

curve, cutting the ordinate at about $\text{Fe} = 79$ per cent (70 per cent for $\epsilon' = 1.54$) is more accurately representative of the relationship than the straight line of Howell & Dawson's figure 1, and would be a better fit for most of their plotted points.

In practice, using various magnifications and conditions of illumination, results on a single ankerite grain have not been reproducible to less than $\pm 5^\circ$. The resultant error of about ± 15 per cent Fe over the central part of the range is too great for the results to be of use. It is possible that the precision could be improved by using phase-contrast illumination, but this is not available to the writer, and at the time of writing the best method for determining accurately two intimately mixed carbonates (x -ray emission methods excepted) seems to be the time-consuming determination of ω on cleavage fragments in crushed material. No staining technique so far published appears to be sufficiently sensitive quantitatively. It would be interesting to hear of any successful solution to this problem.

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NEW MINERALOGICAL DATA FOR XANTHOPHYLLITE FROM JAPAN

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INTRODUCTION

Recently, in a mineralogical study of the contact zone in the Doshinkubo ore body of the Chichibu Mine, located in Saitama Prefecture, Japan, a number of well-developed crystals of xanthophyllite associated with vesuvianite and calcite were discovered. The first description of xanthophyllite from this mine, but from another ore body (Hashikakezawa ore body) was given by Abé (1944). This paper provides additional mineralogical data on this rather uncommon mineral.

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OCCURRENCE

The Chichibu Mine is located in the contact of a quartz-diorite intrusive and Permian limestone, the country rock. The contact can be subdivided

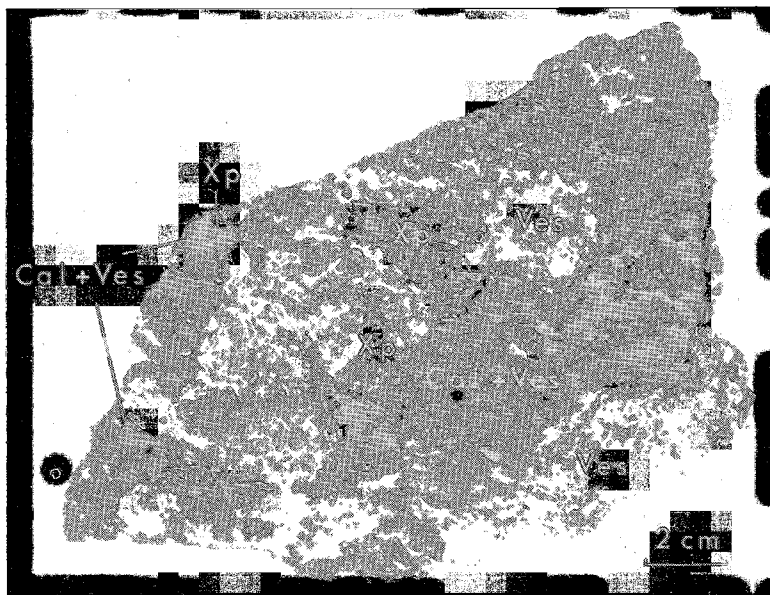


FIG. 1. Crystal aggregates of xanthophyllite in association with vesuvianite. Xp Crystal aggregates of xanthophyllite. Ves Brownish-yellow vesuvianite. Cal + Ves Crystal aggregates of calcite and vesuvianite.

into zones, on the basis of the mineral associations, progressing from the quartz-diorite to the limestone, as follows:

Zone 1. (variable width) plagioclase, quartz, brown hornblende, biotite, actinolite, blue actinolite, chlorite after biotite.

Zone 2. (width 60–90 feet) plagioclase, quartz, brown hornblende, diopside, garnet, chlorite, blue actinolite, calcite.

Zone 3. (width about 6 feet) vesuvianite, garnet, calcite, xanthophyllite, diopside, wollastonite.

Zone 4. (width about 30 feet) garnet (andradite), epidote, chlorite, pyrite.

Zone 5. (width about 90 feet) magnetite (ore body).

Zone 6. (width 3 feet) hedenbergite, ilvaite.

The xanthophyllite occurs in close association with vesuvianite (Fig. 1) and is either dark green or pale green.

Materials

Platy crystals of the dark-green (specimen X-1) and of the pale-green (specimen X-2) varieties were carefully selected under the microscope so as to minimize the presence of impurities. In general, the crystals were 1 to 8 mm. long and 1 to 2 mm. thick and appeared, in polarized light, to have six domains, probably as a result of twinning.

In addition, xanthophyllite from Crestmore, California (Eakle, 1916) was used as a reference material in some phases of the investigation.

