

Crystal Data: Triclinic. *Point Group:* 1. As crude prismatic to thick tabular crystals or irregular grains to 0.3 mm and in open-work aggregates to 0.5 mm.

Physical Properties: *Cleavage:* None. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = ~3 D(meas.) = n.d. D(calc.) = 3.593 Water soluble and hygroscopic. Visually not distinguishable from cryptochalcite.

Optical Properties: Transparent to translucent. *Color:* Light green to green, occasionally with a yellowish hue. *Streak:* Pale green. *Luster:* Vitreous.

Optical Class: Biaxial (-). $\alpha = 1.61(1)$ $\beta = 1.627(4)$ $\gamma = 1.635(4)$ $2V(\text{meas.}) = 70(10)^\circ$ $2V(\text{calc.}) = 68^\circ$ *Pleochroism:* Distinct, $Z =$ bright green, $Y =$ green with a weak yellowish hue, $X =$ pale green to almost colorless. *Absorption:* $Z > Y > X$.

Cell Data: Space Group: $P1$. $a = 10.0682(4)$ $b = 12.7860(7)$ $c = 14.5486(8)$ $\alpha = 102.038(5)^\circ$ $\beta = 100.847(4)^\circ$ $\gamma = 89.956(4)^\circ$ $Z = 4$

X-ray Powder Pattern: Arsenatnaya fumarole, Tolbachik volcano, Kamchatka Peninsula, Russia. 3.946 (100), 6.95 (54), 3.188 (50), 3.404 (39), 3.765 (37), 2.681 (31), 3.104 (28)

Chemistry:	(1)
Na ₂ O	-
K ₂ O	5.47
Rb ₂ O	1.55
Cs ₂ O	10.48
MgO	-
CuO	29.91
ZnO	11.05
<u>SO₃</u>	<u>40.74</u>
Total	99.20

(1) Arsenatnaya fumarole, Second scoria cone, Tolbachik volcano, Kamchatka Peninsula, Russia; average of 5 electron microprobe analyses supplemented by Raman spectroscopy; corresponds to $(\text{K}_{1.14}\text{Cs}_{0.73}\text{Rb}_{0.16})_{\Sigma=2.03}(\text{Cu}_{3.69}\text{Zn}_{1.33})_{\Sigma=5.02}\text{S}_{4.99}\text{O}_{21}$.

Polymorphism & Series: Forms a solid-solution series with cryptochalcite.

Occurrence: As sublimes on basaltic scoria near a volcanic fumarole (>350-400 °C.).

Association: Cryptochalcite, euchlorine, chalcocyanite, dolerophanite, alumoklyuchevskite, anglesite, fedotovite, wulfite, langbeinite, apthitalite, piypite, klyuchevskite, eleomelanite, anhydrite, dravertite, krashennikovite, calciolangbeinite, steklite, hematite, tenorite, pseudobrookite, As-bearing orthoclase, sylvite, halite, lammerite, lammerite- β , urusovite, gold (Arsenatnaya fumarole).

Distribution: From the Arsenatnaya fumarole, Second scoria cone, Tolbachik volcano, Kamchatka Peninsula, Russia.

Name: *Cesi* for the essential cesium content and the Greek δίδυμος, which means “a twin brother” in recognition that the mineral is the Cs-K-ordered analogue of cryptochalcite.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (95349).

References: (1) Pekov, I.V., N.V. Zubkova, A.A. Agakhanov, D.Y. Pushcharovsky, V.O. Yapaskurt, D.I. Belakovskiy, M.F. Vigasina, E.G. Sidorov, and S.N. Britvin (2018) Cryptochalcite, K₂Cu₅O(SO₄)₅, and cesiodymite, CsKCu₅O(SO₄)₅, two new isotypic minerals and the K-Cs isomorphism in this solid-solution series. *Eur. J. Mineral.*, 30(3), 593-607. (2) (2019) *Amer. Mineral.*, 104(12), 1866-1867 (abs. ref. 1).