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Xonotlite from Heguri, Chiba Prefecture, Japan

By

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Introduction

Although xonotlite, $Ca_6[(OH)_2|Si_6O_{17}]$, is not an uncommon mineral in certain altered basic to ultrabasic rocks, skarns and hydrothermal veins, its morphology has not been described yet due to the absence of terminated crystal.

Xonotlite from Heguri, Chiba Prefecture, occurs in veinlets cutting an altered dolerite, forming terminated crystals in their vuggy parts, and is found as accessoric compact masses in strontium-bearing tobermorite veinlets cutting a prehnite-rich greenstone. The terminated crystals allow the optical, x-ray single and morphological studies under the electron microscope, though the x-ray diffraction spots forming its odd layer lines in b-axis oscillation photographs are diffuse.

The unit cell constants measured by four circle goniometer method are $a_o=17.0217$Å, $b_o=7.3486$Å, $c_o=7.0076$Å, $\beta=90.326°$, space group P2/a (for the diffraction spots of even layers along with b-axis (TAKÉUCHI and KUDOH, priv. comm.), and account well for the x-ray powder pattern slightly different from the published one obtained along with the topotypic xonotlite.

The authors thank Dr. Tokiko TIBA, Department of Geology, National Science Museum, for her chemical analysis of the studied material, and Professor Yoshio TAKÉUCHI and Mr. Yasuhiro KUDOH, Mineralogical Institute, University of Tokyo as to the measurement of unit cell constants and determination of space group. Their sincere thanks are also subjected to Dr. Yasuji SAITO, Department of Geology, National Science Museum, for his help to take the electron microscope photographs.

Mode of Occurrence

In the southern part of Boso Peninsula, Chiba Prefecture is exposed the basement of Tertiary and Quaternary deposits, which geologically occupy the considerable part of this peninsula. The basement called Mineoka Group is distributed in a narrow zone confined by faults trending westerly from Kamogawa along Mineoka Mountain Range (Fig. 1), and composed of age unknown (probably Palaeogene) clastic, pyroclastic and basic volcanic rocks intruded by basic plutonic to ultrabasic rocks.

Xonotlite here studied comes from veinlets cutting the basic and pyroclastic rocks at Heguri, where an altered basic tuff with a subordinate amount of basalt is intruded by an altered dolerite and serpentinite. There are many white veinlets and pocket-like

bodies in these rocks, and their mineralogical constituents include diopside, prehnite, hydrogrossular, pectolite, xonotlite, tobermorite analcime, natrolite, calcite, dolomite and aragonite in the order of reconstructed sequence. Xonotlite is found as two

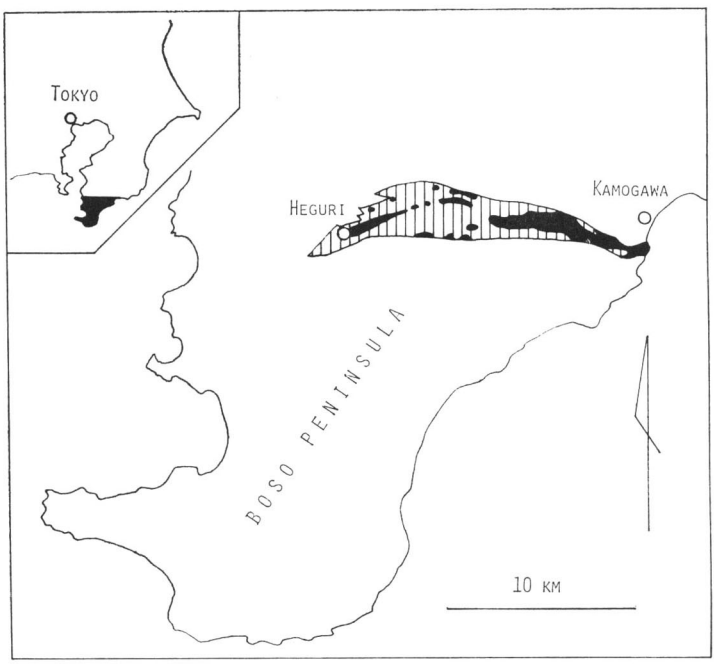

Fig. 1. Index map of xonotlite locality, Heguri. Black: Ultrabasic and basic intrusive rocks. Striated: Sedimentary and pyroclastic rocks of Mineoka Group.

modes of occurrence and one is the principal fissure-filling material of veinlets cutting the altered dolerite (Pl. 1, figs. 1 and 2), and the other is the compact accessoric mass in veinlets of compact strontium-bearing tobermorite cutting a prehnite-rich greenstone, and the material of the former occurrence is here described.

