MINERALOGICAL JOURNAL, VOL. 13, NO. 6, PP. 368–375, APRIL 1987

Stronalsite, $SrNa_2Al_4Si_4O_{16}$, a new mineral from Rendai, Kochi City, Japan

Hidemichi HORI*, Izumi NAKAI**, Kozo NAGASHIMA**[1], Satoshi MATSUBARA*** and Akira KATO***

*Hori Mineralogy Ltd., 4-13 Toyotamanaka, Nerima, Tokyo 176
**Department of Chemistry, The University of Tsukuba, Sakura-mura, Niihari-gun, Ibaraki 305
***Department of Geology, National Science Museum, 3-23-1 Hyakunin-cho, Shinjuku, Tokyo 160

Abstract

A new mineral stronalsite, $SrNa_2Al_4Si_4O_{16}$, is the strontium analogue of banalsite and named after the chemical composition. It is orthorhombic, Ibam or Iba2, a=8.415(4), b=9.901(4), c=16.729(9)Å, Z=4. Average of five microprobe analyses is SiO_2 39.13, Al_2O_3 32.70, CaO 0.17, SrO 15.72, BaO 2.29, Na_2O 9.99, total 99.91%, corresponding to $(Sr_{0.94}Ba_{0.09}Ca_{0.02})_{\Sigma 1.05}Na_{1.99}Al_{3.95}Si_{4.01}O_{16}$ on the basis of O=16. It is white in colour with a vitreous luster and white streak. H.(Mohs)=6½. No cleavage. Density (g/cm^3): 2.95(meas.), 2.95(calc.). It is optically biaxial and positive, 2V=32°(meas.), dispersion indiscernible. Refractive indices: α=1.563(2), β=1.564(calc.), γ=1.574(2). Optic orientation: a=Y, b=Z, c=X. Colourless in thin section. Non-fluorescent under short and long wave ultraviolet lights.

It occurs as veinlets cutting meta basic tuff xenolith enclosed in serpentinite quarried at Rendai, Kochi City, Japan, in association with slawsonite and pectolite. The formation was favoured by a silica-poor condition and concentration of strontium coming from a disintegration of basic plagioclase into such a strontium-excluding calc-silicate as grossular-hydrogrossular. A strontium-sodium-aluminum silicate from Mt. Ohsa, Okayama Prefecture (Kobayashi et al., 1984) has been proved to be the second stronalsite, in which strontium is partially replaced by barium and minor calcium.

Introduction

The occurrence of strontium and barium silicates have been reported in veinlets cutting various kinds of xenoliths in serpentinite exposed in the north- to northwestwards of Kochi City (Matsubara, 1985; Kato and Matsubara, 1986). In a quarry at Rendai to Engyoji, Kochi City, stronalsite was found in one of the veinlets in association with pectolite and slawsonite and only one specimen of fragment has been collected to date without any subsequent find. However, a strontium-sodium-aluminum silicate form Mt. Ohsa, Okayama Prefecture (Kobayashi et al., 1984) turned out to be the second stronalsite after the X-ray powder and microprobe studies, and the results

[1] Deceased on January 6, 1985.

are incorporated herein.

The name comes from the chemical composition as in the case of banalsite, which is the isomorphic barium analogue. The mineral and the name have been approved by the Commission on New Minerals and Mineral Names, I.M.A. Type material has been preserved at Department of Geology, National Science Museum, Tokyo.

Occurrence

The locality is a large quarry for ultrabasic rock operated by Tanaka Olivine Mining Company Ltd. The ultrabasic rock is principally occupied by serpentinite, which involves various kinds of xenoliths, and some of them includes the assemblage of high pressure minerals such as jadeite and glaucophane-crossite (Maruyama, 1981).

The xenoliths are intersected by various kinds of white veinlets. Vein-forming minerals include pectolite, albite, calcite, aragonite, natrolite, thomsonite, prehnite, datolite, slawsonite, rosenhahnite (Kato and Matsubara, 1984), and vuagnatite in the order of decreasing frequency of occurrence. Besides them, tacharanite and tobermorite are found (Minakawa and Noto, 1985).

