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## Carpholite from the Fukuzumi Mine, Hyōgo Prefecture, Japan

By

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### Abstract

Carpholite has been found at the Fukuzumi mine, Hyōgo Prefecture. It forms compact yellow masses or layers in a sheared zone in the silicified foot-wall of the ore body, associated with quartz and a small amount of calcite.

Under the microscope it is fibrous or prismatic. Optically biaxial,  $2V_z = 67.0^\circ$ .  $\alpha = 1.624_8$ ,  $\beta = 1.629_0$ ,  $\gamma = 1.638_6$ ,  $\gamma - \alpha = 0.013_8$ . Pleochroic;  $X'$  golden yellow,  $Z'$  colorless or yellow-tinted. Elongation positive.  $D_{\text{meas.}} 3.04$ ,  $D_{\text{calc.}} 3.03$ . Hardness 5-6.

The chemical composition is  $(\text{Mn}_{0.89}\text{Fe}''_{0.15})(\text{Fe}''_{0.07}\text{Al}_{1.91})(\text{Al}_{0.09}\text{Si}_{1.91})\text{O}_{5.91}(\text{OH})_{4.09}$ .

Unit cell dimensions were determined from the X-ray powder data by LIPSON's method:  $a = 13.83_8$ ,  $b = 20.31_5$ ,  $c = 5.13_0 \text{ \AA}$ .  $a : b : c = 0.681_4 : 1 : 0.252_0$ . The axial ratio is in good agreement with that of ferrocapholite which is a ferrous iron analogue of carpholite.

### Introduction

Carpholite is a manganese aluminum hydrosilicate described in 1817 by A. G. WERNER (E. S. DANA, 1914). H. STRUNZ (1938) stated in his classification of silicate minerals that the crystal system of carpholite was monoclinic and that the physical properties and chemical composition,  $\text{MnAl}_2\text{Si}_2\text{O}_6(\text{OH})_4$ , suggested its resemblance to pyroxene and amphibole. Later, he corrected his previous description as that the crystal system is not monoclinic but orthorhombic and that it is isomorphous with ferrocapholite (H. STRUNZ, 1957).

In 1958 T. YOSHIMURA collected a yellow or orange-yellow mineral at the Fukuzumi mine, but the mineral could not be determined for the difficulty of separation. Recently the author succeeded in separating the mineral from others, and the yellow mineral has been identified as carpholite. This paper thus presents the mineralogical data for Fukuzumi carpholite, of which the thermal reaction has already been reported by the author (1966).

### Mode of Occurrence

The Fukuzumi mine\* is situated in Hyōgo Prefecture near the triplet of the prefectural boundary lines among Ōsaka, Kyōto and Hyōgo Prefectures, and

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belongs to T. YOSHIMURA's Tomisato type\* manganese deposit.

The deposit is found along a contact plane between slate and bedded chert in the Palaeozoic formation, and the foot-wall is strongly silicified (T. YOSHIMURA, 1952). Carpholite occurs in a sheared zone traversing the silicified foot-wall as compact yellow masses or layers, accompanied by quartz and a small amount of calcite.

### Optical and Physical Properties

Under the microscope, carpholite is fibrous or prismatic euhedron with yellow color. It is fibrous in the case of occurring in quartz veinlet (Plate 30). Pleochroic; X' golden yellow, Z' colorless or yellow tinted. Elongation positive. Refractive indices are;  $\alpha=1.624_8$ ,  $\beta=1.629_0$ ,  $\gamma=1.638_6$ ,  $\gamma-\alpha=0.013_8$ . Optic angle  $2V_z=67.0^\circ$ .

Specific gravity  $D=3.04$  (picnometer method). Hardness is not clear because the material is fine-grained and accompanied intimately by quartz, but it is approximately 5-6 after Mohs' scale.

