Woodruffite $Zn_2(Mn^{4+}, Mn^{3+})_5O_{10}\cdot 4H_2O$

Crystal Data: Monoclinic. *Point Group*: 2/*m*. In very fine-grained, concentrically layered, botryoidal crusts and masses; rare acicular crystals to "several hundred" μm (Mexico).

Physical Properties: *Fracture*: Conchoidal. Hardness = 4.5 D(meas.) = 3.71-4.01 D(calc.) = 3.983

Optical Properties: Opaque. *Color*: Iron-black to chocolate-brown; light gray to yellowish gray in reflected light. *Streak*: Brown. *Luster*: Dull.
Optical Class: Uniaxial. *Anisotropism*: Strong. *Bireflectance*: Weak.

Cell Data: *Space Group*: *C*2/*m*. a = 24.625(1) b = 2.8355(1) c = 9.5381(5) β = 94.104(2)° Z = 1

X-ray Powder Pattern: Sandur, India.
4.66 (10), 2.66 (6), 2.48 (6), 9.34 (5), 1.48 (5), 1.86 (4), 1.69 (4)

Chemistry:

	(1)	(2)		(1)	(2)
SiO_2	0.86	1.28	BaO	0.12	0.62
MnO_2	[64.27]	68.29	Na_2O	0.06	0.04
Al_2O_3	0.14	0.96	K_2O	0.55	0.08
Fe_2O_3	0.26	0.89	H_2O^+		8.48
MnO	[7.88]	8.46	H_2O^-		0.83
ZnO	13.89	9.42	H_2O	10.48	.
MgO	0.62	0.48	Total	99.13	[99.83]

(1) Sterling Hill, New Jersey, USA; Mn^{2+}:Mn^{4+} calculated from stoichiometry. (2) Sandur, India; original total given as 99.84%. (3) Durango, Mexico; electron microprobe analysis (not given), H_2O from Ref. 1; corresponds to $Zn_{2.8}Mn_{13.8}O_{28}\cdot 9.7H_2O$.

Occurrence: In the oxidized portion of a metamorphosed stratiform zinc orebody (Sterling Hill, New Jersey, USA); in massive manganese ores (Sandur, India); in the oxidized zone of a Ag-Pb-Zn ore deposit (Lardeau, Canada); a component of ocean-floor Fe-Mn nodules.

Association: Franklinite, chalcophanite (Sterling Hill, New Jersey, USA); pyrolusite, cryptomelane (Sandur, India); smithsonite, gunningite, hydrozincite, aurichalcite (Lardeau, Canada).

Distribution: From Sterling Hill, Ogdensburg, Sussex Co., New Jersey, USA [TL]. At the Willett mine, Lardeau, British Columbia, Canada. From the Lecht mine, near Tomintoul, Aberdeenshire, Scotland. On Mont Chemin, Valais, Switzerland. From Maria Weitscach, near Hiittenberg, Carinthia, Austria. In Germany, at Juliushiitte, Astfeld, Harz Mountains, in slag. From Sandur, Mysore, India. Crystals from near Mapimi, Durango, Mexico.

Name: Honors Samuel *Woodruff*, American miner for the New Jersey Zinc Company, and prolific mineral collector of Franklin-Sterling Hill minerals.

Type Material: Harvard University, Cambridge, Massachusetts, USA, 112987.

References: (1) Frondel, C. (1953) New manganese oxides: hydrohausmannite and woodruffite. Amer. Mineral., 38, 761-769. (2) Naganna, C. and V. Bouska (1963) X-ray study of woodruffite from Sandur ore deposits, Mysore State, India. Mineral. Mag., 33, 506-507. (3) Post, J.E., P.J. Heaney, C.L. Cahill, and L.W. Finger (2003) Woodruffite: A new Mn oxide structure with 3 x 4 tunnels. Amer. Mineral., 88, 1697-1702. (4) Post, J.E., D.A. McKeown, and P.J. Heaney (2020) Raman spectroscopy study of manganese oxides: Tunnel structures. Amer. Mineral., 105(8), 1175-1190.