MINERALOGICAL JOURNAL, VOL. 19, NO. 3, pp. 109–114, JULY 1997

Sibirskite from Fuka, Okayama Prefecture, Japan

Isao KUSACHI*, Chiyoko HENMI and Shoichi KOBAYASHI *****

* *Department of Earth Sciences, Faculty of Education, Okayama University, Okayama 700, Japan*
** *Department of Earth Sciences, Faculty of Science, Okayama University, Okayama 700, Japan*
*** *Division of Earth Sciences, Kurashiki University of Science and the Arts, Kurashiki 712, Japan*

Abstract

Sibirskite was found in a vein consisting of borate minerals which developed along the boundary between crystalline limestone and skarns at Fuka, Okayama Prefecture, Japan. Sibirskite occurs as aggregates of prismatic crystals up to 0.1 mm long and 0.02mm wide, in association with takedaite, frolovite and calcite. Wet and microprobe analyses of sibirskite from Fuka give the empirical formula $Ca_{1.004}H_{1.071}B_{0.974}O_3$ on the basis of O=3. The formula, optical properties and X-ray powder data are consistent with those from the type locality. The space group and cell dimensions determined are $P2_1/a$, a=8.643(6), b=9.523(2), c=3.567(3) Å, β=119.23(3)° and Z=4. The calculated density is 2.59 g cm^{-3}, and agrees with the measured value of 2.58 g cm^{-3}.

It is likely that sibirskite at Fuka was formed by late-hydrothermal alteration of takedaite.

Introduction

Sibirskite is a calcium hydrogen borate, $CaHBO_3$. The mineral was first found in the Urals by Vasilkova (1962). It occurs in datolite-containing garnet-vesuvianite skarns near the contact of Middle Cambrian limestone with granites in close association with calcite, chlorite and pyrite. Subsequently, the mineral was reported from the Novofrolova deposit by Malinko *et al.* (1974), and from the magnesian skarns of the Chersk and Selenyakhsk ridges of Transbaikalia by Aleksandrov and Malinko (1975). The unit-cell parameters and space group for sibirskite from several Russian deposits were reported by Malinko and Dubinchuk (1996).

During a mineralogical survey of the gehlenite-spurrite skarns at Fuka, Okayama Prefecture, Japan, sibirskite was found. This is the first occurrence of sibirskite to be reported in Japan. The present paper deals with its mode of occurrence and mineralogical properties.

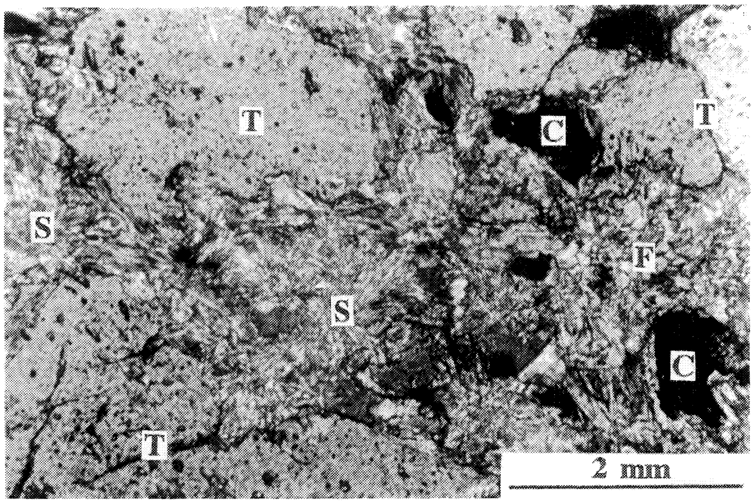

FIG. 1. Photomicrograph of sibirskite. Crossed nicols.
Abbreviations : T, takedaite; S, sibirskite; F, frolovite; and C, calcite.

Occurrence

Sibirskite was found in a vein which developed along the boundary between crystalline limestone and gehlenite-spurrite skarns at Fuka. The vein consists of calcium borate minerals such as takedaite (Kusachi *et al.*, 1995a), nifontovite, olshanskyite (Kusachi and Henmi,1994) and frolovite (Kusachi *et al.*, 1995b). Sibirskite occurred as aggregates of prismatic crystals up to 0.1 mm long and 0.02 mm wide in parts formd by late-hydrothermal alteration of takedaite. The altered parts occur up to 2 cm wide along the boundary between takedaite and the crystalline limestone. The associated minerals were takedaite, frolovite, calcite, and as yet, an unidentified mineral. Fig. 1 shows the occurrence of sibirskite. It is likely that sibirskite was formed by alteration of takedaite.