### Chemical Composition

The material crushed to between 150 and 200 meshes in size was passed through a Franz Isodynamic Separator. Calcite was dissolved away in hot dilute

Table 1. Chemical analyses of carpholites

	(1)	(2)	(3)
SiO <sub>2</sub>	36.61	34.31	35.73
TiO <sub>2</sub>	tr		0.18
Al <sub>2</sub> O <sub>3</sub>	29.36	30.44	26.71
Fe <sub>2</sub> O <sub>3</sub>	1.53	1.59	2.02
FeO	3.05	3.16	2.31
CaO	tr		0.23
MnO	18.08	18.74	19.88
MgO	0.00		—
Na <sub>2</sub> O	0.00		—
K <sub>2</sub> O	0.00		—
H <sub>2</sub> O+	11.03	11.43	12.66
H <sub>2</sub> O-	0.32	0.33	
F <sub>2</sub>	—		0.44
Total	99.98	100.00	100.16

(1) Carpholite from Fukuzumi. Y. AOKI (1965).

(2) Recalculated values to 100% after deducing impure quartz (2.3%) from (1).

(3) Carpholite from Schlaggenwald. H. OTTO: *Min. Petr. Mitt.*, 47, p. 119 (1936).

\* 富里型

Table 2. X-ray powder data for carpholite

I	d Å	Q <sub>obs</sub> × 10 <sup>-4</sup>	Q <sub>calc</sub> × 10 <sup>-4</sup>	hkl
100	5.731	304	306	220
69	5.079	388	388	040
18	4.684	456	456	111
6	3.926	649	650	131
14	3.820	685	{ 686 688	221 330
31	3.460	836	836	400
21	3.388	871	{ 872 874	060 311
10	3.279	930	{ 925 933	160 420
10	3.099	1042	1038	151
31	3.042	1081	1081	260
14	2.862	1221	1223	440
19	2.761	1312	1313	421
51	2.620	1457	1456	351
11	2.539	1551	1551	080
9	2.498	1602	1603	441, 180
7	2.417	1712	{ 1708 1710	460 511
6	2.403	1732	1729	202
9	2.361	1794	1790	132
8	2.226	2017	2014	312
10	2.219	2031	2037	371
9	2.174	2116	2117	242
11	2.163	2137	2140	281
17	2.061	2354	{ 2356 2357	402 621
8	2.047	2388	{ 2386 2392	480 062
7	2.033	2421	2423	0.10.0
4	1.9595	2604	2601	262
9	1.9472	2638	2632	2.10.0
17	1.8661	2872	2873	571
10	1.7049	3440	3439	820
9	1.6923	3492	3496	113
12	1.6801	3543	3545	751
7	1.6560	3647	3648	591
6	1.6460	3691	3690	133
8	1.6237	3793	3788	642
4	1.5896	3958	3953	392
6	1.5618	4100	4103	712
6	1.5574	4123	4126	771
7	1.5262	4293	{ 4292 4297	063 732

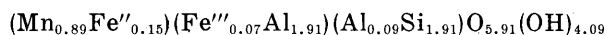
I	d (Å)	Qobs × 10 <sup>-4</sup>	Qcalc × 10 <sup>-4</sup>	hkl
7	1.5212	4322	4325	4.12.0
4	1.4704	4625	4634	911
9	1.4619	4679	4685	752
10	1.4499	4757	4750	513
4	1.4340	4863	4862	802
7	1.4201	4958	4959	822
11	1.3830	5223	5223	10.0.0

Instrumental settings: FeK $\alpha$  ( $\lambda=1.9373$  Å), 30KV, 10 mA, scanning speed  $\frac{1}{2}$  deg/min., chart speed 10 mm/min., time constant 5 sec., full scale 500 cts/sec., slits 2-2-0.4 mm.

Cell dimensions:  $a=13.83_8$  Å,  $b=20.31_5$  Å,  $c=5.13_0$  Å.

hydrochloric acid, and quartz was removed with Toulet solution. The purified material thus obtained still contains 2.3% impure quartz according to an estimation by X-ray powder analysis and microscopic observation.

The chemical composition is given in Table 1, being compared with that of Schlaggenwald carpholite. On the basis of (O, OH)=10.00 atoms in the formula, the values (2) in Table 1 can be recasted to



which is in good accordance with the ideal formula of carpholite,  $\text{MnAl}_2\text{Si}_2\text{O}_6(\text{OH})_4$ , given by H. STRUNZ (1938).