The studied material is a fine- to medium-grained greenish grey meta basic tuff xenolith composed of clinopyroxene, grossular and chlorite. It is intersected by a white veinlet of a few millimeter wide. According to the macroscopic observation, the

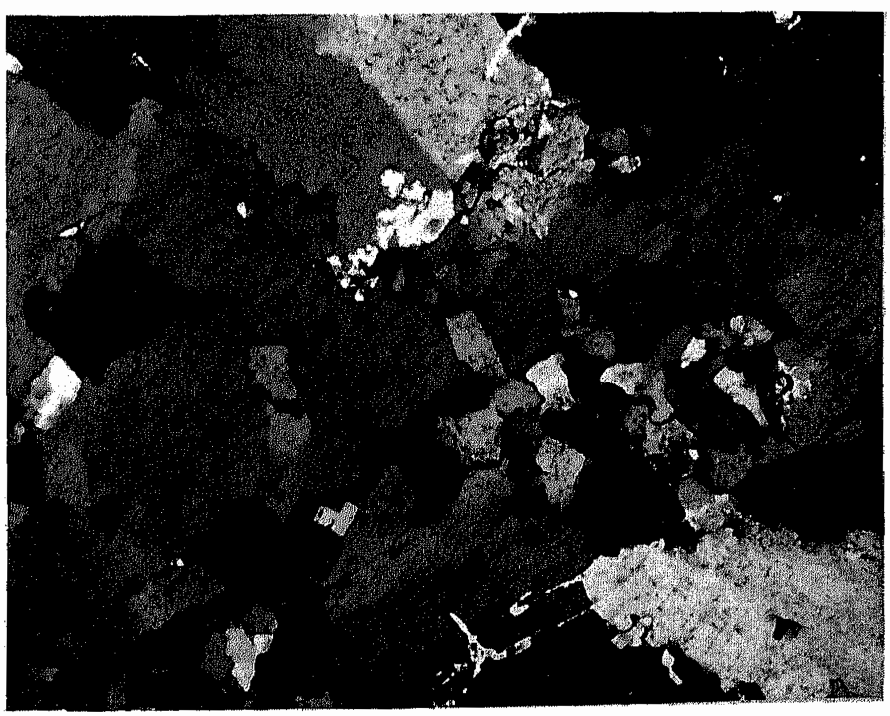

FIG. 1. Photomicrograph of stronalsite (coarse grain) and slawsonite (minute prism). Crossed polars. Field view, approximately 0.8 x 0.6 mm.

veinlet consists of pectolite, slawsonite and stronalsite. Pectolite forms fiber developed along the wall and slawsonite occupies the principal part of it. Stronalsite occurs as a seam-like unit along pectolite-slawsonite boundary composed of white blocky aggregate of short prisms of 0.5 mm across in maximum. Although the visual distinction between stronalsite and slawsonite is difficult, the former is very slightly whiter than the latter.

Under the microscope, stronalsite forms mosaic aggregate composed of blocky grains without any specific feature and slawsonite forms fine-grained aggregate composed of simple short prisms less than 0.1 mm long (Fig. 1).

Physical properties

The mineral is white in colour with a vitreous luster and white streak. Cleavage is lacking but in the marginal part of thin section is observed a rectangular parting along which the extinction is parallel. H. (Mohs)=6½. Measured density is 2.95 g/cm^3, which is well coincident with the calculated value, 2.95 g/cm^3, using the normalized empirical formula. It is optically biaxial and positive, $2V=32^{\circ}$(meas.) and dispersion is indiscernible. Refractive indices measured by the immersion method in the white light are: $\alpha=1.563(2)$, $\beta=1.564$(calc.), $\gamma=1.574(2)$. Optic orientation is: a=Y, b=Z, c=X. Non-fluorescent under short and long wave ultraviolet lights.

