4\text{H}_2\text{O}$. (4) Bisbee, Arizona, USA; crystal-structure analysis yields $\text{Cu}_{36.0}(\text{NO}_3)_{1.0}\text{Cl}_{8.1}(\text{OH})_{62.9} \cdot 5.5\text{H}_2\text{O}$. (5) $\text{Cu}_{36}(\text{NO}_3)_2\text{Cl}_8(\text{OH})_{62} \cdot 10\text{H}_2\text{O}$.

Polymorphism & Series: Forms a series with connellite.

Occurrence: A rare secondary mineral found in the oxidized portions of copper deposits; the nitrate may be of biological origin.

Association: Cuprite, likasite, gerhardtite, malachite, brochantite, silver.

Distribution: From Likasi, Katanga Province, Congo (Shaba Province, Zaire). At the Botallack mine, St. Just, Cornwall, England. In the USA, in Arizona, from the Mildren and Steppe claims, South Comobabi Mountains, Pima Co., in the Toughnut mine, Tombstone, and at Bisbee, Cochise Co; from about seven km north of Coaldale Junction, Esmeralda Co., Nevada; in the Centennial mine, near Calumet, Keweenaw Co., Michigan. At the Great Australia mine, near Cloncurry, Queensland, Australia.

Name: Honors Professor Henri Jean François Buttgenbach (1874–1964), Belgian mineralogist, University of Liège, Liège, Belgium, who long studied Congo minerals.

Type Material: University of Liège, Liège, Belgium, 9.482 and 15.915; The Natural History Museum, London, England, 1933,267.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 572–573. (2) Bannister, F.A., M.H. Hey, and G.F. Claringbull (1950) Connellite, buttgenbachite, and tallingite. *Mineral. Mag.*, 29, 280–286. (3) McLean, W.J. and J.W. Anthony (1972) The disordered, “zeolite-like” structure of connellite. *Amer. Mineral.*, 57, 426–438. (4) Fanfani, L., A. Nunzi, P.F. Zanazzi, and R. Zanzari (1973) The crystal structure of buttgenbachite. *Mineral. Mag.*, 39, 264–270. (5) Hibbs, D.E., P. Leverett, and P.A. Williams (2002) Buttgenbachite from Bisbee, Arizona, USA: a single-crystal X-ray study. *Neues Jahrb. Mineral., Monatsh.*, 225–240. (6) Hibbs, D.E., P. Leverett, and P.A. Williams (2003) A single crystal X-ray study of a sulphate-bearing buttgenbachite, $\text{Cu}_{36}\text{Cl}_{7.8}(\text{NO}_3)_{1.3}(\text{SO}_4)_{0.35}(\text{OH})_{62.2} \cdot 5\text{H}_2\text{O}$, and a re-examination of the crystal chemistry of the buttgenbachite – connellite series. *Mineral. Mag.*, 67, 47–60.

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