

## TWO CHLORITES: GONYERITE AND MELANOLITE\*

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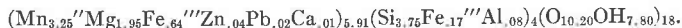
### ABSTRACT

Gonyerite is a new manganese member of the chlorite group. Analysis gave: MgO 11.55, CaO 0.07, MnO 33.83, PbO 0.56, ZnO 0.42, Fe<sub>2</sub>O<sub>3</sub> 9.42, Al<sub>2</sub>O<sub>3</sub> 0.58, SiO<sub>2</sub> 33.06, Ti and As nil, H<sub>2</sub>O+ 10.31, H<sub>2</sub>O- 0.02; total 99.82. Apparently orthorhombic, pseudohexagonal, with  $a_0=5.47$ ,  $b_0=9.46$ ,  $c_0=28.8$  Å. Color deep brown; gravity =  $3.01 \pm .04$  meas., 3.03 calc. Optically negative, with  $n_X=1.646$  (dark brown),  $n_Z=1.664$  (light brown);  $2V=0^\circ$ . Found as radial aggregates of laths with barite and bementite in hydrothermal veinlets at Långban, Sweden.

The ill-defined mineral melanolite described by Wurtz in 1850 from Somerville, Massachusetts, is shown to be a (lepto-) chlorite identical with delessite. Analysis: Na<sub>2</sub>O 0.17, K<sub>2</sub>O 0.07, CaO 1.10, MgO 10.71, FeO 20.96, MnO 0.18, Fe<sub>2</sub>O<sub>3</sub> 10.46, Al<sub>2</sub>O<sub>3</sub> 13.77, TiO<sub>2</sub> 0.16, SiO<sub>2</sub> 29.94, H<sub>2</sub>O+ 10.00, H<sub>2</sub>O- 2.48; total 100.00 after deducting CaCO<sub>3</sub>. Optically negative, with  $n_X < 1.63$  (light olive green),  $n_Z=1.650$  (dark olive green);  $2V$  small to  $0^\circ$ . Gravity = 2.73; spacing  $d_{001}$  14.4 Å. Data are given for both gonyerite and melanolite on the change in  $x$ -ray pattern and optics on heating to  $500^\circ$ .

### GONYERITE

The unusual new manganese member of the chlorite group here noted virtually lacks aluminum. The chemical analysis (Table 1), calculated on the basis of 18(O, OH) with Al and enough Fe<sup>'''</sup> assigned to fill the tetrahedral positions, yields the following formula:



The significant excess of divalent cations appearing when the Fe is calculated as divalent and either (Si, Al) is taken as 4 or (O, OH) as 18, suggests that the ferric iron in large part at least is primary. Pennantite, the only other known high-manganese chlorite (1), is rich in Al (18.60 per cent Al<sub>2</sub>O<sub>3</sub>) and relatively low in Mg and Fe<sup>'''</sup>.

The  $x$ -ray powder pattern closely resembles those of the chlorites in the position and relative intensity of the (00 $l$ ) reflections, and includes the diagnostic 14 Å line, but many of the fainter lines differ. (The pattern of pennantite is identical with that of thuringite from Schmiedefeld.) There also is definite evidence that the  $c$ -axis identity period is 28 Å and not 14 Å. Weissenberg photographs from minute cleavage flakes were marred by disorientation effects, and although no reliable information as to symmetry could be obtained they indicated an orthorhombic cell with  $a_0=5.47$ ,  $b_0=9.46$ ,  $c_0=28.8$  Å. The mineral is dimensionally pseudohexagonal since  $b_0=\sqrt{3}a_0$ . A fairly satisfactory indexing of the

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TABLE 1. CHEMICAL ANALYSIS OF GONYERITE

	1	Iron as Fe'''	Iron as Fe''
MgO	11.55	Mg = 1.954	2.000
CaO	0.07	Ca = .008	.008
MnO	33.83	Mn = 3.252	3.327
PbO	0.56	Pb = .017	.017
ZnO	0.42	Zn = .035	.036
Fe <sub>2</sub> O <sub>3</sub>	9.42	Fe''' = { .64	Fe'' = .823
Al <sub>2</sub> O <sub>3</sub>	0.58	.17	
SiO <sub>2</sub>	33.06	Al = .078	.079
H <sub>2</sub> O+	10.31	Si = 3.754	3.840
H <sub>2</sub> O-	0.02	O = 10.197	10.018
	99.82	OH = 7.803	7.982

1. Gonyerite. Långban, Sweden. Analysis by F. A. Gonyer, 1952. Ti and As absent.

powder photograph is afforded by this cell (Table 2). The spacings are the largest yet reported for a chlorite, due to the high content of Si and of the relatively large Mn'' ion.

