Borisenkoite $Cu_3[(V, As)O_4]_2$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. As prismatic crystals to 0.10 mm usually combined in clusters to 0.4 mm or as rims to 0.05 mm around lammerite.

Physical Properties: *Cleavage*: None. *Tenacity*: Brittle. *Fracture*: Uneven. Hardness = ~4.5 VHN = 234-379, 315 average (20 g load). D(meas.) = n.d. D(calc.) = 4.69

Optical Properties: Translucent. *Color*: Red-brown, golden-brown or brown; brownish gray in reflected light with deep red-brown internal reflections. *Streak*: Yellowish brown.
Luster: Greasy to adamantine.
Optical Class: *n*(calc.) = 2.15 Weak bireflectance and anisotropism.
R_1-R_2: (470) 14.1-15.1, (546) 13.3-14.1, (589) 12.8-13.7, (650) 12.3-13.2

Cell Data: *Space Group*: $P2_1/c$. a = 6.3779(7) b = 8.6021(9) c = 11.3597(11) β = 92.013(8)° Z = 4

X-ray Powder Pattern: Yadovitaya fumarole, Tolbachik volcano, Kamchatka, Russia.
2.830 (100), 2.868 (72), 2.782 (54), 2.917 (50), 4.309 (48), 2.994 (48), 3.424 (40)

Chemistry:

	(1)
CuO	53.25
ZnO	1.13
Fe_2O_3	0.16
P_2O_5	0.05
V_2O_5	25.06
As_2O_5	20.44
Total	100.07

(1) Yadovitaya fumarole, Tolbachik volcano, Kamchatka, Russia; average electron microprobe analysis supplemented by Raman spectroscopy; corresponds to $(Cu_{2.94}Zn_{0.06}Fe_{0.01})_{\Sigma=3.01}(V_{1.21}As_{0.78})_{\Sigma=1.99}O_8$.

Polymorphism & Series: Limited solid-solution series from $Cu_3(AsO_4)_2$ to $Cu_3(V_{1.5}As_{0.5})O_8$, with a gap between $Cu_3(As_{1.75}V_{0.25})O_8$ and $Cu_3(As_{1.25}V_{0.75})O_8$.

Occurrence: A sublimate at an active volcanic fumarole.

Association: Sanidine, hematite, lammerite, lammerite-β, bradaczekite, zincobradaczekite, mcbirneyite, pseudolyonsite, lyonsite, starovaite, tenorite, rutile, tripuhyite, pseudobrookite, piypite, langbeinite, calciolangbeinite, aphthitalite, alumoklyuchevskite, palmierite, cupromolybdite, corundum.

Distribution: From the Yadovitaya fumarole, Second scoria cone, Northern Breakthrough of the Great Tolbachik Fissure Eruption, Tolbachik volcano, Kamchatka, Russia.

Name: Honors Russian geochemist, mineralogist, and geologist Leonid Fedorovich *Borisenko* (1922-2000), a specialist in vanadium deposits and the mineralogy and geochemistry of vanadium. He worked in the Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements (IMGRE) in Moscow.

Type Material: A.E. Fersman Mineralogical Museum, RAS, Moscow, Russia (4824/1).

References: (1) Pekov, I.V., N.V. Zubkova, V.O. Yapaskurt, Y.S. Polekhovsky, M.F. Vigasina, S.N. Britvin, A.G. Turchkova, E.G. Sidorov, and D.Y. Pushcharovsky (2020) A new mineral borisenkoite, $Cu_3[(V,As)O_4]_2$, and the isomorphous series borisenkoite-lammerite-β in fumarolic exhalations of the Tolbachik volcano, Kamchatka, Russia. Physics and Chemistry of Minerals 47(3), 17, 1-12.