

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 H₂O.

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; $X = \text{pale green}$, $Y = \text{green}$, $Z = \text{emerald green}$. *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 ₂ O | 4.11 | 3.82 |
| K ₂ O | 16.46 | 17.43 |
| Rb ₂ O | 0.95 | |
| Cs ₂ O | 0.65 | |
| CuO | 38.88 | 39.25 |
| ZnO | 0.15 | |
| SO ₃ | 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- β , 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).