Chemical composition

The chemical composition was determined by using Link Systems energy-dispersive X-ray spectrometer, together with that of the associated slawsonite (Table 1). Both of them are slightly barium-bearing as reasonably explained by the existence of their isomorphic barium analogues, banalsite and paracelsian, respectively. The BaO contents in stronalsite fluctuate between about 2 and 3 weight percent. They are high in the center of stronalsite grains (Fig. 2) and gradually decrease towards the boundary of slawsonite, which has lower Ba/(Sr+Ba) ratio than stronalsite.

Crystallography

The precession photographs and automatic four-circle diffractometer studies indicated the mineral to be orthorhombic with possible space group Ibam or Iba2, a=8.415(4), b=9.901(4), c=16.729(9)Å refined after reference to the indexing of X-ray powder diffraction pattern. The unit cell contains four molecules of $SrNa_2Al_4Si_4O_{16}$. As compared with banalsite, orthorhombic, Ibam, a=8.496(2), b= 9.983(2), c=16.755(3)Å, Z=4 (Haga, 1973), the above cell dimensions are reasonably

TABLE 1. Chemical analyses of a) stronalsite and the associated b) slawsonite

a) Stronalsite

	1a	1b	2	3
SiO_2	39.09	38.48- 39.25	4.01	4
Al_2O_3	32.70	32.56- 32.83	3.95	4
CaO	0.17	0.00- 0.33	0.02	
SrO	15.71	15.11- 16.17	0.94	1
BaO	2.29	1.98- 3.04	0.09	
Na_2O	9.98	9.76- 10.28	1.99	2
total	99.91	99.55-100.01		

1a. Average of five analyses. Weight percent.
1b. Range of five analyses.
2. Molecule number on the basis of O=16.
3. Ideal molecule number.

b) Slawsonite

	1a	1b	2	3
SiO_2	37.01	36.92- 37.56	2.02	2
Al_2O_3	30.52	30.38- 30.56	1.96	2
SrO	30.68	30.20- 30.72	0.98	
BaO	1.63	1.50- 1.74	0.03	
total	99.84	99.65-100.01		

1a. Average of three analyses.
1b. Range of three analyses.
2. Molecule number on the basis of O=8.
3. Ideal molecule number.

smaller to reflect the accommodation of strontium as the dominant cation in place of barium.

X-ray powder diffraction pattern of stronalsite is given in Table 2, where that of the second locality stronalsite is also tabulated. Both of them are apparently similar to that of banalsite (Matsubara, 1985).

Consideration of genesis and the second occurrence

The formula of ideal stronalsite is derived by a simple addition of one molecule of slawsonite ($SrAl_2Si_2O_8$) and two of potassium-free nepheline ($NaAlSiO_4$), suggesting that the formation of stronalsite was favoured under a silica-poor condition as discussed by one of the authors (Matsubara, 1985). A silica-richer condition will invite

