

Widgiemoolthalite: The new Ni analogue of hydromagnesite from Western Australia

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ABSTRACT

Widgiemoolthalite is a new hydrated nickel carbonate mineral from the 132 North nickel mine near Widgiemooltha in Western Australia. It is found together with a number of other secondary nickel minerals in the weathered zone overlying a nickel sulfide body. Widgiemoolthalite is bluish green with a silky luster and occurs mainly as spheroids of radiating fibers. The fibers are biaxial positive and length fast with $n_{\min} = 1.630(5)$ and $n_{\max} = 1.640(5)$. The measured specific gravity is 3.13; calculated, 3.24. It has a composition corresponding to $\text{Ni}_{4.62}\text{Mg}_{0.38}\text{C}_{4.15}\text{H}_{11.94}\text{O}_{19.28}$, or $(\text{Ni},\text{Mg})_{5.00}(\text{CO}_3)_{4.15}(\text{OH})_{1.70} \cdot 5.12\text{H}_2\text{O}$, on the basis of $\text{Ni} + \text{Mg} = 5$. The ideal formula, based on its crystallographic similarity to hydromagnesite, is $\text{Ni}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{--}5\text{H}_2\text{O}$. The X-ray powder diffraction pattern can be indexed on a monoclinic unit cell similar to that of hydromagnesite, with $a = 10.06(17)$, $b = 8.75(5)$, $c = 8.32(4)$ Å, and $\beta = 114.3(8)^\circ$. Strongest reflections [d in ångströms, (I/I_0), (hkl)] are 5.75(10)(011), 6.30(5)(110), 4.36(4)(020), 2.871(4)($\bar{2}22$, 022), 4.14(3)($\bar{1}02$), and 2.120(3)(132).

INTRODUCTION

Widgiemoolthalite was discovered in specimens collected by Blair J. Gartrell from a stockpile of weathered material excavated at the 132 North nickel mine, 4 km southwest of the small community of Widgiemooltha, which is about 80 km south of Kalgoorlie, Western Australia, Australia.

The assemblage of secondary minerals at the Widgiemooltha mine site, which is described in more detail elsewhere (Nickel et al., in preparation), contains a number of nickel minerals, including gaspeite, carrboydite, pecoraite, glaukosphaerite, hydrohonessite, nepouite, kambaldaite, nullaginite, otwayite, reevesite, retgersite, takovite, annabergite, nickeloan paratacamite, and several unnamed hydrated nickel carbonates, in addition to widgiemoolthalite.

The mineral name is derived from the occurrence at Widgiemooltha, Western Australia, and both mineral and name have been approved by the IMA Commission on New Minerals and Mineral Names. Holotype material has been deposited with the Department of Earth and Planetary Sciences, Western Australian Museum, Perth, Western Australia as specimen no. M.1.1993.

OCCURRENCE AND PROPERTIES

Widgiemoolthalite occurs predominantly as isolated spheroids of radiating fibers, generally perched on cavity surfaces in gaspeite. These spheroids vary mostly be-

tween 1 and 2 mm in diameter and consist of tightly packed radiating crystals a few micrometers wide and up to about 1 mm in length. It also occurs as massive grass green patches, which under the microscope appear as felted fibers.

Closely associated with the widgiemoolthalite are several apparently new unnamed nickel minerals. One of them is a fibrous mineral, similar in appearance to widgiemoolthalite, but occurring in asbestiform parallel-fiber masses. Another is a clear vitreous emerald green isotropic mineral. Preliminary study has shown that they are both hydrated nickel carbonates.

Widgiemoolthalite is generally bluish green in hand specimen (except for the relatively rare grass green massive variety), with a silky luster and a pale bluish green streak. The specific gravity, measured using heavy liquids, is 3.13(1); the calculated specific gravity, based on the unit-cell dimensions given below, is 3.24. The mineral is brittle; its hardness could not be determined because the mineral breaks up along fiber contacts during testing.

In transmitted light, widgiemoolthalite is bluish green and nonpleochroic. Single crystals could not be isolated for the oriented determination of optical parameters because of the small lateral dimensions of the fibers. However, examination of the fibers in immersion oils under the optical microscope shows that they are length fast, with refractive indices $n_{\min} = 1.630(5)$ parallel to the fiber length (= crystallographic b axis), and $n_{\max} = 1.640(5)$

TABLE 1. Chemical composition of widgiemoolthalite

	Wt%	Atomic props.
NiO	54.6	4.62
MgO	2.4	0.38
CO ₂	28.9	4.15
H ₂ O	17.0	11.94
Total	102.9	

Note: NiO and MgO determined by microprobe analysis using Ni metal and MgO as standards; CO₂ and H₂O determined by CHN analyses.

normal to the elongation. The mineral is biaxial positive with a high 2*V*. Gladstone-Dale calculations (Mandarino, 1976) give a compatibility index of 0.076, which represents fair agreement (Mandarino, 1981).

