

## Suzukiite, $\text{Ba}_2\text{V}_2^{4+}[\text{O}_2|\text{Si}_4\text{O}_{12}]$ , a new mineral from the Mogurazawa mine, Gumma Prefecture, Japan

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### Abstract

Suzukiite,  $\text{Ba}_2\text{V}_2^{4+}[\text{O}_2|\text{Si}_4\text{O}_{12}]$ , orthorhombic, *Amam* or *Ama2*,  $a=7.089(2)$ ,  $b=15.261(2)$ ,  $c=5.364(1)\text{Å}$ ,  $Z=2$ , is a new mineral corresponding to the barium analogue of haradaite,  $\text{Sr}_2\text{V}_2^{4+}[\text{O}_2|\text{Si}_4\text{O}_{12}]$ .

The electron microprobe analysis gave: BaO 38.38, SrO 3.21,  $\text{VO}_2$  23.56,  $\text{TiO}_2$  0.20,  $\text{SiO}_2$  33.59, total 98.94%, yielding the empirical formula  $(\text{Ba}_{1.78}\text{Sr}_{0.22})_{\Sigma 2.00}(\text{V}^{4+}_{2.02}\text{Ti}_{0.02})_{\Sigma 2.04}\text{Si}_{3.97}\text{O}_{14}$  on the basis of  $\text{O}=14$ .

It is bright green in colour with a vitreous lustre and pale green streak. Cleavages {010}, perfect; {100} and {001}, distinct. Specific gravity 4.0(obs.), density  $4.03\text{g/cm}^3$ (calc.), H.(Mohs) 4 to  $4\frac{1}{2}$  on {010}. It is optically biaxial negative,  $2V$  about  $90^\circ$ ,  $r < v$ , very strong. Refractive indices:  $\alpha=1.730(5)$ ,  $\beta=1.739$ (calc.),  $\gamma=1.748(5)$ . Optical orientation and axial colours:  $a=X$ =pale green,  $b=Y$ =light yellowish green,  $c=Z$ =bluish green.

Suzukiite is found in massive rhodonite-rhodochrosite ore from the bedded manganese ore deposit of the Mogurazawa mine, Kiryu City, Gumma Prefecture, Japan, in association with quartz, barite, nagashimalite and a barian roscoelite.

### Introduction

In December 1973, a tiny flaky green mineral in massive rhodonite ore from the Mogurazawa mine, Gumma Prefecture, Japan was submitted to the authors for identification by Mr. Hiroshi Takizawa. He subsequently guided the first two authors to the locality for collection of additive materials. The X-ray powder study and microprobe analysis showed it to be a barium vanadium silicate firstly found by Watanabe *et al.* from the Tanohata mine, Iwate Prefecture, Japan in 1973. The mineral was submitted to the Commission on New Minerals and Mineral Names, I. M. A. under the name *suzukiite* in honour of the late Dr. Jun Suzuki (1896-1970), Emeritus Professor of Hokkaido University, an eminent petrologist and mineralogist, and approved. Type material is deposited in National Science Museum, Tokyo, under the catalogue No. NSM M-21385.

## Occurrence

The bedded manganese ore deposit of the Mogurazawa mine is situated in Kiryu City, Gumma Prefecture (Fig. 1) and developed in very weakly metamorphosed Triassic chert. The geologic outline is described by Matsubara and Kato (1980) in their paper on another new mineral nagashimalite from the same deposit.

Suzukiite is found in a rather fine-grained massive rhodonite-rhodochrosite ore. The flaky crystals form aggregates which are concentrated around the patches of quartz or barite in the ore. It is also found in association with alabandite or nagashimalite, which rarely grows on suzukiite flake. Besides them, the associated minerals found in the ore include a manganoan calcite, a barian roscoelite, bornite, tetrahedrite, digenite and gersdorffite, the sulphides

