Högbomite $(Mg, Fe^{2+})_2(Al, Ti)_5O_{10}$

Crystal Data: Hexagonal. *Point Group:* $\overline{3}2/m$ or $6mm$. Rare crystals are tabular, thin to thick, on {0001}, to 5 mm; commonly granular, massive, intergrown and included with other species. *Twinning:* On {0001}, may be repeated; on $\{h0\overline{h}l\}$, probable.

Physical Properties: *Cleavage:* {0001}, another on $\{h0\overline{h}l\}$, may be partings. *Fracture:* Conchoidal. *Tenacity:* Brittle. Hardness = 6.5 VHN = 1064–1216 (100 g load). D(meas.) = n.d. D(calc.) = [3.85] Weakly magnetic.

Optical Properties: Opaque, transparent in thin fragments. *Color:* Black; brown in transmitted light; gray in reflected light. *Streak:* Gray. *Luster:* Metallic adamantine. *Optical Class:* Uniaxial (–). *Pleochroism:* Distinct; O = dark golden brown; E = light golden brown. *Absorption:* $O > E$. $\omega = 1.848$–1.853 $\epsilon = 1.803$–1.823 *Anisotropism:* Distinct.
R_1–R_2: (400) 9.74–10.2, (420) 9.28–9.79, (440) 8.91–9.37, (460) 8.55–9.08, (480) 8.40–8.91, (500) 8.31–8.88, (520) 8.27–8.80, (540) 8.21–8.75, (560) 8.16–8.70, (580) 8.15–8.70, (600) 8.17–8.70, (620) 8.20–8.71, (640) 8.24–8.73, (660) 8.31–8.74, (680) 8.30–8.75, (700) 8.37–8.77

Cell Data: *Space Group:* $R\overline{3}m$(4H), with $a = 5.718$ $c = 4.6$ Z = 3, or *Space Group:* $P6_3mc$(8H), with $a = 5.734(3)$ $c = 18.389(8)$ Z = 3

X-ray Powder Pattern: Mautia Hill, Tanzania (5H).
2.43 (vs), 1.426 (s), 2.49 (ms), 2.079 (ms), 1.978 (ms), 4.60 (m), 2.86 (m)

Chemistry:	(1)	(2)		(1)	(2)		(1)	(2)
TiO_2	6.26	4.74	MnO	0.15	0.19	Na_2O	0.15	
Al_2O_3	58.57	61.25	ZnO	3.86	4.12	H_2O		[1.45]
Fe_2O_3	9.04		GaO	0.16		Total	98.67	[100.09]
FeO	16.04	22.72	MgO	4.44	5.62			

(1) Strangways Range, Australia; by electron microprobe, original analysis elemental, here converted to oxides; Fe^{2+}:Fe^{3+} calculated from charge balance; corresponds to $[Fe^{2+}_{0.95}Fe^{3+}_{0.48}Mg_{0.47}Zn_{0.20}(Ga, Mn, Na)_{0.04}]_{\Sigma=2.14}(Al_{4.87}Ti_{0.33})_{\Sigma=5.20}O_{10}(OH)_{0.67}$. (2) Cape Ryugu, Antarctica; by electron microprobe, total Fe as FeO; corresponding to $(Fe_{1.31}Mg_{0.58}Zn_{0.21}Mn_{0.01})_{\Sigma=2.11}(Al_{4.98}Ti_{0.25})_{\Sigma=5.23}O_{10.07}(OH)_{0.67}$.

Polymorphism & Series: 4H, 5H, 6H, 8H, 15H, 15R, 18R, 24R polytypes, polytypoids.

Occurrence: A primary mineral, or replacing spinel or magnetite, in skarns, gabbros, gneisses, "emery" or other rocks formed during medium- to high-grade metamorphism; rarely detrital.

Association: Corundum, ferroan spinel, magnetite, ilmenite, rutile, nigerite, sapphirine, sillimanite, cordierite, kyanite, garnet, quartz, chlorite, gedrite, phlogopite.

Distribution: In the Ruoutevare Fe–Ti deposit, near Kvikkjokk, Norrbotten, Sweden. At Rödstrand, Norway. From the Shoriya Mountains, western Siberia, Russia. At Cashal, near Toombeola, Co. Galway, Ireland. On Mautia Hill, Tanzania. At the Linganga deposit, Njombe district, Tanzania. From Tsaobis, Namibia. In the USA, at Whittles, Pittsylvania Co., Virginia; Peekskill, Westchester Co., New York; and Franklin, Macon Co., North Carolina. In the Romay mine, San Juan, Catamarca Province, Argentina. From the Strangways Range, Northern Territory, Australia. On the Prince Olav Coast, eastern Antarctica. More localities are known.

Name: For Professor Arvid Gustaf Högbom (1857–1940), of the University of Uppsala, Uppsala, Sweden.

Type Material: The Natural History Museum, London, England, 1923,1019.

