

Byzantievite



Crystal Data: Hexagonal. *Point Group:* 3. As lamellar or tabular grains flattened on {001}, to 1.8 mm, and in aggregates. Grains have poorly formed faces and usually are deformed and fractured.

Physical Properties: *Cleavage:* None. *Fracture:* Conchoidal. *Tenacity:* n.d. *Hardness:* = 4.5-5 VHN= 486 (463-522) (50 g load). *D(meas.)* = 4.10(3) *D(calc.)* = 4.151

Optical Properties: Transparent to translucent. *Color:* Brown. *Streak:* Pale yellow. *Luster:* Vitreous to slightly greasy on fracture surfaces. *Optical Class:* Uniaxial (-). $\omega = 1.940(5)$ $\varepsilon = 1.860(5)$ *Pleochroism:* Strong, *E* = light brown, *O* = very pale brown. *Absorption:* $E \gg O$.

Cell Data: *Space Group:* *R*3. $a = 9.1202(2)$ $c = 102.145(5)$ $Z = 3$

X-ray Powder Pattern: Darai-Pioz massif, Tajikistan.
3.112 (10), 2.982 (4), 4.02 (2), 3.95 (2), 2.908 (2), 2.885 (2), 2.632 (2)

Chemistry:	(1)		(1)
SiO ₂	4.52	Y ₂ O ₃	6.44
Nb ₂ O ₅	11.38	B ₂ O ₃	5.00
P ₂ O ₅	3.58	FeO	0.49
TiO ₂	15.90	BaO	12.51
ThO ₂	1.65	CaO	8.15
UO ₂	0.74	SrO	1.61
La ₂ O ₃	4.06	Na ₂ O	0.10
Ce ₂ O ₃	9.17	BeO	n.a.
Nd ₂ O ₃	3.26	Li ₂ O	n.a.
Pr ₂ O ₃	0.79	H ₂ O	[6.00]
Sm ₂ O ₃	0.73	F	1.50
Dy ₂ O ₃	1.22	- O = F ₂	0.63
Gd ₂ O ₃	0.93	Total	99.10

(1) Darai-Pioz massif, Tajikistan; average of 10 electron microprobe analyses, supplemented by IR spectroscopy, SIMS and ICP-OES; H₂O and OH calculated from structure; corresponds to Ba_{5.05}[(Ca_{8.99}Sr_{0.96}Fe²⁺_{0.42}Na_{0.10}) $\Sigma=10.47$ (Ce_{3.46}La_{1.54}Nd_{1.20}Pr_{0.30}Sm_{0.26}Dy_{0.41}Gd_{0.32}Th_{0.39}U⁴⁺_{0.17}) $\Sigma=8.03$ Y_{3.53}] $\Sigma=22.03$ (Ti_{12.31}Nb_{5.30}) $\Sigma=17.61$ (SiO₄)_{4.65}(PO₄)_{3.12}(BO₃)_{8.89}O_{22.16}[(OH)_{38.21}F_{4.89}] $\Sigma=43.10$ (H₂O)_{1.5}.

Occurrence: In a glacial moraine boulder of coarse-grained alkaline igneous rock.

Association: Quartz, microcline, aegirine, zircon, thorite, calcybeborosilite-(Y), pyrophanite, titanite, nalivkinite, stillwellite-(Y), danburite, pyrochlore.

Distribution: From the Darai-Pioz alkaline massif, at the junction of the Turkestan, Zeravshan, and Alay Mountain Ranges, Tajikistan.

Name: Named for the Byzantine Empire, in allusion to the complexity, effectiveness and beauty this mineral's atomic structure shares with this empire that existed for nearly 12 centuries.

Type Material: A.E. Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow, Russia (3791/1).

References: (1) Pautov, L.A., A.A. Agakhanov, E.V. Sokolova, F. Hawthorne, and V. Yu. Karpenko (2011) Byzantievite Ba₅(Ca,REE,Y)₂₂(Ti,Nb)₁₈(SiO₄)₄[(PO₄),SiO₄]₄(BO₃)₉O₂₁[(OH),F]₄₃(H₂O)_{1.5} - a new mineral. *New Data on Minerals*, 46, 5-12. (2) Sokolova, E., F.C. Hawthorne, L.A. Pautov, and A.A. Agakhanov (2010) Byzantievite Ba₅(Ca,REE,Y)₂₂(Ti,Nb)₁₈(SiO₄)₄[(PO₄),SiO₄]₄(BO₃)₉O₂₁[(OH),F]₄₃(H₂O)_{1.5}: the crystal structure and crystal chemistry of the only known mineral with the oxyanions (BO₃), (SiO₄) and (PO₄). *Mineral. Mag.*, 74(2), 285-308. (3) (2012) *Amer. Mineral.*, 97, 2065-2066 (abs. refs. 1 & 2).