Ludwigite $Mg_2Fe^{3+}BO_5$

Crystal Data: Orthorhombic. *Point Group:* $2/m\ 2/m\ 2/m$. Crystals are unterminated, fibrous, curved, to 20 cm; commonly in fanlike to felted aggregates.

Physical Properties: *Tenacity:* Tough. Hardness = 5–5.5 D(meas.) = 3.80(3) D(calc.) = [3.78] Weakly ferromagnetic, probable.

Optical Properties: Opaque, translucent only in thin fragments and rims of crystals. *Color:* Pitch-black, olive-black. *Luster:* Submetallic. *Streak:* Black to greenish black. *Luster:* Silky.
Optical Class: Biaxial (+). *Pleochroism:* $X = Y$ = dark green; Z = dark reddish brown. *Orientation:* $Z = c$. *Dispersion:* $r \gg v$, extreme. α = 1.83–1.85 β = 1.83–1.90 γ = 1.97–2.03 2V(meas.) = Small. *Anisotropism:* Strong; yellowish brown to bluish violet gray. *Bireflectance:* Pinkish gray to dark greenish gray.
R_1–R_2: (400) 10.1–13.8, (420) 9.7–13.2, (440) 9.3–12.6, (460) 9.0–12.1, (480) 8.7–11.8, (500) 8.5–11.5, (520) 8.2–11.3, (540) 8.1–11.2, (560) 7.9–11.0, (580) 7.8–10.9, (600) 7.6–10.8, (620) 7.5–10.8, (640) 7.4–10.8, (660) 7.3–10.8, (680) 7.2–10.8, (700) 7.2–10.9

Cell Data: *Space Group: Pbam.* $a = 9.2411(6)$ $b = 12.2948(9)$ $c = 3.0213(3)$ Z = 4

X-ray Powder Pattern: Willis quadrangle, Montana, USA.
5.12 (100), 2.547 (70), 2.515 (70), 2.027 (50), 2.167 (35), 2.990 (25), 1.903 (25)

Chemistry:

	(1)	(2)		(1)	(2)		(1)	(2)
SiO_2	0.49		Fe_2O_3	39.00	40.89	CaO	0.11	
TiO_2	0.05		FeO	3.17		H_2O^+	0.15	
B_2O_3	17.43	17.83	MnO	0.33		Total	100.47	100.00
Al_2O_3	0.62		MgO	39.12	41.28			

(1) Ocna de Fier, Romania; B_2O_3 by ICP, H_2O by the Penfield method; corresponds to $(Mg_{1.91}Fe^{2+}_{0.09}Mn_{0.01})_{\Sigma=1.00}(Fe^{3+}_{0.98}Al_{0.02})_{\Sigma=1.00}B_{1.00}O_5$. (2) Mg_2FeBO_5.

Polymorphism & Series: Forms a series with vonsenite.

Mineral Group: Ludwigite group.

Occurrence: Typically formed in magnesian iron skarn and contact metamorphic deposits.

Association: Magnetite, forsterite, clinohumite, vonsenite, szaibélyite.

Distribution: Numerous localities, some with large amounts. From [the Iuliana mine,] Ocna de Fier (Morávicza; Vaskő), Romania. At the Brosso mine, northwest of Ivrea, Torino, Italy. From Broadford, Isle of Skye, Inverness-shire, Scotland. In the Nordmark district, Värmland, Sweden. In Russia, at the Tazheran massif, west of Lake Baikal; large crystals from Titovskoye, Sakha. In the Gole Gohar iron deposit, Bafq district, Iran. In the USA, from the Pomeroy mine, Anaconda, Deer Lodge Co., and at Philipsburg, Granite Co., Montana; from the Crestmore quarry, Riverside Co., California; at the Mountain Lake mine, Big Cottonwood district, Salt Lake Co., Utah. In Canada, in the York River tactite zone, Bancroft, Ontario; from the Cross quarry, near Wakefield, Quebec. In the Hol Kol Au–Cu mine, about 75 km southeast of Pyongyang, Suan Co., North Korea.

Name: Honoring Ernst Ludwig (1842–1915), Austrian Professor of Chemistry, University of Vienna, Vienna, Austria, who analyzed the original material.

Type Material: Natural History Museum, Vienna, Austria, A.a.6315.

References: (1) Palache, C., H. Berman, and C. Frondel (1951) Dana's system of mineralogy, (7th edition), v. II, 321–324. (2) Marincea, S. (1999) Ludwigite from the type locality, Ocna de Fier, Romania: new data and review. Can. Mineral., 37, 1343–1362. (3) Irwin, M.B. and R.C. Peterson (1999) The crystal structure of ludwigite. Can. Mineral., 37, 939–943. (4) Appel, P.W.U. and M.F. Brigatti (1999) Ludwigite from central Sweden: new data and crystal structure refinement. Mineral. Mag., 63, 511–518. (5) Leonard, B.F., F.A. Hildebrand, and A.C. Vlisidis (1962) Members of the ludwigite–vonsenite series and their distinction from ilvaite. In: Petrologic studies. A volume to honor A.F. Buddington. Geol. Soc. Amer. Bull., 523–568.