

Johannsenite from Teragōchi, Okayama Prefecture, Japan

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Johannsenite from Teragōchi, Okayama Prefecture, Japan

By

Hitoshi MOMOI

Abstract

A new occurrence of johannsenite has been found in manganese ore deposits at Teragōchi, Okayama Prefecture, Japan. The mineral occurs as a chief component of the massive manganese ore. Aggregates of bluish johannsenite crystals look quite similar to those of skarn hedenbergite. It has following chemical composition: SiO₂ 48.02, TiO₂ tr., Al₂O₃ 0.80, Fe₂O₃ 0.30, FeO 3.20, MnO 27.53, MgO 0.48, CaO 19.10, Na₂O 0.25, K₂O 0.04, H₂O⁺ 0.23, H₂O⁻ 0.00, total 99.95 wt. %. Silky green variety with following composition was also found: SiO₂ 48.18, Al₂O₃ 0.80, Fe₂O₃ 1.00, FeO 4.82, MnO 26.29, MgO 0.47, CaO 18.79, Na₂O 0.20, K₂O 0.04, H₂O⁺ 0.10, H₂O⁻ 0.00, total 100.69 wt. %. Optical properties for the blue johannsenite: $\alpha=1.707$, $\beta=1.720$, $\gamma=1.736$, $\gamma-\alpha=0.029$, $2V(+)$ 72°. Sp. gr. (blue variety)=3.54 (21° C). Unit cell dimensions obtained by X-ray powder method are: (blue variety) $a_0=9.91_6\text{Å}$, $b_0=9.10_7\text{Å}$, $c_0=5.28_0\text{Å}$, $\beta=74^\circ 49'$; (green variety) $a_0=9.91_3\text{Å}$, $b_0=9.10_4\text{Å}$, $c_0=5.27_4\text{Å}$, $\beta=74^\circ 48'$. Powder data and infrared spectra are also presented together with the heating effect of johannsenite.

Introduction

Occurrences of johannsenite have been recorded from Italy, Mexico, Australia (Broken Hill), New Jersey (Franklin Furnace), New Mexico, and Oregon. Professor YOSHIMURA advised me to study a specimen looking like hedenbergite labelled as from "the Ōnagusa mine, Okayama Prefecture" in the KŌ collection of Kyushu University (YOSHIMURA, 1952, P. 103). In 1959, I visited a manganese mine at Teragōchi, 1 km. northwest of the Nagusa copper mine, Katsuyama town, Maniwa Country, Okayama Prefecture*, and found there a mineral looking similar to the specimen of the KŌ collection, in some piles of manganese ores. At that time, the deposits had not been working. The locality is shown in Figure 1. The specimen was identified as johannsenite by chemical analyses, X-ray powder method, optical properties, and infrared absorption. This paper is a mineralogical description of the johannsenite, found for the first time in Japan.

The manganese ore deposits are developed in siliceous limestone and in green phyllite belonging to the Permian limestone beds and the Sangun metamorphic rocks (YAMADA, 1941; MITSUNO, 1963). It was unable for me to observe the mode of occurrence of johannsenite in situ because of the abandoned mine. Only one massive outcrop, bearing johannsenite was recognized,

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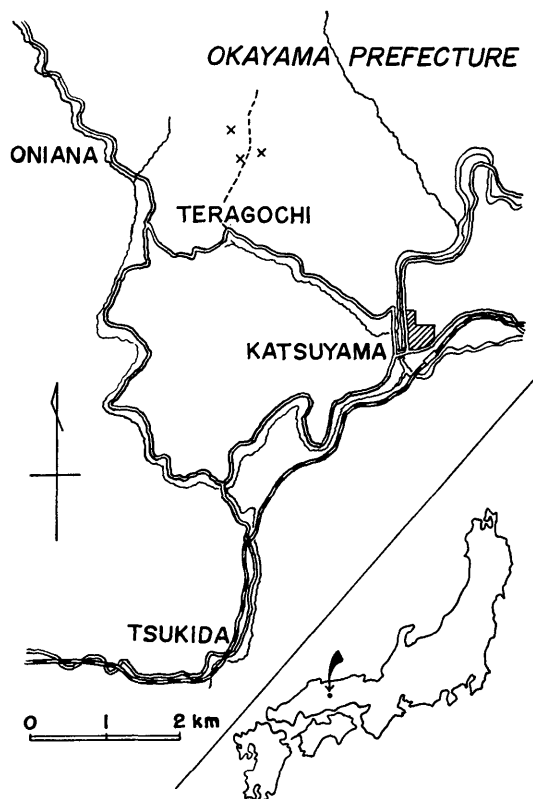