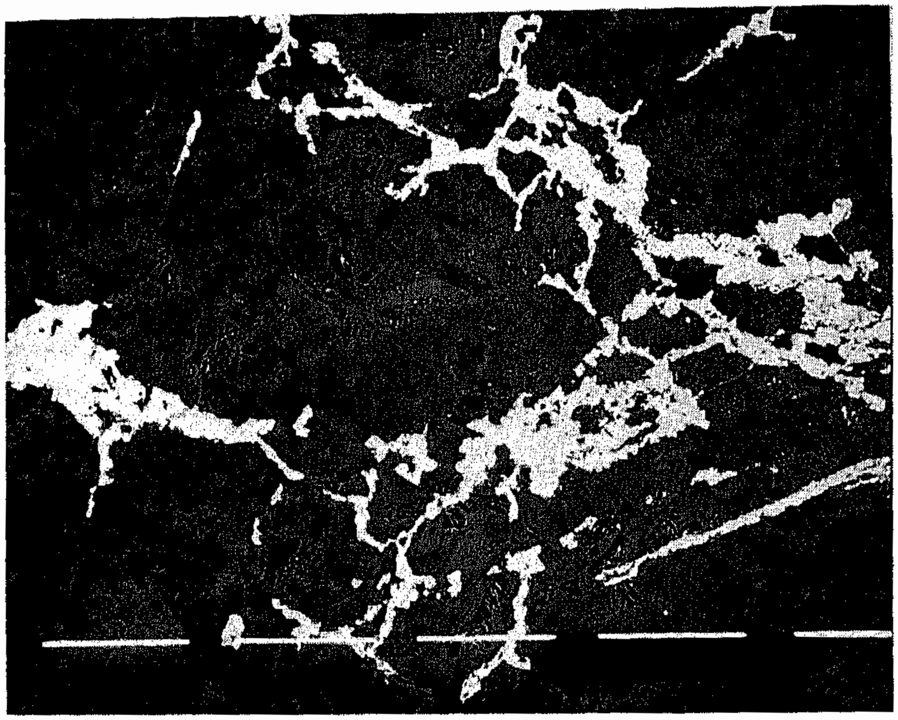

FIG. 2. Back-scattered electron image of analysed stronalsite (gray) and slawsonite (white). A white bar indicates 100 μm.

the formation of assemblage of slawsonite + albite, although slawsonite and albite in the locality occur separately, the latter being involved in veinlets cutting slaty rocks with or without quartz in the veinlets.

Stronalsite is one of the fissure-filling minerals in xenoliths enclosed within serpentinite. Among the xenoliths of this mode of occurrence at or around the locality is found such a high pressure mineral as jadeite (Maruyama, 1981). In relation to this evidence, it is worth mentioning that Kobayashi et al. (1984) report a strontium-sodium-aluminum silicate in association with a jadeite rock in serpentinite at Mt. Ohsa, Okayama Prefecture. Through their kind guidance to the locality, S. M. and A. K. could collect the material, which was identified as stronalsite after X-ray powder (Table 2) and microprobe studies (Table 3). The occurrence of Mt. Ohsa stronalsite will be reported separately by them. At the locality, stronalsite occurs as veinlets and discrete grains in jadeite aggregates, seven representative microprobe analyses in Table 3 demonstrate the compositional variation. The mole ratio of strontium fraction in the larger cationic site varies from 0.93 to 0.47, whereas barium does 0.03 to 0.37, reciprocally to strontium. Calcium contents vary from 0.01 to 0.16 without any apparent relation to those of strontium and barium.

The possible isomorphism of stronalsite to banalsite, having less dense structure (Haga, 1973), suggests that the formation of stronalsite will not always require any high pressure condition if all the constituents are fully available at the site of forma-

TABLE 2. X-ray powder diffraction pattern of stronalsites from Rendai, Kochi City and Mt. Ohsa, Okayama Prefecture.

	1.			2.		
hkl	*I*	$d_{obs.}$	$d_{cal.}$	*I*	$d_{obs.}$	$d_{cal.}$
002	10b	8.370	8.362	12	8.402	8.362
110	20	6.411	6.415	10	6.439	6.439
112	25	5.092	5.090	22	5.110	5.103
020	8	4.951	4.945			
200	38	4.179	4.207	30	4.203	4.222
004						4.185
121	10	4.137	4.134	15	4.145	4.145
211	40	3.765	3.772	45	3.773	3.777
202						3.769
114	80	3.502	3.503	75	3.506	3.509
123	3	3.387	3.386			
220	100	3.204	3.206	100	3.204	3.216
024	50	3.183	3.193			3.199
213			3.180	100	3.197	3.190
130	40	3.069	3.073	50	3.076	3.076
222	40	2.992	2.992	30	2.996	3.002
204	12	2.966	2.966	20	2.968	2.972
132	70	2.881	2.884	50	2.891	2.891
310	8	2.699	2.699			
125	35	2.632	2.632	30	2.636	2.637
312	25b	2.569	2.563	5	2.576	2.577
231			2.566			2.573
116			2.557	15	2.550	2.556
224	25	2.545	2.545			
134	1	2.475	2.476			
040			2.475			
026	20	2.428	2.428	*	2.430	2.432
042	3	2.370	2.374			
141	10	2.348	2.351			
206	3	2.313	2.324			
314	3	2.269	2.267			
136			2.263			
323	2	2.237	2.235			
143	5	2.184	2.185			
330	5	2.135	2.137			
240			2.133			
044	20	2.130	2.129	18	2.134	2.135
400	5	2.104	2.104			
226			2.104			
352			2.101			
008	10	2.041	2.091	7b	2.091	2.092
127			2.085			2.087
332	50	2.067	2.071	45	2.071	2.073
242			2.067			2.073
136			2.066			2.068
217	7	2.034	2.034	12	2.037	2.037
118	12	1.988	1.988	10	1.990	1.990
325	1	1.973	1.972			
316	25	1.937	1.938	*	1.940	1.943
145			1.937			1.941
420			1.936			1.943
413			1.931			1.937
244	3	1.900	1.900			
404	3b	1.882	1.879			
152			1.878			
208	3	1.875	1.873			

