Carbonate-hydroxylapatite $Ca_5(PO_4, CO_3)_3(OH)$

Crystal Data: Hexagonal. *Point Group:* $6/m$. Cryptocrystalline; as fibrous or laminated botryoidal crusts.

Physical Properties: *Cleavage:* Poor on {0001} and $\{10\bar{1}0\}$. *Tenacity:* Brittle. Hardness = 5 D(meas.) = 2.9–3.2 D(calc.) = 2.87 (synthetic).

Optical Properties: Transparent to translucent. *Color:* Colorless, white, yellow, brown. *Luster:* Vitreous, earthy.
Optical Class: Uniaxial (–). $\omega = 1.603$ $\epsilon = 1.598$

Cell Data: *Space Group:* $P6_3/m$ (synthetic). $a = 9.309$ $c = 6.927$ Z = 2

X-ray Powder Pattern: Synthetic $Ca_5(PO_4)_{1.5}CO_3)_{1.5}(OH)$. (ICDD 19-272).
2.78 (100), 2.68 (40), 3.46 (25), 2.231 (16), 1.929 (16), 1.838 (16), 3.04 (10)

Chemistry:

	(1)
SO_3	0.45
P_2O_5	38.7
CO_2	0.87
SiO_2	1.13
La_2O_3	0.14
Ce_2O_3	0.37
CaO	54.8
SrO	0.32
F	0.93
Cl	0.20
OH	2.42
$-O = (F, Cl, OH)_2$	1.57
Total	98.76

(1) The Kaiserstuhl, Germany; by electron microprobe and coulometric analysis, average of six analyses, $(OH)^{1-}$ calculated for stoichiometry; corresponding to $(Ca_{4.97}Sr_{0.02}Ce_{0.01})_{\Sigma=5.00}[(PO_4)_{2.77}(CO_3)_{0.10}(SiO_2)_{0.10}(SO_3)_{0.03}]_{\Sigma=3.00}[(OH)_{0.72}F_{0.25}Cl_{0.03}]_{\Sigma=1.00}$.

Mineral Group: Apatite group.

Occurrence: As cement in phosphatic soils and bioclastic limestones. An accessory mineral in carbonatites and alkaline igneous rocks.

Association: Calcite.

Distribution: Carbonatian hydroxylapatite has been analyzed from many localities, although the species is not well-characterized, as the mechanism whereby carbonate is incorporated is controversial. At the Ødegården apatite mines, Bamble, Norway. From the Kaiserstuhl, Baden-Württemberg, Germany. Found on Tuvalu (Ellice Islands), central Pacific. At Phalaborwa, Transvaal, South Africa. From Magnet Cove, Hot Spring Co., Arkansas, USA.

Name: For a *carbonate*-rich *hydroxylapatite*.

Type Material: n.d.

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) Sommerauer, J. and K. Katz-Lehnert (1985) A new partial substitution mechanism of CO_3^{2-}/CO_3OH^{3-} and SiO_4^4 for the PO_4^{3-} group in hydroxyapatite from the Kaiserstuhl alkaline complex (SW-Germany). Contr. Mineral. Petrol., 91, 360–368.