Physical and optical properties

Sibirskite was white with a vitreous luster in hand specimen, and colorless in thin section. Optically, the mineral is biaxial negative with refractive indices $\alpha = 1.554(2)$, $\beta = 1.638(2)$ and $\gamma = 1.652(2)$. 2V could not be measured owing to the polysynthetic twinning on (100). The calculated value was 42.6°. The Vickers microhardness was 339 (297~383) kg mm^{-2} (25g load) and the density measured by heavy liquid was 2.58 g cm^{-3}. In Table 1, these properties are compared with those reported by Vasilkova (1962). The optical properties resemble each other well.

The infrared absorption spectrum of sibirskite was measured by the KBr method for the region 4000 to 250 cm^{-1}, as shown in Fig. 2. The absorption band at 3420 cm^{-1} is attributed to the OH stretching vibration. Numerous bands observed at 1460 to 310 cm^{-1} are characteristic of borates.

TABLE 1. Physical properties of sibirskite.

	1.	2.
α	1.554	1.555
β	1.638	1.643
γ	1.652	1.658
2V	-	43°
Sign	uniaxial negative	uniaxial negative
D	2.58 g cm^{-3}	-
VHN25	339 kg mm^{-2}	-
Luster	vitreous	-
Color	white pale gray	colorless

1. Fuka, Okayama Prefecture, Japan. Present study.
2. Urals. After Vasilkova (1962).

X-ray study

The X-ray powder data for sibirskite from Fuka was obtained by an X-ray diffractometer using Ni-filtered CuKα radiation, and are given in Table 2, comparing with those of the type locality reported by Vasilkova (1962). Twinned crystals were studied using the precession and Weissenberg methods. The diffraction photographs showed sibirskite to be monoclinic with the space group of $P2_1/a$. The refined unit

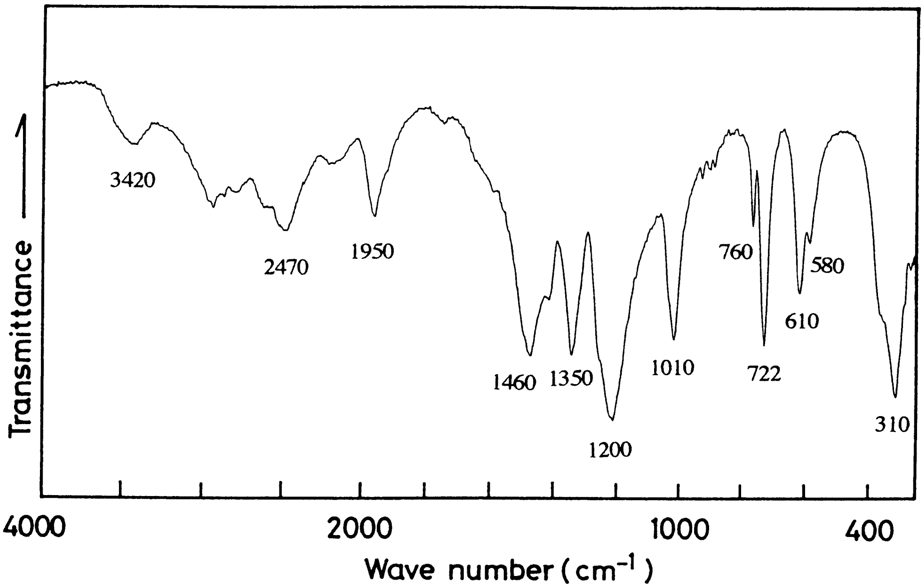

FIG. 2. IR spectrum of sibirskite.

TABLE 2. X-ray powder data for sibirskite from Fuka.