Widgiemoolthalite reacts only weakly with concentrated HCl and not at all with dilute HCl or concentrated H₂SO₄.

CHEMICAL COMPOSITION

Grains of widgiemoolthalite were mounted in polished sections for the electron microprobe, and about 5 mg was hand-picked for microchemical analysis for C and H. The microprobe analyses were made by B.W.R. using a Camebax SX-50 electron microprobe at an accelerating voltage of 15 kV and a specimen current of 30 nA. The only elements detected were Ni and Mg. The analyses, shown in Table 1, represent the average of 14 spot analyses. The range of values is 54.1–60.0% NiO and 1.5–2.9% MgO. There was sufficient material for only one microchemical determination of C and H, using a CHN Analyzer operated by the Australian Microanalytical Service according to the procedure described by MacDonald (1974).

The analyses yield the composition Ni_{4.62}Mg_{0.38}C_{4.15}H_{11.94}O_{19.28}, which translates into (Ni,Mg)_{5.00}(CO₃)_{4.15}(OH)_{1.70}·5.12H₂O, calculated on the basis of Ni + Mg = 5.00. By comparison, the chemical formula of hydromagnesite, to which widgiemoolthalite appears to be related, is Mg₅(CO₃)₄(OH)₂·4H₂O (Bariand et al., 1973; Akao

TABLE 2. X-ray powder diffraction patterns of widgiemoolthalite and hydromagnesite

Widgiemoolthalite			Hydromagnesite			Widgiemoolthalite			Hydromagnesite		
<i>hkl</i>	<i>d_c</i> (Å)	<i>d_o</i> (Å)	<i>hkl</i>	<i>d_c</i> (Å)	<i>hkl</i>	<i>hkl</i>	<i>d_c</i> (Å)	<i>d_o</i> (Å)	<i>hkl</i>	<i>d_c</i> (Å)	<i>hkl</i>
1	9.7	9.169	39	9.20	100	1	2.422	2.428	5	2.442	013
5	6.30	6.330	38	6.40	110			2.401	7	2.417	411
10	5.75	5.730	100	5.79	011			2.369	2	2.387	412
		4.584	7	4.58	200			2.324			123
4	4.36	4.375	17	4.46	020	1	2.324	2.323	14	2.350	223
3	4.14	4.160	31	4.186	102*			2.292	33	2.298	400
		4.061	12	4.090	210			2.201			331
		3.948	8	4.022	120			2.187	4	2.233	040
		3.791			002			2.189	23	2.207	023
		3.789			021			2.169	11	2.189	421
		3.788	1	3.856	121			2.171	11	2.185	321
		3.785	13	3.812	202			2.128	7	2.174	140
		3.479	14	3.503	012			2.148	20	2.161	222
		3.273	28	3.317	121			2.142			413
		3.270			221			2.147	24	2.154	113
		3.165	16	3.207	220	3	2.120	2.119	19	2.146	132
		3.136	22	3.142	211			2.101			141
		3.077	11	3.101	302			2.102			041
		3.084	10	3.088	102			2.110	12	2.137	330
		3.056	6	3.063	300			2.080	1	2.093	204
		2.909	11	2.919	112			2.029	6	2.040	104
		2.885			310			2.024			214
4	2.871	2.865	82	2.899	022			1.998			133
		2.862			222			1.997	8	2.025	233
		2.779	6	2.840	130			2.009	5	2.012	302
		2.722	7	2.779	131			1.974			240
		2.722			031	1	1.971	1.972	27	1.994	423
		2.661	27	2.692	321			1.975			314
		2.617			113			1.976	19	1.988	123
		2.616	5	2.637	213			1.936	4	1.974	142
		2.510			131			1.955	4	1.968	512
		2.509	5	2.556	231	1	1.708	1.958	5	1.962	312
		2.521	4	2.543	122	1	1.548			...	etc ...
		2.505	9	2.529	320						
2	2.458	2.461	22	2.504	230	<i>a</i> (Å)		10.06		10.11	
		2.460	10	2.478	402	<i>b</i> (Å)		8.75		8.94	
		2.465	10	2.469	202	<i>c</i> (Å)		8.32		8.38	
						<i>β</i> (°)		114.3		114.6	

Note: Data for the widgiemoolthalite pattern taken from 114.6-mm Debye-Scherrer film, Ni-filtered Cu radiation; intensities (*I*/*I*_o) estimated visually. Hydromagnesite data taken from Bariand et al. (1973). The *d_c* = observed *d* values; *d_o* = calculated *d* values.