Fig. 1. Location of the manganese ore deposits bearing johannsenite (×) at Teragōchi, Okayama Prefecture, Japan.

being heavily contaminated with manganese dioxide. This ore body has a strike of $N 60^{\circ}W$, and a dip of $NE 70^{\circ}$, which are near the general trend of the wall rocks, and is composed of johannsenite, manganese oxides, rhodonite, quartz, calcite, galena, and sphalerite.

The main portion of johannsenite is seen fully altered to manganese dioxide, (todorokite with low crystallinity) and to powdery opaline silica. The oxide ore has fibrous radial texture pseudomorphous after johannsenite. Tiny rhodonite crystal are seen around a quartz vein which traverses the johannsenite aggregate. Simultaneous crystallization of calcite and sulphides are observed among rhodonite crystals. Quartz veins are also seen accompanied by a small amount of galena and sphalerite. Bustamite and wollastonite were not found in the johannsenite deposits.

Physical properties

Large johannsenite crystals are up to 15 cm. in length, and 5 mm. in width, and show long columnar or fibrous texture. Radial or parallel growth

is common. Color is light cobalt blue, bluish green or dark green with resinous to silky luster. Bluish crystal, surrounded zonally by greenish one, appears very similar to that of hedenbergite. Specific gravity and optical properties were measured on a bluish crystal. Specific gravity; is 3.54 at 21°C (pycnometer method). Optical properties: $\alpha=1.707$, $\beta=1.720$, $\gamma=1.736$, $\gamma-\alpha=0.029$, $2V (+) 72^\circ$, $b=Y$, twinning plane (100), $C\wedge Z=55^\circ$.

Chemical composition

Chemical analyses of blue and green johannsenites were made on pure materials prepared by hand picking. The flame photometric method was adopted for alkalis, and the common gravimetric method for the other metal oxides. The results are given in Table 1, together with some other previous data. Atomic ratios were calculated on the basis of six oxygens with the following results;

Blue variety $(\text{Na}_{0.02}\text{Mg}_{0.08}\text{Ca}_{0.85})_{0.90}(\text{Mn}_{0.96}\text{Fe}''_{0.11}\text{Fe}'''_{0.01}\text{Al}_{0.02})_{1.10}(\text{Al}_{0.02}\text{Si}_{1.98})_{2.00}\text{O}_{6.00}$

Green variety $(\text{Na}_{0.02}\text{Mg}_{0.08}\text{Ca}_{0.83})_{0.88}(\text{Mn}_{0.91}\text{Fe}''_{0.17}\text{Fe}'''_{0.03}\text{Al}_{0.02})_{1.13}(\text{Al}_{0.02}\text{Si}_{1.98})_{2.00}\text{O}_{6.00}$

Both results are very close to the ideal formula of johannsenite, $\text{CaMnSi}_2\text{O}_6$. Difference of color between the two varieties may probably be due to their iron contents.

