

## New determinations of the specific gravity of linarite

5.30 Red Gill, Cumberland (Berman balance)  
 5.25 Mono County, California } C. Frondel, private  
 5.26 Rezbanya, Hungary } communication—May 13, 1946

combined with the volume of the unit cell and any of the closely agreeing analyses clearly indicate a structural formula:



with calculated specific gravity 5.319.

TABLE 1. LINARITE— $\text{PbCuSO}_4(\text{OH})_2$ : X-RAY POWDER PATTERN  
 Monoclinic,  $P2_1/m$ ;  $a=9.70$ ,  $b=5.65$ ,  $c=4.68\text{A}$ ,  $\beta=102^\circ 40'$ ;  $Z=2$

<i>I</i>	<i>d</i> (meas.)	<i>hkl</i>	<i>d</i> (calc.)	<i>I</i>	<i>d</i> (meas.)	<i>hkl</i>	<i>d</i> (calc.)	<i>I</i>	<i>d</i> (meas.)	<i>hkl</i>	<i>d</i> (calc.)
2	4.82A	110	4.851A	1	2.81A	020	2.825A				
4	4.48	$\bar{1}01$	4.518	1	2.68	120	2.707	4	2.16A	410	2.182A
7	3.53	210	3.628	3	2.56	$\bar{3}11$	2.587			$\bar{1}12$	2.161
		011	3.551	1	2.39	021	2.402			320	2.105
		300	3.155	1	2.39	$\bar{1}21$	2.395	4	2.09	$\bar{2}02$	2.097
10	3.12	111	3.153	3	2.30	$\bar{4}01$	2.318			$\bar{3}02$	2.078
		$\bar{2}11$	3.105	3	2.24	$\bar{2}02$	2.259				
2	2.94	201	2.977	3	2.24	$\bar{2}21$	2.249				

<i>I</i>	<i>d</i> (meas.)	<i>I</i>	<i>d</i> (meas.)	<i>I</i>	<i>d</i> (meas.)	<i>I</i>	<i>d</i> (meas.)	<i>I</i>	<i>d</i> (meas.)
6b	1.791A	$\frac{1}{2}$	1.532A	1	1.324A	$\frac{1}{2}$	1.118A	1b	0.869A
1	1.758	$\frac{1}{2}$	1.514	$\frac{1}{2}$	1.299	2	1.056	1b	0.860
$\frac{1}{2}$	1.734	1	1.492	$\frac{1}{2}$	1.287	1	1.047	1b	0.849
2	1.675	$\frac{1}{2}$	1.439	1	1.214	$\frac{1}{2}$	1.025	2b	0.839
$\frac{1}{2}$	1.631	1	1.400	2	1.192	1	0.993	$\frac{1}{2}$ b	0.830
$\frac{1}{2}$	1.610	1	1.375	1	1.152	1	0.914	1	0.821
3	1.566	$\frac{1}{2}$	1.347	$\frac{1}{2}$	1.130	1b	0.896	1	0.813

b—broad line; using  $\text{CuK}\alpha=1.5418\text{A}$ , mass factor 1.6602.

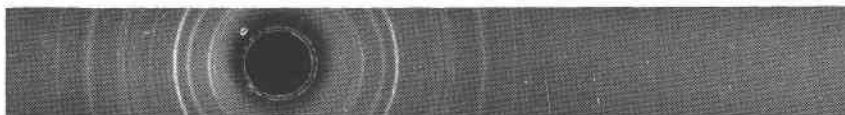


FIG. 1.—X-ray powder photograph, Cu/Ni radiation,  $1^\circ\theta=1$  mm. on film, actual size print.

## THE UNIT CELL OF MAGNETOPLUMBITE

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Magnetoplumbite was described by Aminoff (*Geol. För. Förh.* 47, 283, 1925) from Långban, Sweden, with cell dimensions and analysis by Almström. The mineral was later re-analysed by Blix (*Geol. För. Förh.* 59, 300, 1937); this later analysis showing the true valence state of the manganese. Adelsköld (*Ark. Kemi.*, 12 (29), 1938) determined lattice

dimensions for  $\text{PbO} \cdot 6\text{Fe}_2\text{O}_3$  which he states corresponds to magnetoplumbite. In Dana (*System*, 1, 728, 1944) it is shown that the structural formula deduced from the mineral data bears no similarity to the composition of the artificial lead ferrite.

Recently a powder photograph (Figure 1, Fe/Mn radiation) was taken of magnetoplumbite from a specimen from the type locality (Queen's University Museum). The pattern could not be indexed with the cell dimensions of Aminoff. A small fragment was detached and oriented on the two-circle goniometer with the perfect basal cleavage (0001) polar to the axis of the vertical circle. Rotation, zero and first layer Weissenberg films about the  $c$ -axis yielded the following cell dimensions

$$a = 5.88, \quad c = 23.02\text{A (Magnetoplumbite)}^1$$

$$a = 6.06, \quad c = 23.69\text{A (Aminoff, 1925)}$$

$$a = 5.877, \quad c = 23.02\text{A (PbO} \cdot 6\text{Fe}_2\text{O}_3, \text{Adelsköld, 1938)}$$

The systematic extinctions,  $(h, \bar{h}, 2h, l)$  present only with  $l = 2n$  are characteristic for the space group  $C6/mmc$  as found by Adelsköld for artificial  $\text{PbO} \cdot 6\text{Fe}_2\text{O}_3$ .

