Whitlockite $Ca_9(Mg,Fe^{2+})(PO_4)_6(PO_3OH)$

Crystal Data: Hexagonal. *Point Group:* $3m$. Typically as rhombohedral crystals, $\{01\bar{1}2\}$, rarely flat tabular $\{0001\}$, with $\{11\bar{2}0\}$, $\{10\bar{1}4\}$, several other smaller forms, to 2 cm. May form cave pearls; as anhedral grains and microcrystalline crusts.

Physical Properties: *Fracture:* Uneven to subconchoidal. Hardness = 5 D(meas.) = 3.12 D(calc.) = 3.102 Piezoelectric and pyroelectric.

Optical Properties: Transparent to translucent. *Color:* Colorless, white, gray, yellowish; colorless in transmitted light. *Luster:* Vitreous to subresinous.
Optical Class: Uniaxial (–). $\omega = 1.629$ $\epsilon = 1.626$

Cell Data: *Space Group: R3c.* $a = 10.330(2)$ $c = 37.103(5)$ Z = 3

X-ray Powder Pattern: North Groton, New Hampshire, USA.
2.88 (10), 3.21 (9), 2.60 (9), 5.24 (8), 3.47 (7), 1.72 (7), 1.93 (6)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	45.68	45.8	Na_2O		3.3
Fe_2O_3	1.73		F	0.06	
FeO	1.91	0.2	Cl	trace	
MgO	2.53	3.7	H_2O	0.48	
CaO	46.90	46.1	insol.	0.51	
			Total	99.80	99.1

(1) Palermo #1 mine, New Hampshire, USA; corresponds to $Ca_{8.97}(Mg_{0.67}Fe_{0.52})_{\Sigma=1.19}(PO_4)_6(PO_3OH)$. (2) Dayton meteorite; by electron microprobe, corresponds to $(Ca_{7.65}Na_{0.90})_{\Sigma=8.55}(Mg_{0.87}Fe_{0.03})_{\Sigma=0.90}(PO_4)_6(PO_3OH)$.

Occurrence: An uncommon secondary mineral in complex zoned granite pegmatites; in phosphate rock deposits; may be formed in caves from leached guano; in chondrite meteorites.

Association: Ludlamite, fairfieldite, triphylite, siderite, apatite, quartz (pegmatites); hydroxylapatite (caves and islands); stanfieldite, farringtonite, brianite (meteorites).

Distribution: In the USA, from the Palermo #1 mine, near North Groton, Grafton Co., New Hampshire, as large crystals; in the Bell pit and Dunton quarry, Newry, Oxford Co., Maine; at the Tip Top and Bull Moose mines, near Custer, Custer Co., South Dakota. In the Tanco pegmatite, Bernic Lake, Manitoba, Canada. On Table Mountain, Curaçao, and on Sombrero Island, West Indies. From Enderbury Island, Phoenix Islands, Kiribati. On the Los Monges keys, Gulf of Venezuela. In Isla Mona Cave, Puerto Rico. At Cueva Atabex, Siboney, Cuba. From the Ødegården apatite mines, Bamble, Norway. In the Drachenhöhle, Hungary. From a cave at Sebdou, Oran, Algeria. At the Niah Great Cave, Sarawak, Malaysia. In the Dayton finest octahedrite meteorite.

Name: To honor Herbert Percy Whitlock (1868–1948), American mineralogist, Curator, American Museum of Natural History, New York City, New York, USA.

Type Material: Harvard University, Cambridge, Massachusetts, 95030; National Museum of Natural History, Washington, D.C., USA, 146196.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 684–686. (2) Calvo, C. and R. Gopal (1975) The crystal structure of whitlockite from the Palermo quarry. Amer. Mineral., 60, 120–133. (3) Moore, P.B. and J. Shen (1983) Cerite, $RE_9(Fe^{3+},Mg)(SiO_4)_6(SiO_3OH)(OH)_3$: its crystal structure and relation to whitlockite. Amer. Mineral., 68, 996–1003. (4) Dowty, E. (1977) Phosphate in Angra dos Reis: structure and composition of the $Ca_3(PO_4)_2$ minerals. Earth and Planetary Science Letters, 35, 347–351. (5) Fuchs, L.H., E. Olsen, and E.P. Henderson (1967) On the occurrence of brianite and panethite, two new phosphate minerals from the Dayton meteorite. Geochim. Cosmochim. Acta, 31, 1711–1719. (6) Frondel, C. (1943) Mineralogy of the calcium phosphates in insular phosphate rock. Amer. Mineral., 28, 215–232.