Table 1. Chemical compositions of johannsenites

Locality	Broken Hill Australia	Mt. Civillina Italy	Teragōchi* Japan	
Reference	HUTTON 1956	SCHIAVINATO 1953	This paper	
Color	Pale green	—	Light blue	Silky green
SiO ₂	48.39	47.90	48.02	48.18
TiO ₂	nil.	tr.	tr.	—
Al ₂ O ₃	0.58	tr.	0.80	0.80
Fe ₂ O ₃	nil?	0.25	0.30	1.00
FeO	13.44	0.98	3.20	4.82
MnO	14.14	26.81	57.53	26.29
MgO	2.19	0.96	0.48	0.47
CaO	20.79	21.62	19.10	18.79
Na ₂ O	0.05	—	0.25	0.20
K ₂ O	0.09	—	0.04	0.04
H ₂ O ⁺	0.08	0.26	0.23	0.10
H ₂ O ⁻	0.12	0.50	0.00	0.00
CO ₂	—	1.11	—	—
Total	99.87	100.39	99.95	100.69

* Analyst: H. MOMOI

X-ray powder study

X-ray powder patterns were obtained by a Shimadzu X-ray diffractometer with filtered Fe $K\alpha$ radiation. The experimental conditions were: 30 KV, 10 mA, full scale 500 counts per second, time constant 2.5 or 5.0 seconds, scanning speed 2 or $\frac{1}{4}$ degrees per minute, slits 3-2-0.4 mm. The readings of diffraction angles were corrected with an internal standard of silicon. The unit cell dimensions were determined from the following reflections: (600), (060), (350), (53 $\bar{1}$), and (750). The indexing was made in referring to those of clinopyroxene by KUNO and HESS (1953) and by YAMAGUCHI (1961). The results are listed in Tables 2 and 3. The observed and calculated d-values are in good agreement. The unit cell dimensions of the Thragōchi johannsenites

Table 2. X-ray powder data for johannsenite (blue) from Teragōchi, Okayama Prefecture, Japan
(Fe $K\alpha$ filtered with Mn, $\lambda=1.9373 \text{ \AA}$)

I	2θ	$d_{\text{obs.}} (\text{\AA})$	$d_{\text{calc.}} (\text{\AA})$	hkl
14	16.90	6.592	6.595	110
9	23.39	4.779	4.782	200
5	24.57	4.553	4.553	020
33	34.15	3.229	3.298	220
100	37.41	3.020	{3.031	221
			{3.009	310
16	38.68	2.925	2.930	311
20	43.66	2.605	2.607	131
31	44.40	2.564	2.563	22 $\bar{1}$
25	44.70	2.547	2.546	002
6	47.82	2.390	2.391	400
10	48.72	2.348	2.347	31 $\bar{1}$
8B	51.24	2.240	{2.238	312
			{2.242	112
11	52.28	2.1986	2.1984	330
17	53.12	2.1664	2.1671	331
12	53.88	2.1380	2.1401	421
4	54.45	2.1170	2.1169	420
6	55.53	2.0794	2.0784	041
2w	56.8	2.037	2.0345	202
11	57.03	2.0290	2.0311	402
2	58.20	1.9917	1.9919	132
2w	61.4	1.897	1.8965	331
6	62.34	1.8715	1.8720	510
2w	64.6	1.812	1.8104	42 $\bar{1}$
15	65.51	1.7904	1.7892	150
2w	69.6	1.697	1.6971	042
17B	71.87	1.6505	{1.6488	440
			{1.6526	531
12	72.60	1.6362	1.6352	223
2w	73.5	1.619	1.618	530
9	74.845	1.5940	1.5940	600
—	—	—	1.5904	023
6	75.53	1.5817	1.5815	350
5B	77.28	1.5484	{1.5518	621
			{1.5474	602
12	79.310	1.5178	1.5178	060
—	—	—	1.5156	442
12	83.722	1.4515	1.4515	53 $\bar{1}$
6	85.275	1.4300	1.4300	352

B: broad, w: weak.

