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Banalsite and Serandite from the Shiromaru mine, Tokyo

By

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Abstract Banalsite is found in veinlets involving serandite and minor celsian cutting a celsian-cymrite rock that forms a wallrock of a bedded manganese ore deposit of the Shiromaru mine, Tokyo. The microprobe analysis is: SiO_2 37.04, Al_2O_3 31.27, BaO 19.19, SrO 4.03, Na_2O 9.46, toatl 100.99%, giving the empirical formula $(Ba_{0.81}Sr_{0.25})_{\Sigma 1.06}Na_{1.98}Al_{3.97}Si_{4.00}O_{16}$ (basis O=16). The present findy yields two new informations on banalsite, that is, the formation in weakly metamorphosed rock probably of prehnite-pumpellyite metagraywacke facies and the significant substitution of Sr for Ba. The chemical composition of the associated serandite is: SiO_2 51.19, CaO 12.50, MnO 24.78, Na_2O 8.73, H_2O (calc.) 2.56, total 99.76%, corresponding to $Na_{0.99}(Mn_{1.23}Ca_{0.78})_{\Sigma 2.01}Si_{3.00}O_8(OH)$ (basis O=8.5). Calcium in the assemblage is preferentially incorporated into serandite. Serandites in Japan are formed under extensive metamorphic conditions ranging from epidote-glaucophane schist facies (MORIKIYO, 1984) possibly to zeolite facies, and the compositional range given by Ca/(Ca+Mn+Fe+Mg) is 0.44 to 0.05.

Introduction

Banalsite, $BaNa_2Al_4Si_4O_{16}$, is a rare tectosilicate with a feldspar-like structure (HAGA, 1973) and a silica-poor chemistry composed of one molecule of celsian ($BaAl_2Si_2O_8$) plus two molecules of 'K-free nepheline' ($NaAlSiO_4$). There are only two localities of banalsite hnown to date, the Benallt mine, Carnavonshire (SMITH *et al.*, 1944) and Långban, Sweden (WELIN, 1968). The present banalsite occurs in veinlets with serandite and minor celsian, and the veined rock forming a part of the wallrocks of the bedded manganese ore deposit of the Shiromaru mine, suffers a very weak metamorphism probably of prehnite-pumpellyite metagraywacke facies. The microprobe analysis of banalsite informed a higher SrO content to form a solid solution to the strontium analogue stronalsite, which involves a Ba-substituted variety with Sr: Ba ratio close to unity (HORI *et al.*, 1987).

The comparative study on serandites from Japan leads to the conclusion that both of nearly pure and calcian materials are formed under extensive metamorphic conditions ranging from epidote-glaucophane schist facies (MORIKIYO, 1984) possibly to zeolite facies with or without excess silica.

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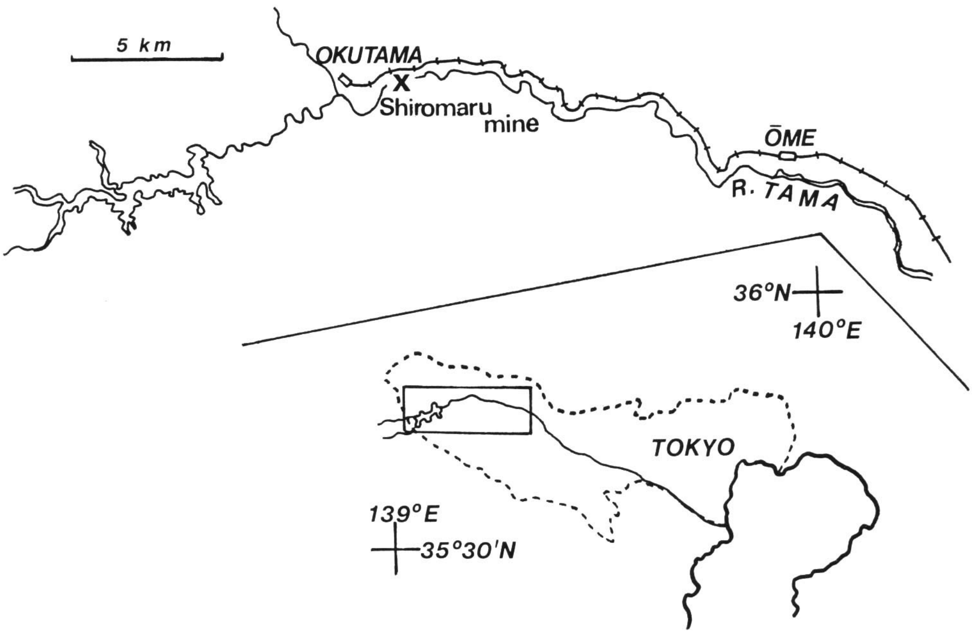