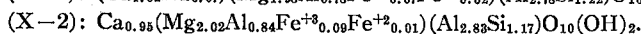
X-ray data

The materials were crushed to less than 200 mesh, and investigated with an x-ray diffractometer. The powder patterns were taken on samples packed in aluminum sample holders. The data obtained are given in Table 1. The x-ray data of all samples were practically identical except that sample X-2 showed a few weak reflections due to the presence of minor impurities. Good agreement with the data from the reference sample was evident.

On the basis of the indexed powder pattern after Forman (1951) and monoclinic angle $\beta = 100.1^\circ$ after Takéuchi & Sadanaga (1959), the following cell dimensions were obtained from the powder data: $a_0 = 5.21$ Å, $b_0 = 9.02$, and $c_0 = 9.84$. These values are consistent with those of previous workers. (Abé, 1944, Forman, 1951, Sanero, 1940, Takano & Takano, 1958, and Takéuchi & Sadanaga, 1959).

Chemical data

Chemical analyses were done by conventional wet methods (Table 2). Structural formulae were calculated from the analyses on the basis of 12 anions, $\text{O}_{10}(\text{OH})_2$, as follows:



Both formulae are similar, and their tetrahedral Al : Si ratio shows remarkable similarity to the value of 2.8 : 1.2 proposed by Forman (1951).

Infra-red absorption spectra

The infra-red spectra were taken with an IR-S spectrophotometer using NaCl optics. The materials were prepared in the form of a mull in Nujol. The absorption spectra are shown in Fig. 2. Both spectra are identical and have two composite absorption bands at 950 cm^{-1} and 800 cm^{-1} , which are in fair agreement with those obtained by Saksena (1961) on clintonite. Interpretation of the work of Stubičan & Roy (1961) suggests that the two bands at 950 cm^{-1} and 800 cm^{-1} may be attributed to absorption due to stretching of Si-O and Si-O-Al^(IV) bonds, respectively. Their spectra for synthetic Al-biotite, $(\text{KMg}_{2.0}\text{Al})(\text{Al}_{2.0}\text{Si}_2)\text{O}_{10}(\text{OH})_2$, gave a relatively weak band at 810 cm^{-1} , which is in contrast to the much stronger band

TABLE I. XANTHOPHYLLITE, X-RAY POWDER DATA (CuK α : 1.5418 Å)

Crestmore		Specimen X-1		Specimen X-2		<i>hkl</i> *
<i>d</i>	<i>I</i>	<i>d</i>	<i>I</i>	<i>d</i>	<i>I</i>	
9.71 Å	32	9.71 Å	40	9.71 Å	31	001
				7.14	2	
4.53	2	4.48	2	4.57	2	020
3.57	2	3.56	2	3.56	2	$\bar{1}12$
3.52	2					
3.22	100	3.23	100	3.22	100	003
3.03	6	3.04	6	3.04	7	
2.998	3					
2.959	2	2.959	3	2.958	2	
		2.921	2			
2.831	1	2.831	4	2.831	3	$\bar{1}13$
		2.763	5	2.763	3	
2.682	1					
		2.606	5	2.606	4	
2.563	9	2.563	9	2.563	10	200, 032, $\bar{1}31$
2.448	2	2.455	4	2.448	3	$\bar{2}02$, 113, 131
2.373	2	2.379	3	2.373	2	201, 014, $\bar{1}32$
2.206	3	2.206	3	2.206	5	$\bar{2}03$, 132
2.117	7	2.117	14	2.117	7	202, $\bar{2}21$, $\bar{1}33$
1.933	20	1.933	25	1.933	25	005, $\bar{2}04$, 133
1.851	2	1.855	3	1.851	2	$\bar{1}34$
1.692	2	1.695	3			240, $\bar{1}51$
1.620	7	1.620	9	1.620	8	$\bar{2}42$, 151
1.610	7	1.610	10	1.610	8	006
1.503	5	1.503	8	1.503	5	060
1.488	10	1.486	14	1.486	10	330
1.380	3	1.380	2	1.380	2	225, 332, $\bar{3}34$

*After Forman (1951) except 001

TABLE 2. XANTHOPHYLLITE, CHEMICAL ANALYSES

	X-1	X-2
SiO ₂	17.26%	16.31%
TiO ₂	tr.	—
Al ₂ O ₃	42.75	43.21
Fe ₂ O ₃	1.35	1.67
FeO	0.53	0.33
MnO	n.d.	—
MgO	18.87	18.79
CaO	13.49	12.37
Na ₂ O	0.55	—
K ₂ O	tr.	—
H ₂ O(—)	0.64	0.94
H ₂ O(+)	4.78	—
Ig. loss (>105°C)	—	5.73
Total	100.22%	99.35%