	1.			2.	
h k l	d(calc.)	d(obs.)	I	d	I
1 1 0	5.913	5.92	16		
0 2 0	4.762	4.77	33	4.65	20
2 0 0	3.771	3.773	13	3.74	40
2 1 0	3.506	3.515	9		
1 1 $\bar{1}$	3.329	3.329	32		
2 0 $\bar{1}$	3.327				
2 1 $\bar{1}$	3.141	3.146	10	3.00	20
0 1 1	2.959	2.955	100	2.93	100
2 2 0	2.956				
1 3 0	2.926	2.927	21		
2 2 $\bar{1}$	2.724	2.726	14	2.69	20
0 2 1	2.606	2.603	94	2.58	100
3 1 $\bar{1}$	2.602				
3 2 $\bar{1}$	2.352	2.353	12	2.33	20
3 2 0	2.223	2.223	16	2.20	40
0 3 1	2.223				
4 0 $\bar{1}$	2.141			2.13	20
3 3 $\bar{1}$	2.059	2.060	14	2.05	40
2 4 0	2.013	2.012	8		
3 3 0	1.971	1.972	16		
2 4 $\bar{1}$	1.936	1.936	9	1.934	40
0 4 1	1.891	1.891	20	1.878	60
3 1 $\bar{2}$	1.734	1.734	9		
5 1 $\bar{1}$	1.701	1.700	10		
2 5 0	1.700				
a (Å)		8.643(6)		3.67	
b (Å)		9.523(2)		4.89	
c (Å)		3.567(3)		19.30	
β (°)		119.23(3)		61	

1. Fuka, Okayama Prefecture, Japan. Present study.
2. Urals. After Vasilkova (1962). The cell dimensions are values reported by Dubinchuk and Malinko (1974).

cell dimensions are a =8.643(6), b = 9.523(2), c = 3.567(3)Å, β = 119.23(3)° and Z = 4 . The calculated density is 2.59 g cm^{-3} and agrees with the measured value.

Thermal behavior

DTA and TG curves were obtained by heating sibirskite from room temperature to 900°C at a rate of 10°C/min. in nitrogen flow. The curves are shown in Fig. 3. The DTA curve has an endothermic peak at 375°C and no exothermic peak. The temperature of the endothermic peak is lower than that at 430°C reported by Vasilkova (1962).

Chemical composition

A sibirskite specimen from Fuka was selected for chemical analyses by hand picking separation under a binocular microscope. The concentration of Ca of sibirskite was obtained using an electron microprobe analyzer. The B content was determined by means of wet chemistry, and the H_2O content was determined from ignition loss at 900°C. The results are given in Table 3, and are compared with those reported by Vasilkova (1962) and the theoretical values calculated from the ideal formula of $CaHBO_3$. The empirical formula of sibirskite from Fuka is $Ca_{1.004}H_{1.071}B_{0.974}$

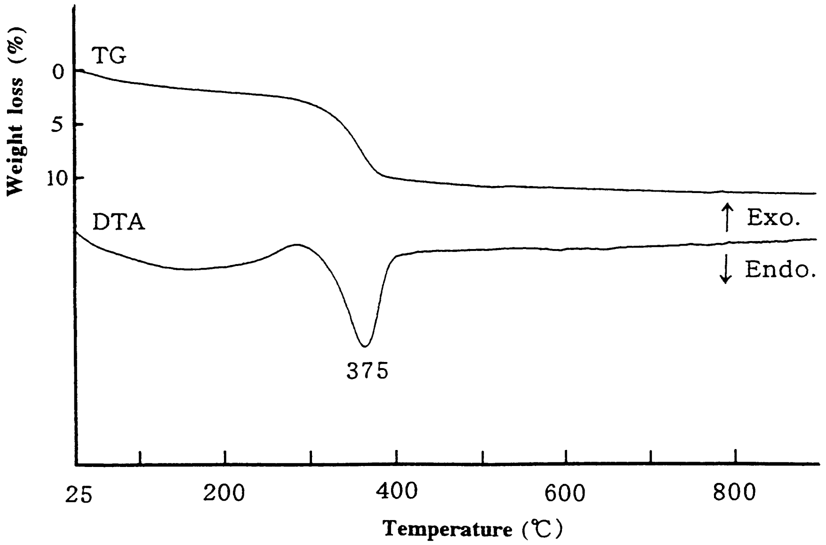

FIG. 3. DTA and TG curves of sibirskite.

TABLE 3. Chemical composition of sibirskite.

	1.	2.	3.
Weight %			
SiO_2			7.72
TiO_2			0.03
Al_2O_3			2.43
B_2O_3	33.83	34.85	13.51
FeO			1.01
MgO			10.06
MnO			0.29
CaO	56.21	56.14	41.78
Na_2O			0.04
CO_2			16.72
$H_2O(+)$	9.62	9.01	6.38
$H_2O(-)$	0.00		0.36
C			0.12
S			0.48
- O=S			0.24
Total	99.66	100.00	100.69
Mole ratios (basis : O = 3)			
Ca	1.004	1	
B	0.974	1	
H	1.071	1	

1. Fuka, Okayama Prefecture, Japan. Present study.
2. Theoretical $CaHBO_3$.
3. Urals. After Vasilkova (1962).

O_3 on the basis of O=3, which is consistent with the ideal formula. Sibirskite was easily soluble in dilute hydrochloric acid.

