Rubinite $Ca_3Ti^{3+}_2Si_3O_{12}$

Crystal Data: Cubic. *Point Group*: 4/*m* $\bar{3}$ 2/*m*. As irregular to subhedral crystals, ~0.5-1 μm (Vigarano), 1-8 μm (Allende), and 1-20 μm (Efremovka).

Physical Properties: *Cleavage*: n.d. *Fracture*: n.d. *Tenacity*: n.d. Hardness = n.d. D(meas.) = n.d. D(calc.) = 3.63

Optical Properties: n.d. *Color*: n.d. *Streak*: n.d. *Luster*: n.d.
Optical Class: n.d.

Cell Data: *Space Group*: *Ia*$\bar{3}$ *d*. *a* = 12.1875 Z = 8

X-ray Powder Pattern: Allende meteorite.
2.725 (100), 1.629 (80), 3.047 (55), 2.488 (50), 1.690 (34), 1.330 (23), 1.113 (20)

Chemistry:

	(1)		(1)
CaO	32.68	ZrO_2	0.80
Ti_2O_3	14.79	MgO	0.79
TiO_2	13.06	V_2O_3	0.61
SiO_2	28.37	FeO	0.53
Al_2O_3	3.82	Y_2O_3	0.07
Sc_2O_3	1.80	Cr_2O_3	0.05
Na_2O	1.01	Total	98.38

(1) Allende meteorite; average electron microprobe analysis, Ti^{3+} and Ti^{4+} partitioned by stoichiometry; corresponds to $(Ca_{2.94}Na_{0.08})(Ti^{3+}_{1.04}Ti^{4+}_{0.59}Sc_{0.13}Mg_{0.10}V_{0.04}Fe_{0.04}Zr_{0.03})(Si_{2.38}Al_{0.38}Ti^{4+}_{0.24})O_{12}$. (2) Efremovka meteorite; analysis not given; corresponds to $(Ca_{2.97}Na_{0.06})(Ti^{3+}_{1.05}Ti^{4+}_{0.66}Mg_{0.12}Sc_{0.09}Zr_{0.03}V_{0.03}Y_{0.01}Fe_{0.01})(Si_{2.36}Al_{0.48}Ti^{4+}_{0.16})O_{12}$.
(3) Vigarano meteorite; analysis not given; corresponds to $(Ca_{1.89}Y_{0.83}Mg_{0.28})(Ti^{3+}_{0.59}Sc_{0.50}Zr_{0.72}Mg_{0.2}V_{0.02}Cr_{0.01})(Si_{1.64}Al_{1.18}Ti^{4+}_{0.07}Fe_{0.06})O_{12}$.

Mineral Group: Garnet supergroup.

Occurrence: From Ca-Al-rich inclusions in carbonaceous chondrite meteorites. Among the first solid materials in the solar nebula formed either as a condensate or through crystallization from an ^{16}O-rich Ca, Al, and Ti-rich melt under highly reduced conditions.

Association: Zr-panguite, spinel, davisite-diopside, forsterite (Vigarano); gehlenitic melilite, perovskite, spinel, hibonite, corundum, davisite, grossmanite, diopside, eringaite, anorthite, grossular, Na-melilite (Allende); gehlenitic melilite, perovskite, spinel, grossmanite (Efremovka).

Distribution: From Ca-Al-rich inclusions (CAIs) in carbonaceous chondrite meteorites Vigarano (fell near Vigarano Pieve, Ferrara, Italy), Allende (fell near Pueblito de Allende, Chihuahua, Mexico), and Efremovka.

Name: Honors Alan E. *Rubin* (b.1953), a cosmochemist at University of California, Los Angeles (UCLA), USA., for his contributions to cosmochemistry and meteorite research.

Type Material: Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, California, USA (VCM3 Vigarano), and in the Division of Earth and Planetary Materials Science, Tohoku University, Japan (AE01 Allende).

References: (1) Ma, C., T. Yoshizaki, A.N. Krot, J.R. Beckett, T. Nakamura, K. Nagashima, J. Muto, and M.A. Ivanova (2017) Discovery of rubinite, $Ca_3Ti^{3+}_2Si_3O_{12}$, a new garnet mineral in refractory inclusions from carbonaceous chondrites. 80th Annual Meeting of the Meteoritical Society 2017 (LPI Contribution No. 1987), 6023.pdf. (2) Ma, C., T. Yoshizaki, T. Nakamura, and J. Muto (2017) Rubinite, IMA 2016-110. CNMNC Newsletter No. 36, April 2017, Mineral. Mag., 81, 408. (3) (2020) Amer. Mineral., 105, 1923 (abs. refs. 1 and 2).