Lammerite $Cu_3(AsO_4, PO_4)_2$

Crystal Data: Monoclinic. *Point Group:* $2/m$. Crystals, to 2 mm, are prismatic along [001] to tabular on {100} and terminated by {011}; additional forms include {010} and striated {120}; in radial spheroidal aggregates.

Physical Properties: *Cleavage:* Perfect on {010}; good on {100}; imperfect on {001}. Hardness = 3.5–4 D(meas.) = 4.9–5.18 D(calc.) = 5.263

Optical Properties: Transparent. *Color:* Dark green. *Streak:* Pale green. *Luster:* Adamantine, vitreous on cleavage surfaces. *Optical Class:* Biaxial (+). *Pleochroism:* Strong; X = pale blue; Y = sky-blue; Z = pale bluish green. *Orientation:* $X = b$; $Z \wedge c \simeq 40°$. *Dispersion:* $r \gg v$, very strong. $\alpha = \sim 1.89$ $\beta = 1.90$–2.06 $\gamma = 1.95$–2.14 2V(meas.) = 54(5)° 2V(calc.) = 50°

Cell Data: *Space Group:* $P2_1/a$. $a = 5.079(1)$ $b = 11.611(2)$ $c = 5.394(1)$ $\beta = 111.72(2)°$ Z = 2

X-ray Powder Pattern: Laurani, Bolivia.
2.89 (10), 2.52 (9), 3.06 (8), 3.00 (8), 2.62 (8), 2.59 (8), 2.84 (7)

Chemistry:

	(1)	(2)
As_2O_5	49.8	32.64
P_2O_5		12.40
FeO	0.2	0.06
CuO	49.9	54.64
ZnO	0.8	0.11
MgO	0.2	
Total	100.9	99.85

(1) Laurani, Bolivia; by electron microprobe, absence of $(OH)^{1-}$ and H_2O confirmed by IR; corresponding to $(Cu_{2.90}Zn_{0.05}Mg_{0.02}Fe_{0.01})_{\Sigma=2.98}(As_{1.00}O_4)_2$. (2) Tolbachik fissure volcano, Russia; by electron microprobe, corresponding to $(Cu_{2.96}Zn_{0.01})_{\Sigma=2.97}[(As_{0.62}P_{0.38})_{\Sigma=1.00}O_4]_2$.

Occurrence: On an old mineral specimen (Laurani, Bolivia); in an oxidized zone in a dolostone-hosted hydrothermal polymetallic ore deposit (Tsumeb, Namibia); in volcanic sublimates (Tolbachik fissure volcano, Russia).

Association: Olivenite (Laurani, Bolivia); chalcanthite, anhydrite, leightonite (Tsumeb, Namibia); euchlorine, melanothallite, dolerophanite, chalcocyanite, leningradite, tolbachite, anglesite, alarsite, fedotovite, klyuchevskite, nabokoite, atlasovite, langbeinite, hematite, tenorite (Tolbachik fissure volcano, Russia).

Distribution: From Laurani, Oruro, Bolivia. At Tsumeb, Namibia. From the Tolbachik fissure volcano, Kamchatka Peninsula, Russia.

Name: Honors Franz Lammer, mineral collector of Leoben, Austria, who provided the first specimen.

Type Material: Institute for Mineralogy and Crystal Chemistry, University of Stuttgart, Stuttgart, Germany; The Natural History Museum, London, England, 1980,357; Harvard University, Cambridge, Massachusetts, 117006; National Museum of Natural History, Washington, D.C., USA, 146966, 148264.

References: (1) Keller, P., W.H. Paar, and P.J. Dunn (1981) Lammerit, $Cu_3[AsO_4]_2$, ein neues Mineral von Laurani, Bolivien. Tschermaks Mineral. Petrog. Mitt., 28, 157–164 (in German with English abs.). (2) (1982) Amer. Mineral., 67, 415 (abs. ref. 1). (3) Hawthorne, F.C. (1986) Lammerite, $Cu_3(AsO_4)_2$, a modulated close-packed structure. Amer. Mineral., 71, 206–209. (4) Filatov, S.K., I.M. Gaykamako, S.F. Glavatskikh, G.L. Starova, and N.D. Sorokin (1984) Lammerite, $Cu_3[(As, P)O_4]_2$ from Kamchatka volcanic exhalations. Doklady Acad. Nauk SSSR, 279, 197–200 (in Russian).