The veinlets are composed of white compact mass of xonotlite with the trace of calcite, showing the radial structure arranged symmetrically. In their vuggy parts, xonotlite aggregate are so loose that separated into isolated needles reaching 10 mm in maximum length and 0.5 mm in maximum width.

The wallrock is an altered dolerite reserving its original texture fairly well. Its mineralogical constituents include chlorite, prehinte, saponite and leucoxene with minor amounts of sphene and calcite. In Pl. 1, figs. 3 and 4 is shown the mode of xonotlite aggregate with prehnite.

Physical and Optical Properties

The xonotlite is pure white in colour with vitreous luster. Perfect cleavage along

{001} is observed under the electron microscope. It is not fluorescent under short and long wave ultraviolet lights. Hardness of compact mass is about 6, whereas that of the fiber is 5–5$^1/_2$. Specific gravity measured by buoyancy method is 2.71, which is very close to the calculated value 2.705.

It is colourless in thin section. Extinction is parallel to outline and the sign of elongation is positive. It is optically biaxial positive, 2V=20–25°, r<v weak, *n*s α=1.584, β=1.584, γ=1.595 (all$\pm$0.002) by immersion method, and the optic plane is nearly parallel to {100}, and b=z. These data are well coincident with those hitherto known (Winchell and Winchell, 1951).

Morphology

Some of the xonotlite needles grown in the vuggy parts of veinlets cutting the dolerite have the following faces due to the observation under the elctron microscope: a (100), b (010), c (001), r (011), s (01$\bar{1}$), t (201), u (101), v (10$\bar{1}$), and some vicinal faces about [010] zone, possibly T (10.0.1) and U (10.0.$\bar{1}$). All the crystals are elongated along b-axis, and a (100) is generally striated (Pl. 1, fig. 5). Also twin-like crystals composed of a (100), r (011) and c (001) are observed (Pl. 1, fig. 6). Seeing from the evidence that prisms of this category have a sharp striation on a (100) whereas those with asymmetrically developed r (011) (actually r (011) and s (01$\bar{1}$)) lack such striation a (100), it is highly expectable that the forms as shown in Pl. 1, fig. 6 is a twin with {001} as the twinning plane. Some representative forms are shown in Fig. 2.

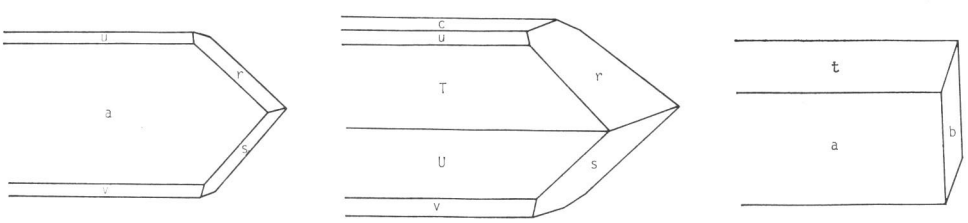

Fig. 2. Crystal forms of xonotlite from Heguri, Chiba Prefecture, Japan.

X-ray Studies

Its preliminary precession study substantiated the crystallographic data obtained by Mamedov and Belov (1955), but the appearance of very weak spots indexed as 0k0 where k=odd, violating the extinction rule for C2, Cm, or C2/m, turns it to be P2/a for the diffractions of even layers along with b-axis. The unit cell constants refined with the aid of four-circle goniometer are: a_o=17.0217Å, b_o=7.3486Å, c_o=7.0076Å, β=90.326° (Takéuchi and Kudoh, priv. comm.). However, when the diffractions of odd layers are considered, it is triclinic, a_o=2×17.0217Å, b_o=7.3486Å, c_o=2×7.0076Å, α_o=90°, β=90.326°, γ=90° (Takéuchi and Kudoh, priv. comm.).