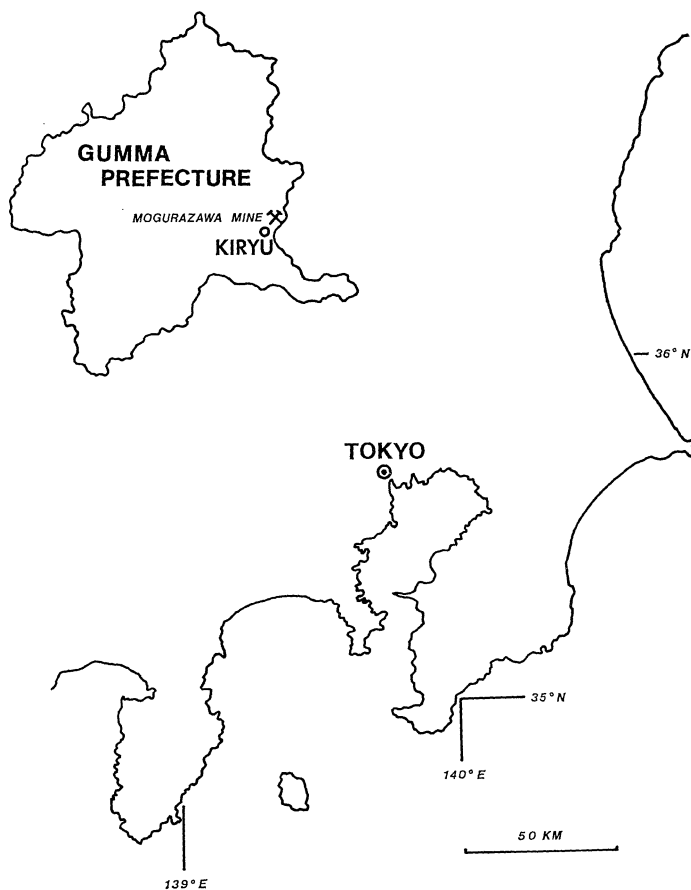


FIG. 1. Index map.

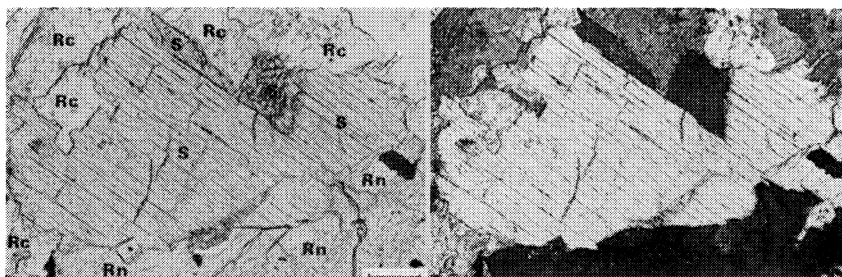


FIG. 2. Photomicrographs of suzukiite-bearing manganese ore. Suzukiite(S) grains are surrounded by rhodonite(Rn) and rhodochrosite(Rc) grains. Opaque mineral is alabandite. Bar indicates 0.1mm. Left: one polar. Right: crossed polars.

being very fine in size.

Under the microscope are observed euhedral to subhedral tablets of suzukiite flattened to  $[010]$  and sometimes elongated to  $[001]$  less than 5mm across (Fig. 2). The associated rhodonite grains are always euhedral but rather tabular. Quartz, barite, and rhodochrosite are interstitial to rhodonite grains. The occurrence and genesis of vanadium-bearing silicates including suzukiite from bedded manganese ore deposits in Japan are discussed by Matsubara and Kato (1980) and the present case is also covered by this discussion.

### Optical and physical properties

Suzukiite is bright green in colour with a vitreous lustre. Streak is pale green. Cleavages are perfect on  $\{010\}$  and distinct on  $\{100\}$  and  $\{001\}$ . Specific gravity measured by Berman microbalance is 4.0, which is very close to the calculated density  $4.03\text{g/cm}^3$ . Mohs' hardness on  $\{010\}$  is 4 to  $4\frac{1}{2}$ .

It is optically biaxial, negative,  $2V$  about  $90^\circ$ , dispersion  $r < v$ , very strong. Refractive indices measured by the immersion method are:  $\alpha = 1.730(5)$ ,  $\beta = 1.739(\text{calc.})$ ,  $\gamma = 1.748(5)$ . Optical orientation is:  $a = X$ ,  $b = Y$  and  $c = Z$ . Pleochroism is distinct with axial colours:  $X = \text{pale green}$ ,  $Y = \text{light yellowish green}$ ,  $Z = \text{bluish green}$ , absorption  $X < Y < Z$ . The axial colours are very similar to those of haradaite (Watanabe *et al.*, 1974), but less bluish and dark, and show yellowish tint. The associated two barium-vanadium minerals, nagashimalite and a barian roscoelite have similar pleochroic colours, though both of them have darker tints.

### X-ray studies

The X-ray powder diffraction pattern obtained by the powder diffractometer method using Cu/Ni radiation is given in Table 1 in which those of synthetic

TABLE 1. X-ray powder diffraction pattern of suzukiite, haradaite and synthetic  $\text{Sr}_2\text{V}_2[\text{O}_2|\text{Si}_4\text{O}_{12}]$ 

<i>hkl</i>	1			2		3	
	<i>d</i> <sub>obs.</sub>	<i>d</i> <sub>calc.</sub>	<i>I</i>	<i>d</i>	<i>I</i>	<i>d</i>	<i>I</i>
020	7.63	7.62	100	7.33	60	7.30	30
111	4.13	4.12	6	4.07	5	4.08	20
040	3.818	3.815	60	3.66	100	3.65	40
031	3.696	3.694	8	3.60	5	3.59	20
140	3.353	3.360	60	3.24	30	3.24	15
131	3.276	3.276	25	3.20	50	3.20	100
211	2.902	2.904	6	2.871	10	2.88	90
002				2.653	10	2.65	40
051	2.653	2.652	18	2.563	20	2.55	30
231				2.513	1	2.51	20
060				2.437	5	2.44	5
151				2.406	5	2.41	15
160	2.394	2.394	35	2.303	20	2.30	30
311, 202				2.120	5	2.12	40
142				2.054	10	2.05	35
222				2.039	1	2.04	25
340				1.971	2	1.971	30
071	2.020	2.020	15	1.947	10	1.943	10
171	1.942	1.943	8	1.875	10	1.876	10
080	1.907	1.908	6	1.829	5	1.829	5
180	1.843	1.842	8				
013				1.771	2	1.757	25
162	1.785	1.787	6	1.742	5	1.740	10
360	1.732	1.731	3				
322, 113				1.705	1	1.707	5
280	1.679	1.680	10	1.621	2	1.620	15
133	1.643	1.642	5				
091	1.617	1.617	6				
431, 213				1.573	2	1.572	15
191	1.576	1.576	6	1.518	5	1.517	10
0.10.0	1.526	1.526	16	1.463	10	1.463	10
460, 362				1.423	10	1.423	15
124				1.282	10	1.282	10
0.12.0	1.271	1.272	5				