The new cell dimensions combined with the measured specific gravity, 5.517 (Dana) give the molecular weight of the cell contents  $M = 2290.6$ . The cell content is calculated from the analysis by Blix in Table 1.

TABLE 1. MAGNETOPLUMBITE: ANALYSIS AND CELL CONTENT

	1	2	3		4		
PbO	20.02	2.08	Pb	2.08	2.08	2	2
MnO	3.73	1.21	Mn''	1.21	23.37	15	24
Al <sub>2</sub> O <sub>3</sub>	1.86	0.41	Al	0.82			
Fe <sub>2</sub> O <sub>3</sub>	52.22	7.55	Fe'''	15.10			
Mn <sub>2</sub> O <sub>3</sub>	17.27	2.52	Mn'''	5.04			
TiO <sub>2</sub>	4.14	1.20	Ti	1.20			
Rem	0.76		O	37.13	37.13		38
	100.00						

1. Magnetoplumbite, Långban, Sweden, anal. Blix (1937). 2. Unit cell content. 3. Atomic content of unit cell. 4. Ideal content corresponding to  $\text{Pb}_2(\text{Fe}_{15}\text{Mn}_7\text{Al,Ti})\text{O}_{38}$ .

The number of atoms (3) indicates a structural formula  $\text{Pb}_2(\text{Fe}_{15}\text{-Mn}_7\text{AlTi})\text{O}_{38}$  with calculated specific gravity 5.59 in close agreement with the measured value. This structural formula is the same as for the arti-

<sup>1</sup> Using wavelength  $\text{CrK}\alpha$  2.2909A, Mass factor 1.6602.

TABLE 2. MAGNETOPLUMBITE— $\text{Pb}(\text{Fe}, \text{Mn}, \text{Al}, \text{Ti})_{12}\text{O}_{19}$ : X-RAY POWDER PATTERN  
Hexagonal,  $C6/mmc$ :  $a = 5.88$ ,  $c = 23.02\text{\AA}$ ,  $Z = 2$

$I$	$\theta(\text{Fe})$	$d(\text{meas.})$	$hkl$	$d(\text{calc.})$	$I$	$\theta(\text{Fe})$	$d(\text{meas.})$	$hkl$	$d(\text{calc.})$
1	11.2°	4.99A	10 $\bar{1}$ 1	4.972A	3	19.7°	2.87A	0008 1122	2.878A
1	11.95	4.68	10 $\bar{1}$ 2	4.657					2.849
$\frac{1}{2}$	13.15	4.26	10 $\bar{1}$ 3	4.243	10	20.5	2.77	10 $\bar{1}$ 7	2.763
2	14.6	3.84	0006	3.837	10	21.6	2.63	11 $\bar{2}$ 4	2.618
			10 $\bar{1}$ 4	3.814	$\frac{1}{2}$	22.3	2.55	20 $\bar{2}$ 0	2.546
$\frac{1}{2}$	16.45	3.42	10 $\bar{1}$ 5	3.415	5	23.5	2.43	20 $\bar{2}$ 3	2.417
5	19.1	2.96	11 $\bar{2}$ 0	2.940	4	25.65	2.24	20 $\bar{2}$ 5	2.228
					3	27.05	2.13	20 $\bar{2}$ 6	2.122

$I$	$\theta(\text{Fe})$	$d(\text{meas.})$	$I$	$\theta(\text{Fe})$	$d(\text{meas.})$	$I$	$\theta(\text{Fe})$	$d(\text{meas.})$
1	29.95°	1.940A	7	36.7°	1.621A	$\frac{1}{2}$	59.95°	1.119A
1	32.35	1.810	6	40.95	1.478	1	60.95	1.108
$\frac{1}{2}$	34.5	1.710	2	44.35	1.386	3	61.75	1.100
5	35.4	1.672	$\frac{1}{2}$	47.35	1.317	2	62.4	1.093
1	36.0	1.648	1	47.95	1.304	2	70.95	1.025
2	36.3	1.636	2	55.45	1.176	1	73.3	1.011

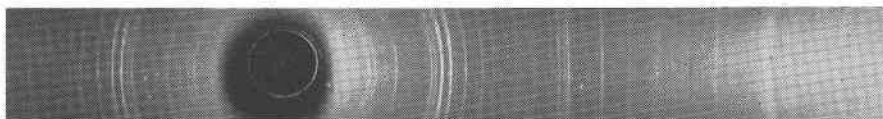


FIG. 1.—X-ray powder photograph, Fe/Mn radiation,  $1^\circ\theta = 1$  mm. on film, actual size print.

ficial ferrite  $2[\text{PbFe}_{12}\text{O}_{19}]$  given by Adelsköld, with substitution of manganese, aluminum and titanium for iron.

The estimated intensities and measured interplanar spacings from the powder pattern (Fig. 1) are given in Table 2 together with indices and spacings calculated from the cell dimensions.