X-ray powder pattern obtained by diffractometer method is given in Table 1 in which that of xonotlite from Tetela de Xonotla, Mexico is tabulated for comparison. Because of the β angle slightly deviating from 90°, splitting of some peaks is observed as seen in the pairs of $(80\bar{4})$–(804) and $(40\bar{6})$–(406).

Table 1. X-ray powder patterns of xontlites from Tetela de Xontla, Mexico and from Heguri, Chiba Preefcture, Japan

1.		2.				
d (Å)	I	d (Å)	I	Qobs	Qcal	hkl
8.5	20	8.54	4	0.0137	0.0138	200
7.05	40	7.02	45	0.0203	0.0204	001
		5.44	3	0.0338	0.0340	$20\bar{1}$
					0.0344	201
4.27	40	4.263	35	0.0550	0.0552	400
3.96	20					
3.65	70	3.648	40	0.0752	0.0752	$40\bar{1}$
					0.0760	401
		3.504	15	0.0815	0.0815	002
3.23	70	3.248	100	0.0948	0.0945	411
					0.0949	$20\bar{2}$
3.07	100	3.089	15	0.1048	0.1048	510
					0.1051	320
		3.044	2	0.1080	0.1080	$22\bar{1}$
					0.1084	221
2.83	50	2.836	16	0.1243	0.1243	600
					0.1247	511
2.71	40	2.698	35	0.1374	0.1375	402
2.65	20	2.636	10	0.1439	0.1441	$60\bar{1}$
2.51	40	2.507	8	0.1591	0.1588	$12\bar{2}$
					0.1592	122
2.34	30	2.336	20	0.1833	0.1833	003
2.25	30	2.258	25	0.1962	0.1965	$20\bar{3}$
		2.130	3	0.2204	0.2209	800
2.04	85	2.041	15	0.2401	0.2397	403
					0.2405	$80\bar{1}$
					0.2409	$52\bar{2}$
1.95	85	1.947	12	0.2637	0.2629	$72\bar{1}$
					0.2642	721
		1.862	2	0.2886	0.2876	$32\bar{3}$
					0.2893	323
1.84	40	1.836	5	0.2966	0.2963	040
		1.823	12	0.3008	0.3009	$80\bar{2}$
		1.800	2	0.3088	0.3093	603
1.756	30	1.751	6	0.3260	0.3258	004
					0.3260	722
1.710	40	1.712	20	0.3411	0.3404	204
					0.3422	$52\bar{3}$
1.687	20	1.683	3	0.3530	0.3536	920

Table 1. (continued)

1.		2.				
d (Å)	I	d (Å)	I	Qobs	Qcal	hkl
1.655	20	1.653	8	0.3659	0.3665	10.0.1
1.639	20	1.638	4	0.3726	0.3723	441
					0.3729	713
					0.3732	$92\bar{1}$
1.598	10					
1.575	20	1.578	12	0.4018	0.4019	$80\bar{3}$
		1.528	3	0.4283	0.4285	$72\bar{3}$
					0.4285	10.0.2
1.519	30	1.521	5	0.4323	0.4321	324
					0.4322	$44\bar{2}$
					0.4325	514
		1.495	3	0.4474	0.4478	$60\bar{4}$
		1.432	4	0.4879	0.4881	524
1.427	20	1.427	5	0.4914	0.4917	11.2.0
		1.420	4	0.4962	0.4969	$25\bar{1}$
					0.4970	12.0.0
1.393	20	1.392	12	0.5158	0.5156	12.1.0
					0.5162	$12.0.\bar{1}$
		1.382	2	0.5237	0.5239	205
1.348	10	1.356	10	0.5438	0.5437	$80\bar{4}$
		1.349	4	0.5493	0.5498	804
		1.333	15	0.5631	0.5624	$40\bar{5}$
		1.323	6	0.5715	0.5711	$11.2.\bar{2}$
1.319	10	1.319	5	0.5747	0.5753	11.2.2
1.306	20	1.306	10	0.5865	0.5862	$12\bar{5}$
					0.5871	650
					0.5871	125
		1.276	3	0.6139	0.6128	$32\bar{5}$
					0.6141	660
		1.258	2	0.6318	0.6305	$60\bar{5}$
					0.6320	750
1.252	10	1.254	3	0.6360	0.6352	$24\bar{4}$
					0.6365	$42\bar{5}$
					0.6367	244
1.22	10b	1.224	10	0.6673	0.6665	060
					0.6671	$52\bar{5}$
					0.6672	$10.0.\bar{4}$
		1.216	8	0.6762	0.6758	$44\bar{4}$
					0.6760	$92\bar{4}$
					0.6765	14.0.0
					0.6765	13.2.1
					0.6769	12.0.3
1.200	10					
		1.173	8	0.7266	0.7262	$80\bar{5}$
		1.155	5	0.7491	0.7490	$72\bar{5}$
1.125	10	1.128	6	0.7866	0.7861	$40\bar{6}$