Analyst: K. Harada, 1961

n.d.: nondetectable; tr.: trace

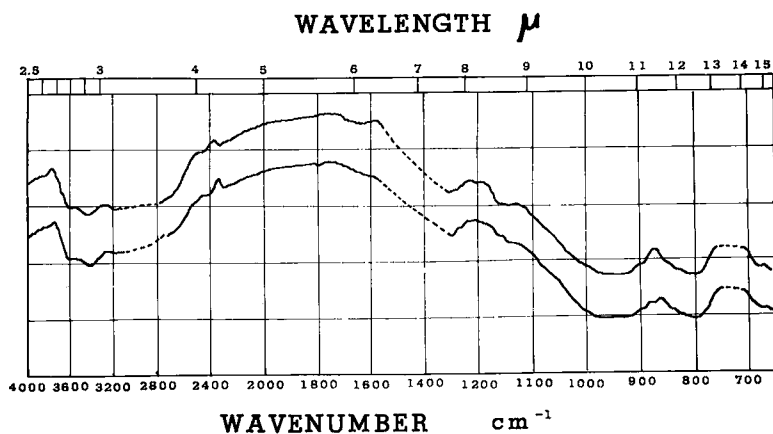


FIG. 2. Infra-red absorption spectra of xanthophyllite (upper, X-1 and lower X-2). Note: Dotted line indicates the elimination of the peak due to Nujol.

shown at 800 cm^{-1} in xanthophyllite. This is reasonable since xanthophyllite has a higher Al for Si substitution which is considered to be the cause of this absorption band.

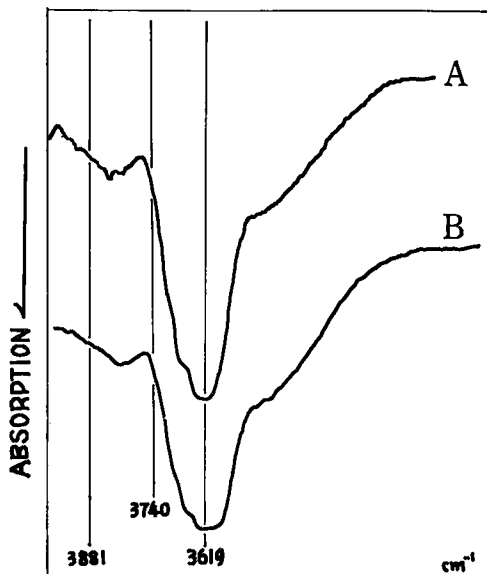


FIG. 3. Infra-red absorption spectra in the region of OH of xanthophyllite for cleavage flake oriented at right angle to the incident beam. Note: Wave numbers indicate the positions based on the three absorption peaks due to H_2O in air.

It is well known that the O—H bond of iron-bearing phyllosilicates is very weak. Infra-red studies with thin plates of the samples, however, gave clear single absorption peaks at 3619 cm^{-1} (Fig. 3). The spectra were recorded for normal incidence on the cleavage plane with an IRM-1 infra-red microphotometer. This result suggests (Serratosa & Bradley, 1958) that some of the O—H bonds in xanthophyllite may be oriented nearly parallel to the cleavage plane and also that there may be some vacant sites in the octahedral layer.

