

**Crystal Data:** Orthorhombic. *Point Group:*  $mm2$ . As tabular prismatic crystals to 2 mm, elongated along [010] and with pitted faces; in aggregates to 1 cm.

**Physical Properties:** *Cleavage:* Perfect, 2 directions parallel to elongation and a third || (010). *Fracture:* Stepped. *Tenacity:* Brittle. Hardness = 2.5 D(meas.) = 3.23(2) D(calc.) = 3.19 Soluble in  $H_2O$ .

**Optical Properties:** Transparent. *Color:* Dark green, deep emerald green, deep bluish green. *Streak:* Light green. *Luster:* Vitreous. *Optical Class:* Biaxial (+).  $\alpha = 1.582(3)$   $\beta = 1.610(3)$   $\gamma = 1.715(3)$   $2V(\text{calc.}) = 58^\circ$  *Orientation:*  $Z = b$ . *Pleochroism:* Strong;  $X =$  pale green,  $Y =$  green,  $Z =$  emerald green. *Absorption:*  $X < Y < Z$ .

**Cell Data:** *Space Group:*  $Pn2_1a$ .  $a = 14.2810(6)$   $b = 4.9478(2)$   $c = 24.1127(11)$   $Z = 4$

**X-ray Powder Pattern:** Arsenatnaya fumarole, Tolbachik volcano, Kamchatka, Russia. 9.27 (100), 2.780 (33), 7.16 (22), 2.725 (20), 3.125 (16), 2.882 (16), 2.725 (14)

Chemistry:	(1)	(2)
Na <sub>2</sub> O	4.11	3.82
K <sub>2</sub> O	16.46	17.43
Rb <sub>2</sub> O	0.95	
Cs <sub>2</sub> O	0.65	
CuO	38.88	39.25
ZnO	0.15	
SO <sub>3</sub>	39.11	39.50
Total	100.31	100.00

(1) Arsenatnaya fumarole, Tolbachik volcano, Kamchatka, Russia; average of 6 electron microprobe analyses supplemented by IR spectroscopy; corresponding to  $Na_{2.95}(K_{4.75}Rb_{0.25}Cs_{0.14})_{\Sigma=5.14}(Cu_{7.95}Zn_{0.04})_{\Sigma=7.99}S_{7.99}O_{36}$ . (2)  $K_3NaCu_4O_2(SO_4)_4$ .

**Occurrence:** As sublimates at a fumarole as incrustations on the surface of basalt scoria or on tenorite or apthitalite crusts.

**Association:** Euchlorine, fedotovite, hematite, johillerite, fluoborite, langbeinite, calciolangbeinite, arcanite, krashennikovite, lammerite, lammerite- $\beta$ , bradaczekite, urusovite, gahnite (Cu-bearing variety), orthoclase (As-bearing variety), fluorophlogopite.

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

**Name:** Honors Russian crystallographer Georgiy Viktorovich Wulff (1863-1925), who suggested the model of X-ray interference in crystals (1913) and published fundamental works showing the relationships between the crystal structure and physical properties of minerals.

**Type Material:** A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (94130).

**References:** (1) Pekov, I.V., N.V. Zubkova, V.O. Yapaskurt, D.I. Belakovskiy, N.V. Chukanov, I.S. Lykova, D.P. Savelyev, E.G. Sidorov and D.Yu. Pushcharovsky (2014) Wulffite,  $K_3NaCu_4O_2(SO_4)_4$ , and parawulffite,  $K_5Na_3Cu_8O_4(SO_4)_8$ , two new minerals from fumarole sublimates of the Tolbachik Volcano, Kamchatka, Russia. *Can. Mineral.*, 52(4), 699-716. (2) (2016) *Amer. Mineral.*, 101, 1017-1018 (abs. ref. 1).