	1.			2.		
hkl	*I*	$d_{obs.}$	$d_{cal.}$	*I*	$d_{obs.}$	$d_{cal.}$
336	10	1.697	1.696			
246			1.694			
406	5	1.679	1.679			
347	1	1.650	1.654			
318			1.653			
060			1.650			
345	10	1.623	1.623	20	1.625	1.625
062						1.623
440	3	1.603	1.603			
156	4	1.586	1.586			
521			1.586			
0.2.10			1.585			
2.0.10	5	1.555	1.555	1	1.555	1.556
163			1.555			
514	2	1.544	1.542	1	1.548	1.547
260	10	1.535	1.536			
064			1.535			
262	2	1.509	1.551			
239			1.511			
354			1.509			
338	1	1.495	1.495			
248			1.493	10**	1.497	1.496
2.2.10	4	1.484	1.483	12	1.484	1.484
408			1.483			
1.3.10	8	1.466	1.469	8	1.469	1.469
347			1.466			1.469
264	3	1.440	1.442			
525			1.439	2	1.443	1.443
451	3	1.436	1.436			
158	12	1.416	1.417			
361			1.417			
2.1.11			1.415			
170	10b	1.394	1.395			
0.0.12			1.394	3	1.395	1.395
446	10	1.392	1.390			
419	4b	1.377	1.379			
363	4	1.374	1.376			
172			1.276			
622	2	1.331	1.333			
604			1.330			
3.3.10	4	1.317	1.317			
2.4.10			1.316			
349	1	1.314	1.313			
2.3.11			1.312			
3.2.11	1	1.292	1.291			
439	3b	1.283	1.283			
462			1.283			
615			1.283			
550			1.282			
448	3	1.270	1.272			
1.3.12			1.269			
1.5.10	1	1.263	1.263			
370			1.263			
464	4	1.239	1.240			
3.1.12			1.239			
268			1.238			

TABLE 2. (Continued)

		1.			1.				1.			2.	
hkl	*I*	$d_{obs.}$	$d_{cal.}$	*I*	$d_{obs.}$	$d_{cal.}$	*hkl*	*I*	$d_{obs.}$	$d_{cal.}$	*I*	$d_{obs.}$	$d_{cal.}$
424	2	1.761	1.763				2.1.13	4	1.220	1.221			
343			1.261				169			1.221			
228	12	1.750	1.751				640			1.220			
154			1.751				538			1.219			
253	2	1.704	1.706				626	1	1.215	1.215			
129			1.704				0.4.12			1.215			
							374	3	1.208	1.209			
							642			1.208			

1. Stronalsite. Rendai, Kochi City. Ni filtered Cu Kα radiation (λ=1.5405Å). Diffractometer method. a=8.415(4), b=9.901(4), c= 16.729(9)Å.
2. Stronalsite. Mt. Ohsa, Okayama Prefecture. Ni filtered Cu Kα radiation (λ=1.5405Å). Diffractometer method. a=8.444(4), b=9.929(4), c=16.739(9)Å.

