Carbonate-fluorapatite $Ca_5(PO_4, CO_3)_3F$

Crystal Data: Hexagonal. *Point Group:* $6/m$. As minute prismatic crystals; in spherulites, to 5 mm, and fibrous crusts; usually cryptocrystalline massive.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 3.14–3.27 D(calc.) = 3.10

Optical Properties: Transparent to translucent. *Color:* Colorless, white, green, blue, yellow, brown, black; colorless to brown in thin section. *Luster:* Vitreous to earthy. *Optical Class:* Uniaxial (–), biaxial (–), isotropic when cryptocrystalline. *Orientation:* $X = c$. $n = 1.57$–1.63 [isotropic]. $\omega = 1.622$–1.640 $\epsilon = 1.614$–1.633 [uniaxial]. $\alpha = 1.612$–1.622 $\beta = 1.621$–1.627 $\gamma = 1.622$–1.627 [biaxial]. 2V(meas.) = 0°–25°

Cell Data: *Space Group:* $P6_3/m$. $a = 9.346$ $c = 6.887$ Z = 2

X-ray Powder Pattern: Staffel, Germany (fossil bone).
2.692 (100), 2.790 (55), 2.240 (45), 3.054 (34), 1.783 (25), 3.433 (20), 8.04 (18)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	38.13	40.33	K_2O		0.38
CO_2	3.40	2.70	F	3.71	3.89
Fe_2O_3	0.34		Cl		trace
MgO	0.10	1.35	H_2O	0.47	0.63
CaO	53.94	51.42	insol.	1.83	trace
Na_2O		1.17	$-O = F_2$	1.56	1.64
			Total	100.36	100.23

(1) Wheal Franco, Devon, England; corresponding to $(Ca_{4.99}Mg_{0.01})_{\Sigma=5.00}[(PO_4)_{2.79}(CO_3)_{0.40}]_{\Sigma=3.19}[F_{1.01}(OH)_{0.26}]_{\Sigma=1.27}$. (2) Staffel, Germany (fossil bone); corresponding to $Ca_{4.78}[(PO_4)_{2.70}(CO_3)_{0.28}]_{\Sigma=2.98}[F_{0.92}(OH)_{0.08}]_{\Sigma=1.00}$.

Mineral Group: Apatite group.

Occurrence: Typically of secondary origin. An important constituent of fossil bone, teeth, and marine phosphorite deposits. In carbonatites and nepheline syenite pegmatites. In fractures in phosphate-rich nodules.

Association: Glauconite, quartz, dolomite, clay minerals (phosphorites); beryl, fluorite, calcite, hematite, phlogopite, quartz (pegmatites).

Distribution: High-carbonate fluorapatite has been analyzed from many localities, although none can be considered well-characterized, as the mechanism whereby carbonate is incorporated in the mineral is still controversial. From Wheal Franco, near Tavistock, Devon, England. In Germany, at Dehrn and Staffel, near Limburg, Hesse. In the USA, at the Little Green Monster mine, Clay Canyon, about nine km west of Fairfield, Utah Co., Utah; at Point of Rocks, Colfax Co., New Mexico; abundant (billions of tons of ore-grade material) in the Coastal Plain phosphorite deposits of the southeastern USA and western USA Phosphoria Formation. From Mont Saint-Hilaire and near Saint-Amable, Quebec, and along Rapid Creek, Yukon Territory, Canada. At the Zheleznyi iron mine, Kovdor massif, and in many pegmatites in the Lovozero massif, Kola Peninsula, Russia.

Name: For a *fluorapatite* with essential *carbonate*.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 879–889. (2) Chang, L.L.Y., R.A. Howie, and J. Zussman (1996) Rock-forming minerals, (2nd edition), v. 5B, non-silicates, 297–334. (3) Brophy, G.P. and J.T. Nash (1968) Compositional, infrared, and X-ray analysis of fossil bone. Amer. Mineral., 53, 445–454. (4) Binder, G. and G. Troll (1989) Coupled anion substitution in natural carbon-bearing apatites. Contr. Mineral. Petrol., 101, 394–401.