* This reflection erroneously given as 002 in Bariand et al. (1973).

et al., 1974; Akao and Iwai, 1977). From the X-ray evidence it can be assumed that widgiemoolthalite is the Ni analogue of hydromagnesite, and so the ideal widgiemoolthalite composition can be expressed as $\text{Ni}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 4\text{--}5\text{H}_2\text{O}$. The possibility that widgiemoolthalite might be related to the rather poorly defined mineral dypingite, $\text{Mg}_5(\text{CO}_3)_4(\text{OH})_2 \cdot 5\text{H}_2\text{O}$, was also considered, but the X-ray powder diffraction patterns of the two minerals are quite dissimilar (cf. Raade, 1970).

CRYSTALLOGRAPHY

The Debye-Scherrer powder diffraction pattern of widgiemoolthalite is diffuse, resulting in rather low accuracy of measurement. Data for the pattern are given in Table 2, together with those of hydromagnesite (Bariand et al., 1973). The patterns are quite similar, except that widgiemoolthalite contains far fewer measurable reflections. Least-squares indexing using the hydromagnesite pattern as a starting point gives $a = 10.06(17)$, $b = 8.75(5)$, $c = 8.32(4)$ Å, and $\beta = 114.3(8)^\circ$. The d values calculated for this monoclinic unit cell are in reasonable agreement with the measured values, except for the reflection at 9.7 Å, which is appreciably larger than the calculated one. This discrepancy may be due to stacking disorder.

Numerous attempts were made to extract single crystals of widgiemoolthalite for single-crystal X-ray diffraction, but they were all in vain because of the small lateral dimensions of the fibers. The best that could be done was to obtain patterns from fiber bundles. Rotation films obtained from these bundles indicate a rotation axis of about 8.8 Å, which corresponds to the b crystallographic axis; in addition, the patterns exhibit weak superlattice reflections indicating a 62-Å supercell, which represents seven hydromagnesite-type layers. Weissenberg zero- and first-level reflections are very diffuse and streaked, making interpretation very difficult, and higher-level reflections are virtually useless. However, they do indicate a pseudoorthorhombic unit cell, which has also been reported for hydromagnesite (Murdoch, 1954), and which may be due to twinning.

DISCUSSION

The diffuse X-ray diffraction pattern of widgiemoolthalite suggests a high degree of structural disorder, and the pseudoorthorhombic cell displayed by the Weissenberg films indicates the possibility of twinning. These factors have prevented the definitive crystallographic characterization of the mineral, but the close similarity of its X-ray diffraction pattern to that of hydromagnesite indicates that it is the Ni analogue of the latter. The five H_2O molecules indicated by the chemical analysis of widgiemoolthalite, compared with four in ideal hydromagnesite, may be due to the incorporation of extra H_2O in the large cavities reported for the crystal structure of hydromagnesite (Akao et al., 1974).

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REFERENCES CITED

- Akao, M., and Iwai, S. (1977) The hydrogen bonding of hydromagnesite. *Acta Crystallographica*, B33, 1273–1275.
- Akao, M., Marumo, F., and Iwai, S. (1974) The crystal structure of hydromagnesite. *Acta Crystallographica*, B30, 2670–2672.
- Bariand, P., Cesbron, F., Vachey, H., and Sadrzadeh, M. (1973) Hydromagnesite from Soghan, Iran. *Mineralogical Record*, 4, 18–20.
- MacDonald, R.D. (1974) Developments in quantitative elemental microanalysis. *Royal Australian Chemical Institute Proceedings*, February 1974, 37–40.
- Mandarino, J.A. (1976) The Gladstone-Dale relationship. I. Derivation of new constants. *Canadian Mineralogist*, 14, 498–502.
- (1981) The Gladstone-Dale relationship. IV. The compatibility concept and its application. *Canadian Mineralogist*, 19, 441–450.
- Murdoch, J. (1954) Unit cell of hydromagnesite. *American Mineralogist*, 39, 24–29.
- Raade, G. (1970) Dypingite, a new hydrous basic carbonate of magnesium, from Norway. *American Mineralogist*, 55, 1457–1465.

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