## Byzantievite

**$Ba_5(Ca,REE,Y)_{22}(Ti,Nb)_{18}(SiO_4)_4[(PO_4),SiO_4]_4(BO_3)_9O_{21}[(OH),F]_{43}(H_2O)_{1.5}$**

**Crystal Data:** Hexgonal. *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* >> *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 | $Y_2O_3$ | 6.44 |
| $Nb_2O_5$ | 11.38 | $B_2O_3$ | 5.00 |
| $P_2O_5$ | 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 |
| $La_2O_3$ | 4.06 | $Na_2O$ | 0.10 |
| $Ce_2O_3$ | 9.17 | BeO | n.a. |
| $Nd_2O_3$ | 3.26 | $Li_2O$ | n.a. |
| $Pr_2O_3$ | 0.79 | $H_2O$ | [6.00] |
| $Sm_2O_3$ | 0.73 | F | 1.50 |
| $Dy_2O_3$ | 1.22 | $- O = F_2$ | 0.63 |
| $Gd_2O_3$ | 0.93 | Total | 99.10 |

(1) Darai-Pioz massif, Tajikistan; average of 10 electron microprobe analyses, supplemented by IR spectroscopy, SIMS and ICP-OES; $H_2O$ and OH calculated from structure; corresponds to $Ba_{5.05}[(Ca_{8.99}Sr_{0.96}Fe^{2+}_{0.42}Na_{0.10})_{\Sigma=10.47}(Ce_{3.46}La_{1.54}Nd_{1.20}\ Pr_{0.30}Sm_{0.26}\ Dy_{0.41}Gd_{0.32}Th_{0.39}U^{4+}_{0.17})_{\Sigma=8.03}\ Y_{3.53}]_{\Sigma=22.03}(Ti_{12.31}Nb_{5.30})_{\Sigma=17.61}(SiO_4)_{4.65}(PO_4)_{3.12}(BO_3)_{8.89}O_{22.16}[(OH)_{38.21}F_{4.89}]_{\Sigma=43.10}(H_2O)_{1.5}$.

**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 $Ba_5(Ca,REE,Y)_{22}(Ti,Nb)_{18}(SiO_4)_4[(PO_4),SiO_4]_4(BO_3)_9O_{21}[(OH),F]_{43}(H_2O)_{1.5}$ - 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 $Ba_5(Ca,REE,Y)_{22}(Ti,Nb)_{18}(SiO_4)_4[(PO_4),SiO_4]_4(BO_3)_9O_{21}[(OH),F]_{43}(H_2O)_{1.5}$: the crystal structure and crystal chemistry of the only known mineral with the oxyanions ($BO_3$), ($SiO_4$) and ($PO_4$). Mineral. Mag., 74(2), 285-308. (3) (2012) Amer. Mineral., 97, 2065-2066 (abs. refs. 1 & 2).