Turquoise **$CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$**

Crystal Data: Triclinic. *Point Group:* $\overline{1}$. Rare steep pinacoidal crystals, {010}, {$1\overline{1}0$}, {001}, to 3 mm; fine granular to cryptocrystalline, nodular to globular crusts, veinlets, massive.

Physical Properties: *Fracture:* Small conchoidal to smooth. Hardness = 5–6
D(meas.) = 2.86, less if massive. D(calc.) = 2.91

Optical Properties: Transparent in crystals; translucent to opaque if massive.
Color: Sky-blue, bluish green, apple-green, greenish gray. *Streak:* White to pale greenish blue.
Luster: Vitreous in crystals; dull to waxy if massive.
Optical Class: Biaxial (+). *Pleochroism:* Weak in thick grains; X = colorless; Z = pale blue or pale green. *Orientation:* X (-30°,60°); Y (63°,83°); Z (163°,32°) [using (ϕ,ρ)]. *Dispersion:* $r < v$, strong. $\alpha = 1.61$ $\beta = 1.62$ $\gamma = 1.65$ 2V(meas.) = 40(2)°

Cell Data: *Space Group:* $P\overline{1}$. $a = 7.409(1)$ $b = 9.914(2)$ $c = 7.635(1)$ $\alpha = 111.356°$ $\beta = 114.973°$ $\gamma = 69.532°$ Z = 1

X-ray Powder Pattern: Lynch Station, Virginia, USA; nearly identical to faustite.
3.674 (100), 2.900 (80), 6.165 (75), 5.986 (45), 4.786 (45), 3.429 (45), 2.062 (40)

Chemistry:

	(1)	(2)		(1)	(2)
P_2O_5	34.13	34.90	CuO	9.00	9.78
Al_2O_3	36.50	37.60	H_2O	20.12	17.72
Fe_2O_3	0.21		Total	99.96	100.00

(1) Lynch Station, Virginia, USA; H_2O by the Penfield method, corresponds to $Cu_{0.95}(Al_{5.98}Fe_{0.02})_{\Sigma=6.00}(PO_4)_{3.91}(PO_3OH)_{0.10}(OH)_8 \cdot 5.27H_2O$. (2) $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$.

Polymorphism & Series: Forms two series, with chalcosiderite, and with planerite.

Mineral Group: Turquoise group.

Occurrence: A secondary mineral formed in the potassic alteration zone of hydrothermal porphyry copper deposits; a vein-filling in volcanic rocks and phosphate-rich sediments.

Association: Kaolinite, montmorillonite, allophane, wavellite, pyrite.

Distribution: Dozens of localities, of which only a few can be mentioned, for commercial amounts or good crystals. In Iran, at Ma'dan, 45 km northwest of Neyshabur (Nishapur). From Ottré, near Vielsalm, Belgium. At the Bunny mine, St. Austell, and elsewhere in Cornwall, England. From Katonto, north of Kolwezi, Katanga Province, Congo (Shaba Province, Zaire), good crystals. In the USA, crystallized from the Bishop mine, Lynch Station, Campbell Co., Virginia; in the Cerrillos district, Santa Fe Co., and the Burro Mountains district, Grant Co., New Mexico; in Arizona, commercial production from Mineral Park, Mohave Co., Morenci, Greenlee Co., the Globe-Miami district, Gila Co., and others; numerous small deposits in Lander Co. and elsewhere in Nevada. In the Itatiaiuçu iron mine, southwest of Belo Horizonte, Minas Gerais, Brazil, large crystals. At Chuquicamata, Antofagasta, Chile. In Australia, at Narooma, New South Wales, as crystals; in the Iron Monarch quarry, Iron Knob, South Australia. In China, from Yunxian and Zhushan, Wudang Mountains, Hubei Province, and near Shanyang, Shaanxi Province.

Name: From the French *Turquie*, as Iranian material was early imported through Turkey.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 946–951. (2) Foord, E.E. and J.E. Taggart, Jr. (1998) A reexamination of the turquoise group: the mineral aheylite, planerite (redefined), turquoise and coeruleolactite. Mineral. Mag., 62, 93–111. (3) Cid-Dressner, H. (1965) Determination and refinement of the crystal structure of turquois, $CuAl_6(PO_4)_4(OH)_8 \cdot 4H_2O$. Zeits. Krist., 121, 87–113. (4) Guthrie, G.D., Jr. and D.L. Bish (1991) Refinement of the turquoise structure and determination of the hydrogen positions. Geol. Soc. Amer., Annual Meeting Abs. with Prog., 23(5), 158A (abs.). (5) Pogue, J.E. (1915) The Turquois, a study of its history, mineralogy, geology, ethnology, archaeology, mythology, folklore, and technology. Nat. Acad. of Sci. Mem., 12, part 2, 207 pp.