;$hgbomite - 8H = magnesiohgbomite - 2N2Shgbomite - 10T = magnesiohgbomite - 2N3S; hgbomite - 24R = magnesiohgbomite - 6N6S; zinchgbomite - 8H = zinchgbomite - 2N2S; zinchgbomite - 16H = zinchgbomite - 2N6S; nigerite - 6T = ferronigerite - 2N1S; nigerite - 24R = ferronigerite - 6N6S; pengzhizhongite - 6T = magnesionigerite - 2N1S; pengzhizhongite - 24R = magnesionigerite - 6N8S; taaffeeite = magnesiotaaffeite - 2N'2S; musgravite = magnesiotaaffeite - 6N'3S; perhmanite = ferrotaaffeite - 6N'3S; Criddle, A.J. and C.J. Stanley, Eds.$ (1993) *Quantitative data file for ore minerals*, 3rd ed. Chapman & Hall, Londo

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Crystal Data: Monoclinic, pseudotetragonal. *Point Group:* $2/m$. Crystals short prismatic with flat pyramidal termination, to several cm; radial fibrous, massive. *Twinning:* Common on {101} or $\{10\overline{1}\}$.

Physical Properties: *Cleavage:* Prismatic, distinct. *Tenacity:* Brittle. Hardness = 6 VHN = 488–560 ∥ [001], 620–689 ⊥ [001] (100 g load). D(meas.) = 4.95 D(calc.) = [4.93]

Optical Properties: Opaque. *Color:* Black, grayish black to silvery gray; in reflected light, white. *Streak:* Black. *Luster:* Metallic, splendent.
Optical Class: Biaxial. *Pleochroism:* Weak. *Anisotropism:* Strong.
R_1–R_2: (400) 31.3–37.7, (420) 31.2–37.4, (440) 31.1–37.1, (460) 30.5–36.5, (480) 29.7–35.9, (500) 29.1–35.0, (520) 28.5–34.2, (540) 27.8–33.1, (560) 27.1–32.2, (580) 26.6–31.5, (600) 26.3–30.9, (620) 26.1–30.4, (640) 25.8–30.0, (660) 25.6–29.5, (680) 25.3–29.0, (700) 25.0–28.4

Cell Data: *Space Group:* $I2/m$. $a = 10.013(1)$ $b = 2.8801(2)$ $c = 9.733(1)$ $\beta = 90.970(4)^\circ$ Z = 1

X-ray Powder Pattern: Langenberg, Germany; easily mistaken for coronadite.
3.13 (10), 2.40 (9), 3.47 (8), 2.15 (8), 1.55 (7), 1.83 (6), 6.98 (5)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2		0.58	MnO	5.12	
MnO_2	65.63	62.91	PbO		4.45
Al_2O_3	0.94	1.45	BaO	17.59	13.81
Fe_2O_3	10.56	12.63	Na_2O		0.58
Mn_2O_3		4.57	K_2O		0.23
			Total	99.84	[101.21]

(1) Kajlidongri, India; corresponds to $Ba_{0.95}[Mn^{4+}_{6.23}Mn^{2+}_{0.59}(Fe,Al)_{1.24}]_{\Sigma=8.06}O_{16}$. (2) Stuor Njvoskes, Sweden; by electron microprobe, average of several analyses, Mn^{4+}:Mn^{3+} calculated for charge balance; corresponds to $(Ba_{0.75}Pb_{0.16}Na_{0.10}K_{0.04})_{\Sigma=1.05}(Mn^{4+}_{6.08}Fe^{3+}_{1.32}Mn^{3+}_{0.50}Al_{0.23}Si_{0.08})_{\Sigma=8.21}O_{16}$.

Mineral Group: Cryptomelane group.

Occurrence: A primary mineral in contact metamorphic manganese ores, and a secondary weathering product of earlier manganese-bearing minerals.

Association: Bixbyite, braunite, piemontite, other manganese oxides.

Distribution: In India, at Kajlidongri and Sitapar, Chhindwara district, Madhya Pradesh; in the Nagpur and Balaghat districts, Maharashtra; at Banswara, Rajasthan; and elsewhere. From Sörhårrås, Ultevis, Sweden. In Norway, from Tangen, Hurdal. At Langenberg, Saxony, Germany. From Inken, Tiovine region, Morocco. In the USA, in the Artillery Mountains, Mohave Co., and in the Apache mine, Sierra Ancha district, Gila Co., Arizona.

Name: For Dr. Thomas Henry Holland (1868–1947), Director of the Indian Geological Survey.

Type Material: n.d.

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 743–744. (2) Frondel, C. and E.W. Heinrich (1942) new data on hetaerolite, hydrohetaerolite, coronadite, and hollandite. Amer. Mineral., 27, 48–56. (3) Frondel, C., U.B. Marvin, and J. Ito (1960) New data on birnessite and hollandite. Amer. Mineral., 45, 871–875. (4) Post, J.E., R.B. Von Dreele, and P.R. Buseck (1982) Symmetry and cation displacements in hollandites: structure refinements of hollandite, cryptomelane, and priderite. Acta Cryst., 38, 1056–1065. (5) Miura, H. (1987) The crystal structure of hollandite. Mineral. J. (Japan), 13, 119–129, 397–398. (6) Post, J.E. and D.L. Bish (1989) Rietveld refinement of crystal structures using powder X-ray diffraction data. In: D.L. Bish and J.E. Post, Eds., Modern powder diffraction. Reviews in mineralogy, vol. 20, 277–308, esp. 296–300.