The mineral occurs at Långban, Sweden, associated with barite, berzeliite, bementite and garnet in small hydrothermal veinlets cutting skarn. It forms rounded radial aggregates of laths and plates up to several millimeters in length. A few tiny aggregates of apparently hex-

TABLE 2. X-RAY POWDER DATA FOR GONYERITE

Iron radiation, manganese filter, in Ångstroms. Indexing for orthorhombic cell with  $a_0=5.47$  Å,  $b_0=9.46$ ,  $c_0=28.8$

<i>I</i>	<i>d</i>	<i>hkl</i>	<i>d</i> <sub>calc.</sub>	<i>I</i>	<i>d</i>	<i>hkl</i>	<i>d</i> <sub>calc.</sub>
3	14.6	002	14.4	2	2.888	00.10	2.88
$\frac{1}{2}$ †	8.0	012	7.90	2	2.801		
10	7.23	004	7.20	3	2.697	202	2.69
$\frac{1}{2}$ *	5.79	005	5.76	1	2.610	00.11	2.61
						211	2.61
1*	5.33	101	5.37	$\frac{1}{2}$	2.550	204	2.55
5	4.79	006	4.80	1	2.441		
8	3.61	008	3.60	$\frac{1}{2}$	2.056	00.14	2.05
						231	2.05
1	3.33	123	3.35	$\frac{1}{2}$ *	1.696	00.17	1.69
$\frac{1}{2}$	3.22	009	3.20	3	1.634		
$\frac{1}{2}$	3.13	030	3.15	5	1.574		
$\frac{1}{2}$	3.03	033	3.00	1*	1.437	00.20	1.44

\* broad line.

† = very broad line.

agonal plates intergrown in the manner of "iron-roses" were observed. The bementite forms buff-colored aggregates of small lamellar-fibrous grains. A manganoan variety of penninite has been described by von Eckermann (2) from Långban, but this mineral is normal in composition, with MnO 1.06, Al<sub>2</sub>O<sub>3</sub> 16.17, Fe<sub>2</sub>O<sub>3</sub> 0.56, and is distinct from the present species.

Color is deep brown with reddish internal reflections; powder milk-chocolate brown. Cleavage (001) perfect; foliae are flexible but inelastic. Hardness 2½. Gravity 3.01 ± .04. The gravity calculated from the cell and the formula first given is 3.03. Optically negative with 2V = 0°; *n*X or *n*E = 1.646 (dark brown), *n*Z or *n*O = 1.664 (light brown) in white light. Rapidly decomposed by cold concentrated HCl and slowly by cold 3N HCl with the separation of flaky-gelatinous silica; insoluble in cold concentrated H<sub>2</sub>SO<sub>4</sub>. After heating at 500° for 30 minutes the mineral becomes brownish black in color. There is no change in the powder pattern, other than an increased diffuseness, eliminating some of the fainter lines, and a very marked increase in the intensity of the 14.4 Å line over the 7.2 Å line. There is an accompanying small decrease in the spacings of (00*l*). Optically the heated material shows high birefringence and much decreased absorption in brown. The indices are greatly increased, with *n*Z, somewhat variable, ranging up to 1.84. The differential analysis curve places the breakdown of the brucite-type layer at about 600°.

The presence of the 14 Å line in unheated material and the behavior on heating indicate that this mineral structurally is of the chlorite type. The increase in intensity of the 14 Å line and the decrease in (00*l*) spacing on heating is typical of high-iron chlorites. The name gonyerite is proposed for this mineral after Forest A. Gonyer, analytical chemist, associated for many years with this Department and now retired.

Gonyerite differs from the problematic manganese silicates bementite (with which gonyerite is associated), ectropite and caryopilite both chemically, in its large content of ferric iron and magnesium, and structurally. Since bementite appears to be related in structure to antigorite and gonyerite to the chlorites there are certain analogies between them, both in the formula ratios and the diffraction patterns. Thus the 7 Å and 3.5 Å powder lines are common to both, but bementite lacks the 14 Å line and differs otherwise. Larsen (7) and Pardee, Larsen and Steiger (8) have held on optical and chemical grounds that caryopilite, ectropite and bementite are identical, and Larsen suggests that bementite is a manganese member of the serpentine group. Caryopilite and ectropite were here found to give identical powder patterns, and this pattern is very close to that of bementite; both patterns are similar to, but not quite identical with, that of antigorite. Gonyerite differs com-

pletely in properties and powder pattern from the following manganese and iron silicates: gageite, leucophoenicite, alleghanyite, parsettensite, manganpyrosmalite, friedelite, schallerite, ganophyllite, macgovernite and cronstedtite. Among Långban minerals, gonyerite closely resembles in outward appearance the manganese arsenite-silicate dixenite.

