Betafite $(Ca, U)_2(Ti, Nb, Ta)_2O_6(OH)$

Crystal Data: Cubic; typically metamict. *Point Group:* $4/m\ \overline{3}\ 2/m$. Crystals commonly octahedra modified by {110}, {100}, {113}, {233}, and {230}; some crystals elongated ‖ [001] or [111]; to 15 cm.

Physical Properties: *Fracture:* Conchoidal to uneven. *Tenacity:* Brittle. Hardness = 3–5 VHN = 354–412 (Norway); 249–287 (Madagascar). D(meas.) = 3.7–4.9 D(calc.) = [3.79–4.01] Radioactive.

Optical Properties: Translucent to opaque. *Color:* Red; greenish brown, dark brown to black when metamict, commonly superficially altered yellow; almost colorless in transmitted light.
Luster: Waxy, greasy to adamantine, semimetallic.
Optical Class: Isotropic. $n = 1.910$–2.197
R: (400) 13.5, (420) 13.2, (440) 13.0, (460) 12.8, (480) 12.6, (500) 12.4, (520) 12.3, (540) 12.2, (560) 12.0, (580) 11.9, (600) 11.7, (620) 11.6, (640) 11.6, (660) 11.6, (680) 11.5, (700) 11.5

Cell Data: *Space Group:* $Fd3m$ (heat-reconstituted metamict material). $a = 10.20$–10.42 $Z = 8$

X-ray Powder Pattern: Antanifotsy, Madagascar; after heating at 1000 °C.
2.98 (10), 1.82 (8), 1.55 (6), 3.99 (3), 2.49 (3), 1.154 (3), 3.19 (2)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
UO_3	26.60	27.15	ThO_2	1.30	1.12	MgO	0.40	trace
Nb_2O_5	34.80	34.80	Al_2O_3	2.10	1.50	CaO	3.45	3.12
Ta_2O_5		1.00	Fe_2O_3	2.87	0.50	K_2O		0.38
TiO_2	18.30	16.20	ΣY_2O_3	0.90		H_2O	7.60	12.50
SnO_2	0.30	0.37	ΣCe_2O_3	0.60	1.00	Total	99.22	99.64

(1) Ambolotara, Madagascar; corresponds to $(U_{0.32}Ca_{0.21}Mg_{0.03}Y_{0.03}Ce_{0.01})_{\Sigma=0.60}(Nb_{0.90}Ti_{0.79}Al_{0.14}Fe_{0.12}Th_{0.03}Sn_{0.01})_{\Sigma=1.99}[O_{4.09}(OH)_{2.91}]_{\Sigma=7.00}$. (2) Ambalahazo, Madagascar; corresponds to $(U_{0.30}Ca_{0.18}K_{0.03}Ce_{0.02})_{\Sigma=0.53}(Nb_{0.84}Ti_{0.65}Al_{0.09}Fe_{0.02}Th_{0.01}Sn_{0.01}Ta_{0.01})_{\Sigma=1.63}[O_{2.56}(OH)_{4.44}]_{\Sigma=7.00}$.

Mineral Group: Pyrochlore group, betafite subgroup; $U_A > 20\%$; $2Ti_B \geq (Nb + Ta)_B$.

Occurrence: Typically a primary mineral in granite pegmatites; rare in carbonatites.

Association: Thorite, allanite, zircon, beryl, titanite, magnetite, biotite, microcline, quartz.

Distribution: In Madagascar, large crystals at a number of localities, including: from Ambolotara, west of Betafo; Ambatolampikely; Ambatofotsy; Ambatomboahangy; Ambalahazo; Tomboarivo; and Antanifotsy. In Norway, at Höysjåen, near Kragerø; Landsverk quarry, near Evje; and Ljosland. From Slyudyanka, near Lake Baikal, Siberia, Russia. In the Silver Crater mine, Wilberforce, Ontario, and elsewhere in Canada. In the USA, in the Brown Derby pegmatite, Gunnison Co., Colorado; in the Pidlite pegmatite, Mora Co., New Mexico; and from the Cady Mountains, San Bernardino Co., California.

Name: For the locality near Betafo, Madagascar.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 803–805. (2) Vlasov, K.A., Ed. (1966) Mineralogy of rare elements, v. II, 511–519. (3) Frondel, C. (1958) Systematic mineralogy of uranium and thorium. U.S. Geol. Sur. Bull. 1064, 320–325. (4) Hogarth, D.D. (1961) A study of pyrochlore and betafite. Can. Mineral., 6, 610–633. (5) Hogarth, D.D. (1977) Classification and nomenclature of the pyrochlore group. Amer. Mineral., 62, 403–410. (6) Junge, W., J. Knoth, and R. Rath (1983) Chemische und optische Untersuchungen von komplexen Titan-Niob-Tantalaten (Betafiten). Neues Jahrb. Mineral., Abh., 147, 169–183 (in German with English abs.).