Discussion

Vasilkova (1962) reported that the symmetry of sibirskite is orthorhombic. Subsequently, Dubinchuk and Malinko (1974) reported that sibirskite from the type locality is monoclinic with the cell dimensions of a =3.67, b =4.89, c =19.30Å and β = 61°. Malinko and Dubinchuk (1996) also reported that the cell dimensions for sibirskite from several Rissian deposits are a = 3.67~3.68, b = 4.89, c = 19.30~19.32Å and β =62~63°. The single-crystal studies of sibirskite from Fuka showed different cell dimensions from those reported by Dubinchuk and Malinko, and Malinko and Dubinchuk, i.e., a = 8.643(6), b = 9.523(2),

$c = 3.567(3)$Å and $\beta = 119.23(3)$°. These parameters are consistent with the X-ray powder data for sibirskite from the type locality.

The X-ray powder pattern of sibirskite from Fuka is distinctly different from that of synthetic $CaHBO_3$ reported by Lehmann *et al.* (1958). His powder data are similar to those of synthetic $2CaO \cdot B_2O_3 \cdot H_2O$ reported by Schäfer (1968). The unit cell dimensions of the $2CaO \cdot B_2O_3 \cdot H_2O$ are monoclinic with $a = 6.719(2)$, $b = 5.434(3)$, $c = 3.555(1)$Å and $\beta = 92.87(4)$°. Sibirskite from Fuka and the type locality, therefore, appear to have a different structure from the synthetic $CaHBO_3$ and $2CaO \cdot B_2O_3 \cdot H_2O$.

Acknowledgements–We would like to express our thanks to Mrs. M. Shimada and S. Kishi for field work conducted, to Dr. A. Kato, National Science Museum, Tokyo for his supply of useful information, to Prof. T. Sakamoto of Okayama University of Science for thermal analyses, and to Mr. L. E. Anthony of Okayama University of Science for proof-reading the final manuscript. We also wish to thank the Research Instruments Center of Okayama University of Science for use of their facilities. This work was supported in part by a Grant-in-Aid for Scientific Research from the Ministry of Education, Science, Sports and Culture.

References

ALEKSANDROV, S. M. and MALINKO, S. V. (1975) Geochemical peculiarities of endogenic and hypergenic alterations of carbonatoborates. *Geokhimiya*, **1**, 3–16 (in Russian).

DUBINCHUK, V. T. and MALINKO, S. V. (1974) Electron-microscopic study of calciborite and sibirskite. *Dokl. Akad. Nauk SSSR*, **216**, 166–168 (in Russian).

KUSACHI, I. and HENMI, C. (1994) Nifontovite and olshanskyite from Fuka, Okayama Prefecture, Japan. *Mineral. Mag.*, **58**, 279–284.

KUSACHI, I., HENMI, C. and KOBAYASHI, S. (1995a) Takedaite, a new mineral from Fuka, Okayama Prefecture, Japan. *Mineral. Mag.*, **59**, 549–552.

KUSACHI, I., HENMI, C. and KOBAYASHI, S. (1995b) Frolovite from Fuka, Okayama Prefecture, Japan. *Mineral. J.*, **17**, 330–337.

LEHMANN, H.-A., ZIELFELDER, A. and HERZOG, G. (1958) Die hydrogenmonoborate des calciums. *Zeits. anorg. allgem. Chem.*, **296B**, 199–207.

MALINKO, S. V., DUBINCHUK, V. T. and MESHCHANKINA, V. I. (1974) Electron microscopic study of the surface changes of endogenous borates. *Dokl. Akad. Nauk SSSR*, **218**, 186–188 (in Russian).

MALINKO, S. V. and DUBINCHUK, V. T. (1996) New data on calcium borates : sibirskite and korzhinskite. *Zapiski Vses. Mineralog. Obshch*, **125**, 60–71 (in Russian).

SCHÄFER, U. L. (1968) Synthese und rontgenographische Untersuchung der Borate $3CaO \cdot B_2O_3$, $2CaO \cdot B_2O_3$ und $2CaO \cdot B_2O_3 \cdot H_2O$. *Neues Jahrb. Mineral. Monatsh.*, 75–80.

VASILKOVA, N. N. (1962) A new calcium borate, sibirskite. *Zapiski Vses. Mineralog. Obshch*, **91**, 455–464 (in Russian).

Received may 6, 1997; accepted July 7, 1997