(*intensity immesurable due to overlapped diffraction of analcime)
(**intensity may be enhanced due to the same reason as above)

TABLE 3. Chemical analyses of stronalsite from Mt. Ohsa, Okayama Prefecture. (Nos. 1–3, vein-formed; 4–7, discrete grains)

No.	SiO_2	Al_2O_3	CaO	SrO	BaO	Na_2O	total
1	38.57	32.82	0.40	17.68	1.23	9.90	100.60%
2	38.68	32.92	0.42	17.44	0.64	10.08	99.61
3	38.87	32.30	0.41	17.11	0.80	10.12	99.61
4	39.12	32.45	0.25	13.56	4.33	9.98	99.69
5	39.49	32.88	0.57	12.09	5.22	10.10	100.35
6	38.26	31.73	0.13	9.85	9.56	9.92	99.45
7	38.71	31.88	1.43	7.70	9.27	10.07	99.06

Empirical formulae (basis O=16) :

1. $(Sr_{1.06}Ba_{0.05}Ca_{0.04})_{\Sigma 1.15}Na_{1.97}Al_{3.97}Si_{3.96}O_{16}$
2. $(Sr_{1.05}Ca_{0.05}Ba_{0.03})_{\Sigma 1.13}Na_{2.00}Al_{3.97}Si_{3.96}O_{16}$
3. $(Sr_{1.03}Ca_{0.05}Ba_{0.03})_{\Sigma 1.11}Na_{2.02}Al_{3.92}Si_{4.00}O_{16}$
4. $(Sr_{0.81}Ba_{0.17}Ca_{0.03})_{\Sigma 1.01}Na_{2.00}Al_{3.95}Si_{4.04}O_{16}$
5. $(Sr_{0.72}Ba_{0.21}Ca_{0.06})_{\Sigma 0.99}Na_{2.00}Al_{3.96}Si_{4.04}O_{16}$
6. $(Sr_{0.60}Ba_{0.39}Ca_{0.01})_{\Sigma 1.00}Na_{2.03}Al_{3.94}Si_{4.03}O_{16}$
7. $(Sr_{0.47}Ba_{0.37}Ca_{0.16})_{\Sigma 1.00}Na_{2.02}Al_{4.00}Si_{4.00}O_{16}$

tion under a silica-poor condition as stated above. The occurrence of banalsite from the Shiromaru mine, Tokyo (Matsubara, 1985) substantiates this interpretation, where the pressure of regional metamorphism was lower than those at the two stronalsite localities.

Higher concentration of strontium would have been favoured by the formation of any strontium-excluding rock-forming silicate like grossular-hydrogrossular after the disintegration of any parental phase capable of being potential strontium source, which would be a calcic plagioclase. The examined material does not allow any comparable studies on vein-free rocks in the locality with those veined by the assemblage including stronalsite due to the scarcity of material. This impedes the find of any proof to know whether the strontium silicates were the products in situ or not, although their hydrothermal formation seems probable.

Acknowledgements–The authors thank for Professor Hiroshi Miyake and Dr. Shoichi Kobayashi, Faculty of Science, Okayama University of Science, for their kind guidance to the second locality of stronalsite, Mt. Ohsa, Okayama Prefecture.

References

HAGA, N. (1973) *Miner. Jour.*, 7, 262-281.

KATO, A. & MATSUBARA, S. (1984) *Bull. Natn. Sci. Museum, Ser.* C, **10**, 1-8.

KATO, A. & MATSUBARA, S. (1986) *Proc. 13th General Meeting of I.M.A. Pt. 3. Crystal Chemistry of Minerals*, 595-605.

KOBAYASHI, K., MIYAKE, H. & SHOJI, T. (1984) *Abstr. Autumn Meeting of Soc. Mining Geologists in Japan, Japanese Assoc. Miner. Petrol. and Econ. Geol., and Miner. Soc. Japan, Matsuyama.* 86 (in Japanese).

MARUYAMA, S. (1981) *Jour. Geol. Soc. Japan*, 87, 569-583.

MATSUBARA, S. (1985) *Bull. Natn. Sci. Museum, Ser.* C, **11**, 37-95.

MINAKAWA, T. & NOTO, S. (1985) *Abstr. Annual Meeting of Miner. Soc. of Japan. Nagoya.* 90 (in Japanese).

Received November 4, 1986; revised January 26, 1987.