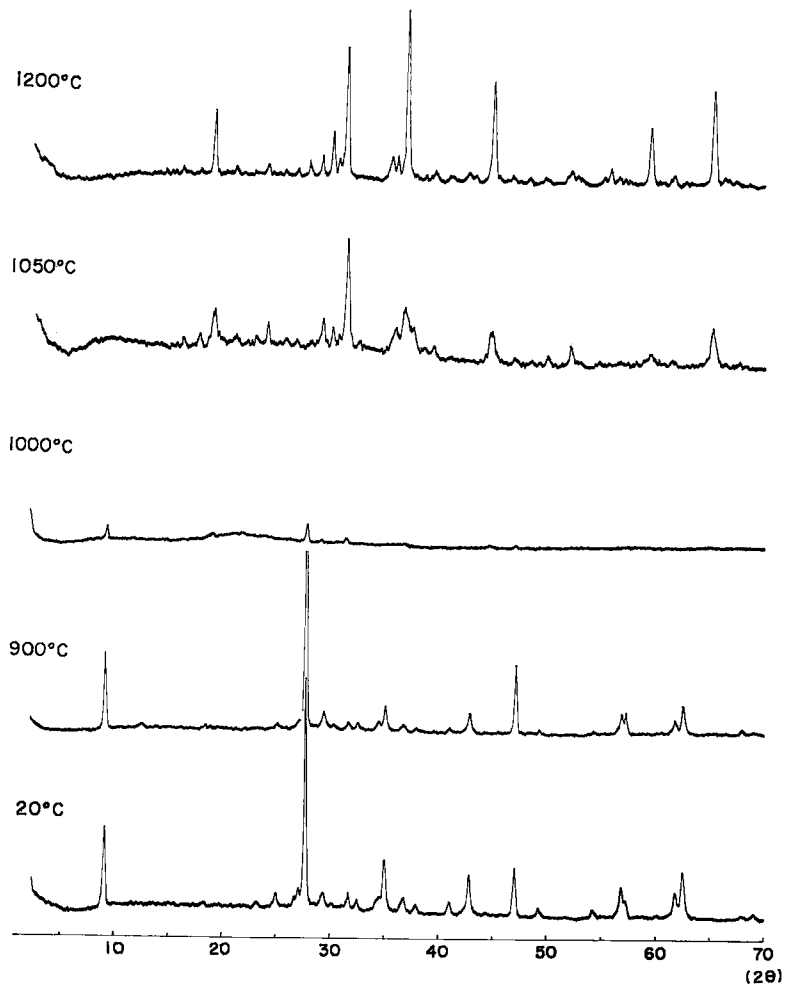
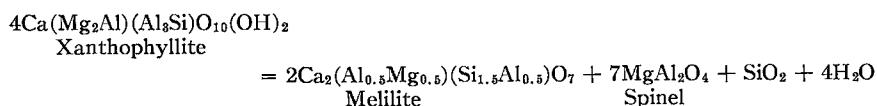


FIG. 4. X-ray powder patterns of xanthophyllite (X-1) at room temperature and after several heat treatments.

Thermal transformation

Heating experiments were carried out on an oriented specimen of X-1 in which heat treatment was applied at intervals of 100° C for one hour from 500° C to 1000° C. The specimen was heated, also, at 1050° C. X-ray examinations were made at room temperature after each heat treatment (Fig. 4). No changes in pattern were observed until 1000° C, at which temperature the xanthophyllite reflections became quite weak. At 1050° C, spinel and melilite lines were observed (Table 3) and at 1200° C the spinel lines were very well developed and more intense than those of melilite. No xanthophyllite lines were visible above 1000° C. It is suggested that the thermal decomposition may have taken the following form:



Since no SiO₂ lines were observed, it was assumed to be in the non-crystalline state.

TABLE 3. X-RAY POWDER DATA FOR XANTHOPHYLLITE HEATED AT 1050° C
(CuK α : 1.5418 Å)

<i>d</i>	<i>I</i>	Spinel <i>hkl</i>	Melilite <i>hkl</i>	<i>d</i>	<i>I</i>	Spinel <i>hkl</i>	Melilite <i>hkl</i>
5.47* Å	5			2.508	10		002
5.04	5		001	2.448	19	311	310
4.67	15	111		2.398	11		102, 221
4.23	5		101	2.286	4		112, 301
3.88*	5			2.027	12	400	212
3.70	10		111	1.941	3		400
3.47	4		210	1.880	2		410
3.35*	3			1.830	5		222
3.07	11		201	1.758	8		312, 411
2.978*	8			1.555	4	511	203
2.921*	5			1.509	3		213
2.857	43	220	211	1.430	15	440	223, 422
2.763	3		220				

*Unidentified lines

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CELL DATA OF ORIENTITE AND ITS RELATION TO
ARDENNITE AND ZOISITE

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Orientite is an abundant constituent of the manganese ores deposited by the replacement of latite tuffs, Bueycito region, Oriente Province, Cuba.

A single crystal displaying only prismatic and basal pinacoidal faces, and of approximate dimensions $.05 \times .05 \times .10$ mm, was selected for this study. The specimen is filed in the University of Chicago collections, No. 3323, and was donated by Hewett who first described it as a new mineral (Hewett & Shannon, 1921).

Oscillation, Weissenberg, precession, and powder photographs were used to determine cell data. The morphological observations agree with point-group $2/m \ 2/m \ 2/m$ established previously (Hewett & Shannon, 1921). The systematic extinctions observed upon inspection of $h0l$, $h1l$, $hk0$ and $hk1$ Weissenberg photographs and $0kl$, $1kl$, $h0l$, and $h1l$ precession

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