*Melanolite (= Delessite)*

This chlorite was described in 1850 by H. Wurtz (3) from the long-abandoned Milk Row diabase quarry on Granite Street, Somerville, Massachusetts. The petrography of the diabase has been described by

TABLE 3. CHEMICAL ANALYSES OF MELANOLITE

	1	2	Iron as given	Iron as Fe''
Na <sub>2</sub> O	1.85	0.17	Na = .04	.04
K <sub>2</sub> O		0.07	K = .01	.01
CaO		1.10	Ca = .13	.13
MgO		10.71	Mg = 1.74	1.79
FeO	25.09	20.96	Fe'' = 1.92	2.84
MnO		0.18	Fe''' = .86	6.01
Fe <sub>2</sub> O <sub>3</sub>	23.13	10.46	Mn = .02	.02
Al <sub>2</sub> O <sub>3</sub>	4.48	13.77	Ti = .01	.01
TiO <sub>2</sub>		0.16	Al { 1.04	{ 1.17
SiO <sub>2</sub>	35.24	29.94	.73	.65
H <sub>2</sub> O+}	10.21	10.00	Si = 3.27	3.35
H <sub>2</sub> O-}		2.48	O = 10.71	10.53
	100.00	100.00	OH = 7.29	7.47

1. Melanolite. Somerville, Massachusetts. Analysis of Wurtz (1850) given as recalculated to 100 by Wurtz after deducting 12.77 per cent CaCO<sub>3</sub>.

2. Melanolite. Somerville, Massachusetts. Analysis by E. H. Oslund, University of Minnesota, 1954. Recalculated to 100 from original sum of 99.55 after deducting CO<sub>2</sub> 1.81 as CaCO<sub>3</sub>.

Jaggar (4). The original analysis of Wurtz (Table 3) was made on very impure material and is faulty in other regards. Dana (5) classed melanolite as an ill-defined chloritic material, and the mineral has not been noticed in modern reviews of the chlorites. X-ray and thermal study of specimens from the collections of Harvard University and Wellesley College indicate that melanolite is a chlorite, and a new chemical analysis is cited in Table 3. The high content of ferric iron and the deficit of six-coordinated ions place the mineral as a leptochlorite. The analysis corresponds exactly to an orthochlorite, however, when the iron is all calculated as Fe'' (Table 3). The content of Fe''' is regarded as secondary and due to oxidation, in contrast to gonyerite.

Melanolite falls in the composition field of delessite in the classification of Hey (6). The name melanolite apparently has priority over delessite, but in any case it should be abandoned in favor of the widely used name delessite. Melanolite appeared in the July issue of the 1850 volume of the *American Journal of Science* (the paper itself is dated April 1, 1850), while delessite appeared in the 1850 edition of Naumann's *Mineralogie* (foreword dated July 6, 1850).

Melanolite occurs as dense, slickensided lamellar coatings along joint planes and fissures in the diabase. Thin films of a slightly ferroan calcite ( $n_O \sim 1.661$ ) penetrate between the foliae. Color black with a greenish tinge. Streak and powder olive green to greenish gray. Gravity = 2.73 (2.69, Wurtz). Easily soluble in cold concentrated HCl and slowly in cold 3N HCl with separation of flaky to granular semigelatinous silica; insoluble in cold concentrated  $H_2SO_4$ . Optically biaxial negative with 2V small to 0°;  $n_X < 1.63$  (light olive green),  $n_Z = 1.650$  (dark olive green) in white light. The x-ray powder pattern is very similar to that of thuringite, but with the unusual feature that the 14 Å line is darker than the 7 Å line, opposite to the rule in the chlorites. The spacing  $d_{001}$  is 14.4 Å. On heating to 500° for 30 minutes the 14 Å line is preserved in position and relative intensity. The heated material, brown in color, has high birefringence and diminished absorption in brown. The indices are greatly increased, with  $n_Z$  variable and ranging up to 1.86.

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## NOTE ADDED IN PRESS

Recent correspondence with Dr. Frans E. Wickman of the Royal Museum, Stockholm, has shown that the mineral here described as gonyerite had been recognized as a new species many years ago by G. Aminoff, although a description never had been published. The following analysis, an average of two, was made in 1937 by R. Blix.

(Na, K) <sub>2</sub> O	MgO	MnO	Al <sub>2</sub> O <sub>3</sub>	Fe <sub>2</sub> O <sub>3</sub>	TiO <sub>2</sub>	SiO <sub>2</sub>	H <sub>2</sub> O—	H <sub>2</sub> O+	Total
0.31	12.22	32.89	0.50	9.90	nil	32.84	1.01	9.96	99.63