Table 3. Unit cell dimensions of johannsenites

Locality	Reference	a_0 (Å)	b_0 (Å)	c_0 (Å)	β
Teragōchi Japan	This paper (Blue)	9.916	9.107	5.280	74°49'
Ditto.	(Green)	9.913	9.104	5.279	74°48'
Civillina Italy	SCHIAVINATO 1953	9.81	9.02	5.26	75°
Herault California (Hedenbergite)	KUNO and HESS 1953	9.854	9.024	5.263	75°40'

are somewhat larger than those of an Italian specimen (SCHIAVINATO, 1953). The calculated densities are 3.56_g (blue) and 3.57_g (green).

Infrared absorption spectra

The infrared absorption spectra of blue johannsenite were obtained with a Hitachi double beam infrared spectrometer using KBr disks. The results are shown in Table 4 and Figure 2. The absorptions by CO₂ and H₂O are excluded because they were probably contaminated in air. The spectra of hedenbergite (FeO 18.75 wt.%) from the Mitate mine, Miyazaki Prefecture are also shown in the same table and figure for comparison's sake. It is clear that both minerals have very close resemblances in absorption. The absorptions of johannsenite are observed at the slightly longer sides in wave length than those of hedenbergite owing to the absorption differences between ferrous iron in hedenbergite and divalent manganese in johannsenite.

Table 4. Infrared absorption spectra of johannsenite, its heating product, and related minerals

Hedenbergite		Johannsenite		Heated johannsenite		Bustamite	
Mitate mine		Teragochi				Kanoiri mine	
1060	s	1062	s	1080	s	1085	s
—	—	—	—	1020	s	1025	s
955	s	952	s	945	s	940	s
905	w	910	m	905	s	905	s
855	s	860	s	—	—	—	—
660	vw	—	—	675	vw	685	w

(Wave number, cm⁻¹)

Heating product of johannsenite

Johannsenite has a modification belonging to a high temperature form, called bustamite. This is a well known fact since johannsenite was named (SCHALLER, 1938). The johannsenite from Teragōchi, described here, was also

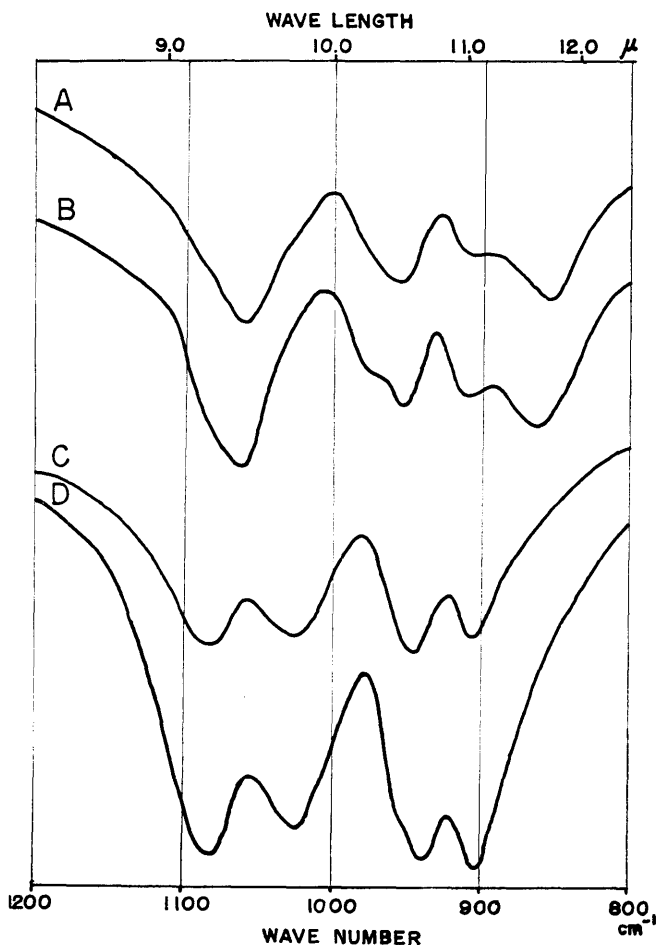


Fig. 2. Infrared absorption spectra
 A: Hedenbergite from the Mitate mine, Miyazaki Prefecture.
 B: Johannsenite from Teragōchi, Okayama Prefecture.
 C: Heated johannsenite, ditto.
 D: Bustamite from the Kanoiri mine, Tochigi Prefecture.

easily modified into bustamite by heating at 1000°C for 1 hour in air. The heating product with pale grey color was examined by the X-ray powder method and by the infrared absorption spectra in the same condition to above. The results for the blue specimen are shown in Tables 4 and 5, and in Figure 2.