- 1, Suzukiite. Mogurazawa mine, Gumma Prefecture, Japan. Cu/Ni radiation. Diffractometer method. (This study)
2. Haradaite. Yamato mine, Kagoshima Prefecture, Japan. Cu/Ni radiation. Diffractometer method. After Ito (1965).
3. Synthetic  $\text{Sr}_2\text{V}_2[\text{O}_2|\text{Si}_4\text{O}_{12}]$  (No. 6). Cu/Ni radiation. Diffractometer method. After Ito (1965).

Sr<sub>2</sub>V<sup>4+</sup><sub>2</sub>Si<sub>4</sub>O<sub>14</sub> and haradaite from the Yamato mine (Ito, 1965) are shown for comparison. The indexing of pattern was made by referring to the single crystal data, orthorhombic, space group *Amam* or *Ama2*. The refined unit cell parameters are:  $a=7.089(2)$ ,  $b=15.261(2)$ ,  $c=5.364(1)\text{\AA}$ ,  $Z=2[\text{Ba}_2\text{V}^{4+}_2\text{Si}_4\text{O}_{14}]$ ,

### Chemical composition

Electron microprobe analysis using analysed yoshimuraite (for Ba, Sr, Ti and Si) and synthetic V<sub>6</sub>O<sub>11</sub> (for V) as standards gave the result as shown in Table 2. According to the examination of absorption spectrum of suzukiite from the Tanohata mine (Kato *et al.*, 1974), the vanadium in this mineral is tetravalent.

The empirical formula calculated on the basis of O=14 is: (Ba<sub>1.78</sub>Sr<sub>0.22</sub>)<sub>Σ2.00</sub> (V<sup>4+</sup><sub>2.02</sub>Ti<sub>0.02</sub>)<sub>Σ2.04</sub>Si<sub>3.97</sub>O<sub>14</sub>, yielding the ideal formula Ba<sub>2</sub>V<sup>4+</sup><sub>2</sub>[O<sub>2</sub>|Si<sub>4</sub>O<sub>12</sub>] from the analogy with haradaite, Sr<sub>2</sub>V<sup>4+</sup><sub>2</sub>[O<sub>2</sub>|Si<sub>4</sub>O<sub>12</sub>] (Takéuchi and Joswig, 1967).

The hydrothermal synthesis of Ba<sub>2</sub>V<sup>4+</sup><sub>2</sub>[O<sub>2</sub>|Si<sub>4</sub>O<sub>12</sub>] was succeeded by Hariya (priv. comm.) from the mixture of oxides with the desired ratio at 500°C and 500 bar. He realized the upper temperature limit of stability range as about 800°C from the X-ray powder studies. According to Feltz *et al.* (1975), another orthorhombic BaVSi<sub>2</sub>O<sub>7</sub> ( $a=6.01(2)$ ,  $b=10.00(4)$ ,  $c=9.55(5)\text{\AA}$ ,  $Z=4$ ) is synthetically prepared. They confirm the stable presence of this phase at about 1300°C or up to its melting point. Thus, suzukiite is the low temperature phase of BaVSi<sub>2</sub>O<sub>7</sub>, provided that the strontium and minor titanium replacing barium and vanadium respectively in the mineral can be neglected.

TABLE 2. Chemical analysis of suzukiite.

	wt. %	molecular quotient	metal number	oxygen number	metal number (O=14)	ideal number	ideal weight percent	
BaO	38.38	0.2503	0.2503	0.2503	1.78	} 2.00	2	43.02
SrO	3.21	0.0313	0.0313	0.0313	0.22			
VO <sub>2</sub>	23.56	0.2840	0.2840	0.5681	2.02	} 2.04	2	23.27
TiO <sub>2</sub>	0.20	0.0025	0.0025	0.0050	0.02			
SiO <sub>2</sub>	33.59	0.5590	0.5590	1.1181	3.97	4	33.71	
total	98.94						100.00	

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Si<sub>4</sub>O<sub>12</sub>]. Also they are indebted to Mr. Hiroshi Takizawa, Mumeikai Group, Tokyo, who first brought this mineral to the authors' attention.

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