Khmaralite $Mg_4(Mg_3Al_9)O_4[Si_5Be_2Al_5O_{36}]$

Crystal Data: Monoclinic. *Point Group*: 2/*m.* As foliated aggregates ~3 cm across of parallel tablets, to 7 mm, flattened parallel to {010}.

Physical Properties: *Cleavage*: None. *Fracture*: Uneven. *Tenacity*: Brittle. Hardness = ~7 D(meas.) = n.d. D(calc.) = 3.61

Optical Properties: Transparent. *Color*: Very dark green. *Streak*: Green-gray. *Luster*: Vitreous. *Optical Class*: Biaxial (-). α = 1.725(2) β = 1.740(2) γ = 1.741(2) 2V(meas.) = 34.4(1.8)° 2V(calc.) = 29° *Pleochroism*: *X* = colorless or very light tan, *Y* = blue-green, *Z* = deep blue-green. *Dispersion*: *v* > *r*, strong. *Orientation*: *Y* || *b.*

Cell Data: *Space Group*: $P2_1/c$. a = 19.800(1) b = 14.371(1) c = 11.254(1) β = 125.53(1)° Z = 4

X-ray Powder Pattern: Khmara Bay, Enderby Land, Antarctica.
2.446 (100), 2.0106 (85), 2.0140 (61), 2.826 (45), 2.4387 (44), 2.3405 (43), 2.9852 (38)

Chemistry:

	(1)
SiO_2	20.27
Al_2O_3	51.15
Fe_2O_3	[0.70]
FeO	[9.43]
MgO	15.49
CaO	0.16
BeO	2.51
B_2O_3	0.05
Total	99.76

(1) Khmara Bay, Enderby Land, Antarctica ; average electron microprobe, FeO and Fe_2O_3 calculated from FeO = 10.06; corresponds to $Ca_{0.04}Mg_{5.46}Fe^{3+}_{0.12}Fe^{2+}_{1.87}Al_{14.26}Be_{1.43}B_{0.02}Si_{4.80}O_{40}$.

Polymorphism & Series: Likely continuous solid solution between Be-free sapphirine of composition $(Mg,Fe)_{7.5}(Al,Fe)_{17}Si_{3.5}O_{40}$ and khmaralite. Distinguishing the two minerals using microprobe analyses, powder X-ray patterns, and optical properties would be equivocal.

Occurrence: In a pegmatite metamorphosed at granulite-facies likely from pre-existing pegmatitic Be phases such as beryllian cordierite.

Association: Surinamite, musgravite, sillimanite, garnet, biotite, apatite, rutile, dumortierite, quartz, microcline.

Distribution: From "Zircon Point", Khmara Bay, Enderby Land, Antarctica [TL].

Name: For the locality, from which the first samples were collected, named for Ivan Fedorovich *Khmara* (1936-1956), a tractor driver on the Soviet Antarctic Expedition who perished in Antarctica.

Type Material: National Museum of Natural History, Washington, D.C., USA (NMNH 171532).

References: (1) Barbier, J., E.S. Grew, P.B. Moore, and S.-C. Su (1999) Khmaralite, a new beryllium-bearing mineral related to sapphirine: A superstructure resulting from partial ordering of Be, Al, and Si on tetrahedral sites. Amer. Mineral., 84, 1650-1660. (2) Christy, A.G. and E.S. Grew (2004) Synthesis of beryllian sapphirine in the system MgO-BeO-Al_2O -SiO_2-H_2O and comparison with naturally occurring beryllian sapphirine and khmaralite, Part 2: A chemographic study of Be content as a function of P, T, assemblage and $FeMg_{-1}$ exchange. Amer. Mineral., 89, 327-338.