

Crystal Data: Orthorhombic. *Point Group:* $2/m2/m2/m$. As prismatic crystals, striated || [001], to 45 cm, or tabular on {010}. More commonly as aggregates of capillary to acicular crystals, in divergent sprays, or reniform, botryoidal, or stalactitic masses with concentric or radial fibrous internal structure; nearly cryptocrystalline in "limonite".

Physical Properties: *Cleavage:* {010}, perfect; {100}, less perfect. *Fracture:* Uneven. *Tenacity:* Brittle. Hardness = 5–5.5 VHN = 667 (100 g load). D(meas.) = 4.28(1) D(calc.) = 4.18

Optical Properties: Opaque, transparent on thin edges. *Color:* Blackish brown; yellowish to reddish brown in massive aggregates, may be banded; shades of yellow in thin section; gray with bluish tint in reflected light, with yellow, red, brown internal reflections. *Streak:* Brownish yellow, yellow-orange, ocher-yellow. *Luster:* Imperfect adamantine metallic to dull earthy; silky when fibrous.

Optical Class: Biaxial (-); uniaxial (-) for red light. *Pleochroism:* Strong; X = yellow to colorless; Y = yellow-brown, reddish orange; Z = yellow-orange, deep reddish orange. *Orientation:* X = b; Y = c; Z = a. *Dispersion:* $r > v$, extreme. *Absorption:* $Z > Y > X$. $\alpha = 2.260$ – 2.275 $\beta = 2.393$ – 2.409 $\gamma = 2.398$ – 2.515 $2V(\text{meas.}) = 0^\circ$ – 27° *Anisotropism:* Distinct; in bluish grays. R_1 – R_2 : (400) 17.5–19.2, (420) 16.7–18.3, (440) 15.9–17.4, (460) 15.2–16.7, (480) 14.6–16.0, (500) 14.1–15.5, (520) 13.7–15.0, (540) 13.3–14.6, (560) 13.0–14.3, (580) 12.8–14.0, (600) 12.5–13.7, (620) 12.4–13.5, (640) 12.2–13.4, (660) 12.0–13.2, (680) 12.0–13.1, (700) 11.9–13.0

Cell Data: *Space Group:* $Pbnm$. $a = 4.608$ $b = 9.956$ $c = 3.0215$ $Z = 4$

X-ray Powder Pattern: Hindlow quarry, Derbyshire, England. 4.183 (100), 2.450 (50), 2.693 (35), 1.7192 (20), 2.190 (18), 2.253 (14), 4.98 (12)

Chemistry:	(1)	(2)
SiO ₂	0.36	
Fe ₂ O ₃	89.65	89.86
H ₂ O	10.19	10.14
Total	100.20	100.00

(1) El Paso Co., Colorado, USA. (2) FeO(OH).

Polymorphism & Series: Trimorphous with feroxyhyte and lepidocrocite.

Occurrence: A common weathering product derived from numerous iron-bearing minerals in oxygenated environments; an important component of ore in weathered iron deposits. Also a primary precipitate in hydrothermal, marine, and bog environments upon oxidation of reduced iron-bearing waters.

Association: Lepidocrocite, hematite, pyrite, siderite, pyrolusite, manganite, many other iron- and manganese-bearing species.

Distribution: Widespread; some localities for good crystals include: from Siegen, North Rhine-Westphalia, and near Giessen, Hesse, Germany. At Příbram, Czech Republic. Exceptional crystals from the Restormel mine, Lanlivery; the Botallack mine, St. Just; and elsewhere in Cornwall, England. From Chaillac, Indre-et-Loire, France. In the USA, from the Pikes Peak district and Florissant, El Paso Co., Colorado; an ore mineral in the Lake Superior district, as at the Jackson mine, Negaunee, and the Superior mine, Marquette, Marquette Co., Michigan.

Name: Honors the German poet, dramatist, and philosopher, Johann Wolfgang von Goethe (1749–1832).

References: (1) Palache, C., H. Berman, and C. Frondel (1944) Dana's system of mineralogy, (7th edition), v. I, 680–687. (2) Deer, W.A., R.A. Howie, and J. Zussman (1962) Rock-forming minerals, v. 5, non-silicates, 118–121. (3) Harrison, R.K., N. Aitkenhead, B.R. Young, and P.F. Dagger (1975) Goethite from Hindlow, Derbyshire. Bull. Geol. Surv. Great Britain, 52, 51–54. (4) Ramdohr, P. (1980) The ore minerals and their intergrowths, (4th edition), 1071–1076.

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