Table 1. (continued)

1. d (Å)	I	d (Å)	I	2. Qobs	Qcal	hkl
		1.124	6	0.7913	0.7906	406
					0.7910	670
1.106	20	1.109	8	0.8126	0.8115	915
					0.8125	12.4.$\bar{1}$
					0.8133	11.2.$\bar{4}$
a_o=16.53 Å		a_o=17.0217 Å				
b_o= 7.33 Å		b_o= 7.3486 Å				
c_o= 7.04 Å		c_o= 7.0076 Å				
$\beta \div 90°$		β =90.326°				

1. Xonotlite. Tetela de Xonotla, Mexico. Camera method. Cu/Ni radiation. A.S.T.M. Card No. 10–488.
2. Xonotlite. Heguri, Chiba Prefecture, Japan. Diffractometer method. Cu/Ni radiation. The present study.

Although the rarity of appropriate xonotlite single crystals to be studied by x-ray diffraction methods impedes the further study, it seems necessary to examine xonotlites of the other mode of occurrence by detailed x-ray powder study unless appropriate single crystals are available. And, as to the treatment of the results of studies, it is important to refer to the work by Gard (1966) realizing the existence of some polytypic phases found in synthetic xonotlites.

Chemical Composition

About two grammes of hand-picked material proved to be pure according to the

Table 2. Chemical analysis of xonotlite from Heguri, Chiba Prefecture, Japan (Analyst: Tokiko Tiba)

	Wt. %	molecular quotient	metal number	oxygen number	metal number as O=19
SiO_2	49.99	0.8320	0.8320	1.6640	5.903
Fe_2O_3	0.48	0.0030	0.0060	0.0090	0.043
FeO	none				
MnO	0.16	0.0023	0.0023	0.0023	0.014
CaO	46.19	0.8364	0.8364	0.8364	5.933
Na_2O	0.17	0.0027	0.0055	0.0027	0.039
K_2O	0.02	0.0001	0.0002	0.0001	0.001
H_2O (+)	2.95	0.1639	0.3279	0.1639	2.325
H_2O (−)	0.10				
Sum	100.06%				

Empirical formula (as O=19):
$(Ca_{5.933}Na_{0.039}Mn_{0.014}K_{0.001})_{5.987}(S_{5.903}Fe^{3+}_{0.043})_{5.946}O_{16.675}(OH)_{2.325}$

x-ray powder and microscopic examination is analysed by ordinary wet chemical method as given in Table 2. The calculation based on the total O=19 leads to the empirical formula: $(Ca_{5.933}Na_{0.039}Mn^{2+}_{0.014}K_{0.001})_{5.987}$ $(Si_{5.903}Fe^{3+}_{0.043})_{5.946}O_{16.675}$ $(OH)_{2.325}$, close to its ideal formula $Ca_6[(OH)_2|Si_6O_{17}]$.

It is soluble in HCl (1: 1), leaving a colourless flaky material.

Xonotlite of the Other Mode of Occurrence

In massive green-gray greenstone of basic tuff origin are white procelain-like veinlets reaching two centimeters in width. The greenstone has a very fine texture under the microscopic and is composed of the aggregate of prehnite with minor chlorite. The white porcelain-like part is massive and stiff, and pulverized with difficulty. Under the magnifier, very minute needles of xonotlite forming radial aggregates are on the vein walls and the rest looks homogeneous. X-ray powder, chemical and optical studies by SAKATA (1972) show it to be a strontium-bearing tobermorite. Its wet chemical analysis by Professor K. NAGASHIMA of Tokyo University of Education gives SiO_2 43.82, Al_2O_3 3.11, Fe_2O_3 (total iron) 0.85, CaO 33.53, SrO 1.65, MgO 0.06, Na_2O 0.55, K_2O 0.37, H_2O (+) 12.17, H_2O (−) 3.68, total 99.77%.