### X-Ray Powder Data

The powder pattern was taken with a Shimadzu X-ray diffractometer, using filtered Fe radiation ( $\lambda=1.9373$  Å). Instrumental settings were as written in the foot-note of Table 2. The readings of diffraction angles were corrected with an internal standard of silicon. The powder data obtained for carpholite are given in Table 2.

The powder data of Table 2 were indexed assuming the crystal system of

Table 3. Cell dimensions, axial ratios and specific gravities of carpholites compared with those of ferrocapholite

	Carpholite (Fukuzumi)	Carpholite (Schlaggenwald)	Ferrocapholite (Celebes)
Ideal formula	$\text{MnAl}_2\text{Si}_2\text{O}_6(\text{OH})_4$	$\text{MnAl}_2\text{Si}_2\text{O}_6(\text{OH})_4$	$\text{FeAl}_2\text{Si}_2\text{O}_6(\text{OH})_4$
$a$ (Å)	13.83 <sub>8</sub>	13.86	13.77
$b$ (Å)	20.31 <sub>5</sub>	20.13	20.18
$c$ (Å)	5.13 <sub>0</sub>	5.12	5.10 <sub>9</sub>
$a : b : c$	0.681 <sub>4</sub> :1:0.252 <sub>0</sub>	0.688 <sub>5</sub> :1:0.248 <sub>5</sub>	0.682:1:0.253
$D_{\text{meas.}}$	3.04	2.9	3.04
$D_{\text{calc.}}$	3.030	3.060	3.087

carpholite to be orthorhombic and its space group *Ccca*, and the cell dimensions were calculated by LIPSON's method (H. LIPSON, 1949). The cell dimensions obtained are as follows:

$$a=13.83_8 \text{ \AA}, \quad b=20.31_5 \text{ \AA}, \quad c=5.13_0 \text{ \AA}.$$

The calculated Q values of Table 2 based on this cell are in good agreement with the observed values.

Table 3 shows cell dimensions, axial ratios and specific gravities of carpholites from two localities in comparing with those of ferrocapholite from Celebes. In Table 3, *a* and *c* values of Fukuzumi carpholite agree fairly well with those of Schlaggenwald, but *b* values of the former is larger than that of the latter. The cell dimensions of Fukuzumi carpholite are larger than those of ferrocapholite, of which the crystal structure is analysed by MACGILLAVRY et al. (1956). Axial ratio of the Fukuzumi carpholite is in good agreement with that of the ferrocapholite.

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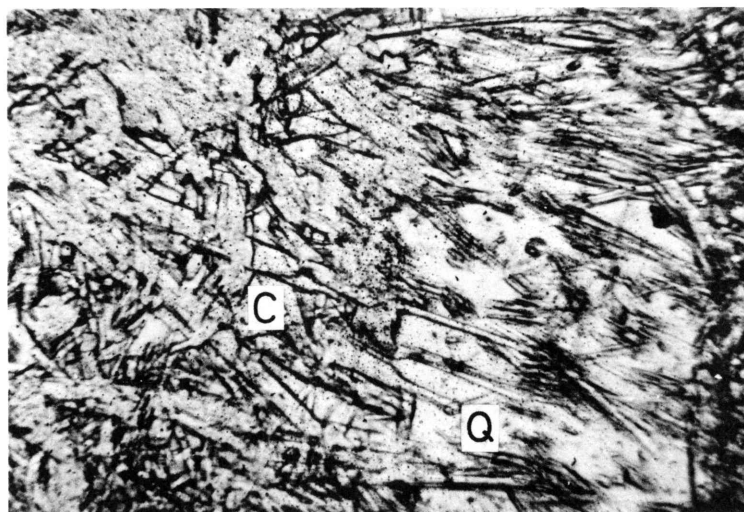
Plate 30

### Explanation of Plate 30

Figs. 1-2. Photomicrographs of carpholite from the Fukuzumi mine, Hyōgo Prefecture.

1. Carpholite (C) and quartz (Q). Open nicols.
2. Ditto. Crossed nicols.





1



2

0 0.2 mm

A horizontal scale bar with a vertical tick mark at the left end and a vertical tick mark at the right end. The text '0' is positioned at the left end, and '0.2 mm' is positioned at the right end.