The infrared absorption spectra of the heated johannsenite were compared with those of bustamite from the Kanoiri mine, Tochigi Prefecture. They agree closely with each other.

The X-ray powder data for the heated materials from Japan and from Australia (HUTTON, 1956) are in good agreement in spite of the difference in iron content (FeO 3.20 in Japanese and 13.44 wt.% in Australian). The contents of calcium in the original johannsenite were, CaO 19.10 in Japanese and 20.79 wt.% in Australian. The structure of the heated products may be

Table 5. X-ray powder data of heated johannsenite

Johannsenite, heated in air, 1000°C, 1 hr. Teragochi, Japan		Ferroan johannsenite, heated in air, 1070°C, 15.5 hrs. Broken Hill, Australia	
I	d (Å)	I	d (Å)
8	7.52	1	7.50
—	—	1	5.20
—	—	2	4.89
—	—	1	4.48
—	—	1	4.24
—	—	7	4.055
23	3.755	2	3.76
8	3.566	—	—
35	3.446	3	3.44
12	3.320	2	3.33
52	3.237	3	3.25
49	2.994	5	3.044
—	—	1	2.989
100	2.916	10	2.922
6	2.734	1	2.751
8	2.655	3	2.6885
9	2.567	8	2.555
9	2.503	1	2.508
8	2.477	—	—
20b	2.429	4	2.437
9b	2.343	3	2.306
23	2.248	3	2.251
12b	2.142	3	2.149
—	—	3	2.116
8b	1.976	1	1.980
6b	1.943	1	1.9525
5	1.898	—	—
15	1.793	4	1.803
11	1.720	3	1.7295
9b	1.678	4	1.686

controlled more effectively by the calcium atoms.