The xonotlite in direct contact with this peculiar tobermorite does not contain any strontium according to its x-ray fluorescent analysis and its x-ray powder pattern is actually identical with that of the studied material. It is concluded that calcium in xonotlite of such a mode of occurrence is not significantly replaced by strontium.

References

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Explanation of Plate 1

Fig. 1. Xonotlite veinlet (white, center) in altered dolerite (black). Measure indicates 1 cm.

Fig. 2. Xonotlite crystals on veinlet wall. Measure indicates 2 mm.

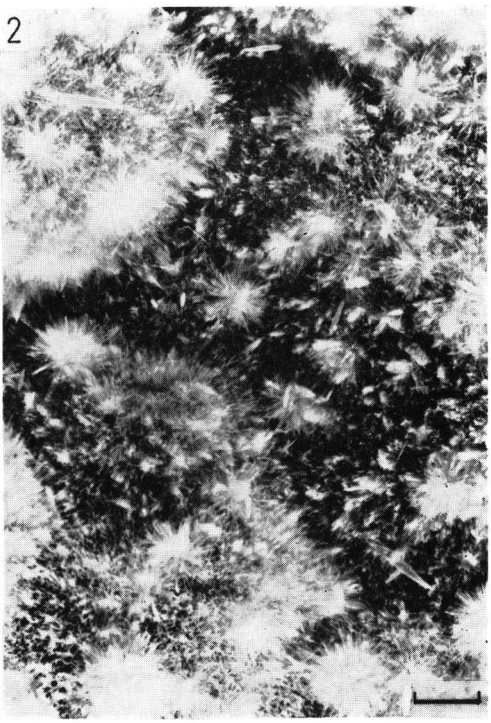
Fig. 3. Photomicrograph of xonotlite aggregate (right half), prehnite (left half, colourless), and chlorite with leucoxene (black). One Nicol. Measure indicates 0.2 mm.

Fig. 4. Ditto. Crossed Nicols.

Fig. 5. Electron microscope scanning picture of xonotlite aggregate composed of subparallel fibers. Observed faces are a (100) (striated), c (001), r (011) and s ($01\bar{1}$). Measure indicates 5 μ.

Fig. 6. Electron microscope scanning picture of xonotlite crystal probable twinned on {001}. Measure indicates 5 μ.


1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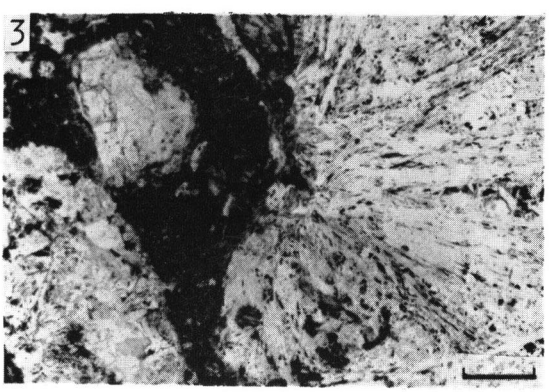
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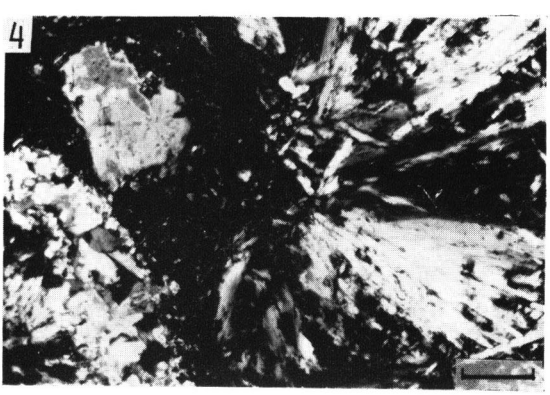
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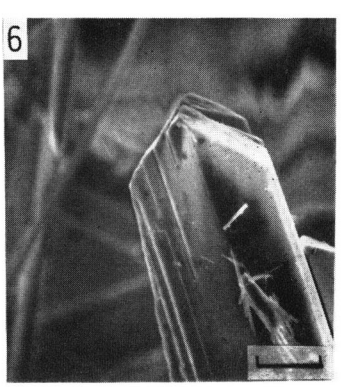
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