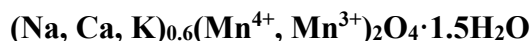


Birnessite

Crystal Data: Monoclinic, pseudo-hexagonal. *Point Group:* $2/m$. Rarely in platelets, to 50 μm ; commonly extremely finely crystalline, spherulitic, cellular.

Physical Properties: Hardness = 1.5 D(meas.) = 3.0 D(calc.) = [3.4]

Optical Properties: Nearly opaque. *Color:* Black; dark brown in transmitted light. *Luster:* Dull. *Optical Class:* Pseuduniaxial (-); impossible to identify by optics. $\omega = \sim 1.73$ $\epsilon = \sim 1.69$

Cell Data: *Space Group:* $C2/m$ (synthetic $\approx \text{Na}_{0.58}(\text{Mn}^{4+}_{1.42}\text{Mn}^{3+}_{0.58})_{\Sigma=2.00}\text{O}_4 \cdot 1.5\text{H}_2\text{O}$).
 $a = 5.175(1)$ $b = 2.850(1)$ $c = 7.337(3)$ $\beta = 103.18(2)^\circ$ $Z = 1$

X-ray Powder Pattern: Marine nodule, Caribbean; all reflections are typically very broad.
 7.08 (100), 2.333 (43), 1.711 (29), 3.547 (28), 2.031 (24), 2.468 (17), 1.426 (17)

Chemistry:	(1)	(2)		(1)	(2)
SiO ₂	0.9		CaO	0.39	
MnO ₂	75.8	61.40	Na ₂ O	1.9	7.30
Mn ₂ O ₃		18.58	K ₂ O	1.8	
FeO	0.55		Cl	0.1	
CoO	0.14		H ₂ O	[10.89]	12.72
NiO	0.80		<u>S</u>	<u>0.2</u>	
CuO	0.33		Total	[100.0]	100.00
MgO	6.2				

- (1) Marine nodule, Caribbean; by electron microprobe, total Mn as MnO₂, H₂O by difference.
 (2) $\text{Na}_{0.50}(\text{Mn}^{4+}_{1.50}\text{Mn}^{3+}_{0.50})_{\Sigma=2.00}\text{O}_4 \cdot 1.5\text{H}_2\text{O}$.

Polymorphism & Series: Hexagonal polytypes (1H, 2H1, 2H2, 3R1, 3R2, 3H1, and 3H2) and orthogonal analogs (1O, 2O1, 2O2, 1M1, 1M2, 3O1, and 3O2).

Occurrence: A major manganese-bearing mineral of many soils; a common alteration product of manganese-rich mineral deposits; a component of bacterially-precipitated manganese oxides; an important constituent of “desert varnish” and marine manganese nodules.

Association: Rhodonite, rhodochrosite, tephroite, spessartine, alleghanyite, cummingtonite (Cummington, USA); manganese and iron oxides, calcium carbonate (marine nodules).

Distribution: Increasingly recognized as a common manganese oxide mineral. From Birness, Aberdeenshire, Scotland [TL]. In the Treburland mine, Altarnun, and the Penberthy Croft mine, St. Hilary, Cornwall, England. On Groote Eylandt, Northern Territory, and near Noarlunga, Mount Lofty Ranges, South Australia. At the Ioi mine, Ritta, Shiga Prefecture, Japan. In the USA, at Sterling Hill, Sussex Co., New Jersey; from Cummington, Hampshire Co., Massachusetts; in the Kramer borate deposit, Boron, Kern Co., California; at Silver Cliff, Custer Co., Colorado; and elsewhere. From Mont St. Hilaire, Quebec, Canada. Sea floor and sea mount occurrences occur.

Name: For the type locality at *Birness*, Scotland.

References: (1) Jones, L.H.P. and A.A. Milne (1956) Birnessite, a new manganese oxide mineral from Aberdeenshire, Scotland. *Mineral. Mag.*, 31, 283-288. (2) (1957) *Amer. Mineral.*, 42, 440 (abs. ref. 1). (3) Glover, E.D. (1977) Characterization of a marine birnessite. *Amer. Mineral.*, 62, 278-285. (4) Post, J.E. and D.R. Veblen (1990) Crystal structure determinations of synthetic sodium, magnesium, and potassium birnessite using TEM and the Rietveld method. *Amer. Mineral.*, 75, 477-489. (5) Drits, V.A., B. Lanson, and A.-C. Gailloti (2007) Birnessite polytype systematics and identification by powder X-ray diffraction. *Amer. Mineral.*, 92, 771-788. (6) Ling, F.T., J.E. Post, P.J. Heaney, C.M. Santelli, E.S. Ilton, W.D. Burgos, and A.W. Rose (2020) A multi-method characterization of natural terrestrial birnessites. *Amer. Mineral.*, 105, 833-847.