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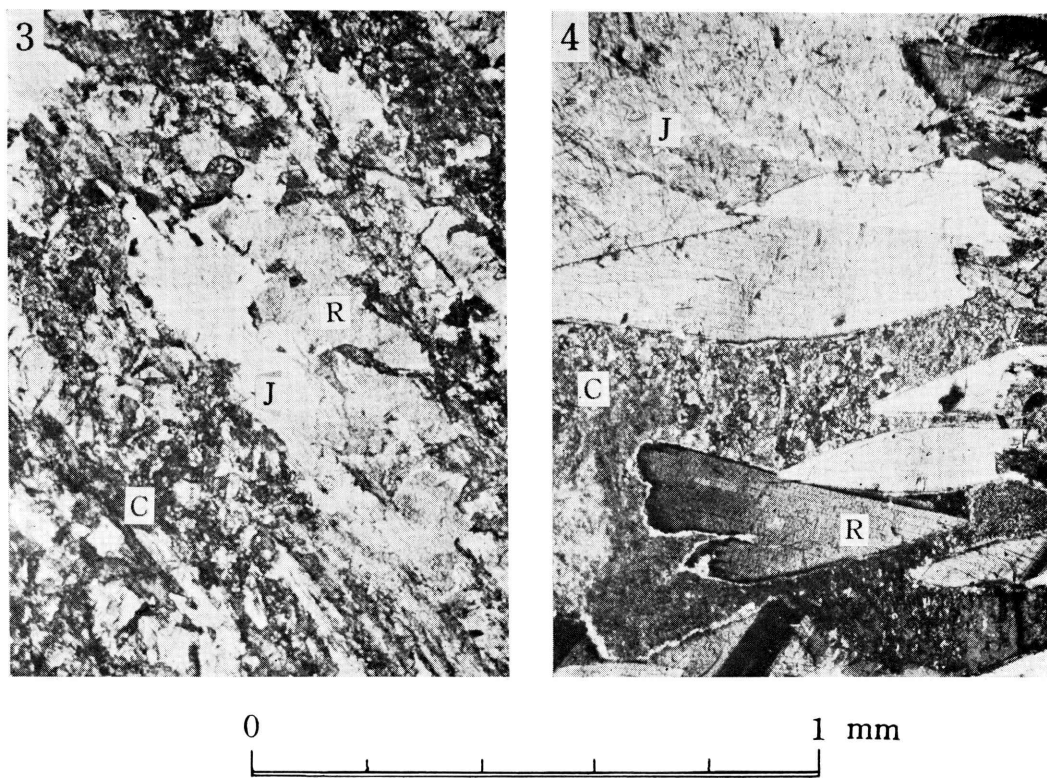
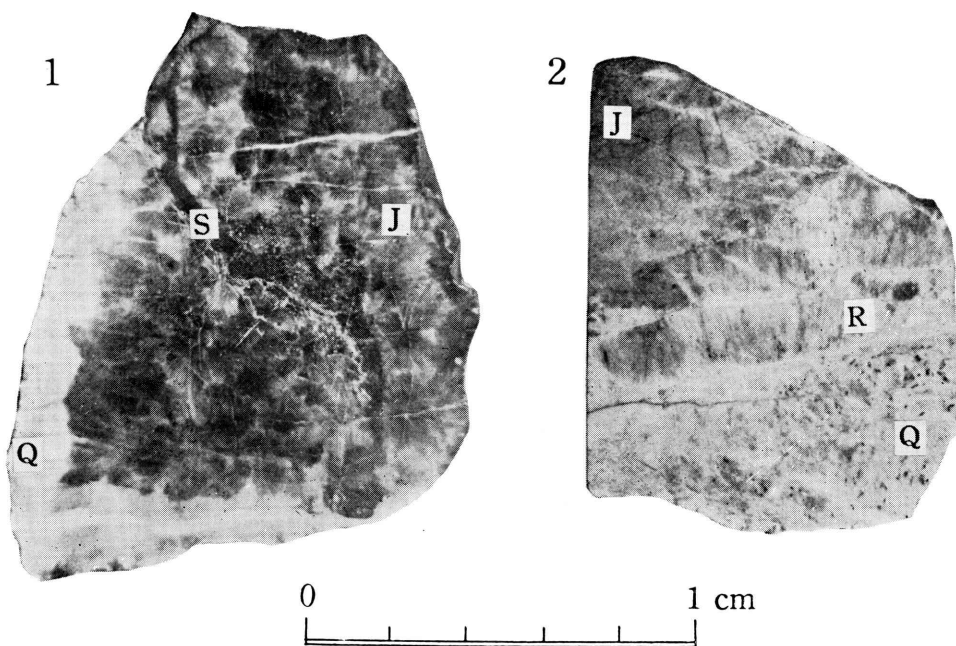
Johannsenite from Teragōchi, Okayama Prefecture

Plate 6

Explanation of Plate 6

- Fig. 1-2. Polished hand specimens of johannsenites from Teragōchi, Okayama Prefecture.
1. Spherulitic green johannsenite (J) cutted by quartz vein (Q) with silicified aureoles and by sphalerite vein (S).
 2. Fibrous green johannsenite (J) being partially replaced by pink rhodonite (R). Lower part (Q) consists of rhodonite (grey), sphalerite (dark spots), and quartz (white).
- Fig. 3-4. Microphotographs of Johannsenite-rhodonite ore. Crossed nicoles.
3. Relicts of johannsenites (J) replaced by rhodonite (R) and carbonitization along the columner texture of johannsenite.
 4. Idiomorphic rhodonites (R) and calcites (C) replaced johannsenite (J).

Photos by H. MOMOI



H. MOMOI: Johannsenite from Teragochi, Okayama Prefecture