Fig. 1. Index map of the Shiromaru mine, Tokyo.

and Culture, for the defrayal as his Research Staff in abroad in 1983, enabling his stay in London, where the late Dr. M. H. HEY and Miss E. E. FEJER, Department of Mineralogy, British Museum (Natural History), advised him valuable informations including those on type banalsite. His sincere gratitude is subjected to them.

Occurrence

The ore deposit of the Shiromaru mine is located about 800 meters east of Shiromaru Station of Ome line, JR Company Ltd. It had been already mined out about 35 years ago. The ore deposit, the exposure of ore bed and the dump are now covered by the water of Shiromaru Dam and the examined materials were all collected in October of 1974 at the time of water clearacne (Fig. 1).

The ore deposit is developed in middle to upper Jurassic sedimentary rocks composed of slate, chert and sandstone and the principal orebody is a bed of braunite conformably present therein. The general strike is close to N–S direction and the dip is westerly with a steep angle. From the hanging to foot wall of the ore bed, the following sequence of rock units was observed on the exposure. They are: 1) chert, 2) albite-quartz rock with hematite, 3) celsian-cymrite rock with albite and hematite, 4) celsian-cymrite rock with braunite, piemontite and hematite, 5) braunite ore bed, 6) slate, and 7) sandstone. All of them except sandstone are fine in grain size and minutely banded. The total thickness of the second to sixth units reaches about 4 meters,

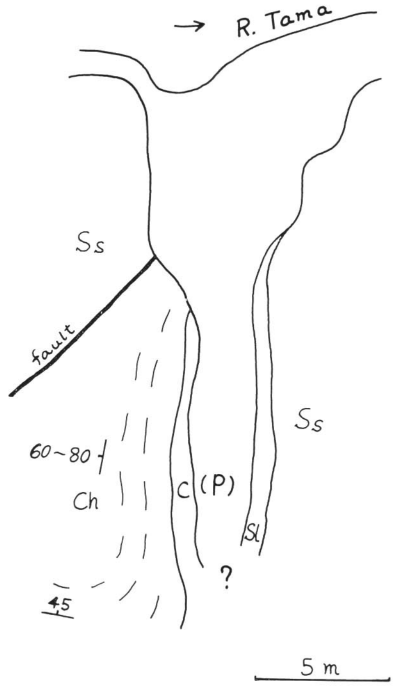

Fig. 2. Plan of the exposure around the ore deposit of the Shiromaru mine. The right margin of C(celsian-cymrite rock, the third unit) is an overhanging wall to the east, where the second unit(albite-quartz rock) and the fourth unit(celsian-cymrite rock with braunite etc.) are observed. The pit part(P) corresponds to the braunite ore bed after the excavation. A thin unobservable part may be present between the braunite ore bed and slate(Sl). Two sandstone beds(Ss) are apparently similar, although the bed of the footwall side comprises harmotome. Streaks in chert(Ch) denote the change of stricke and dip in the exposure.

including a break of less than half a meter thick between the fifth and sixth units (Fig. 2).

Banalsite is found as a principal constituent of veinlets and as an invisible constituent of a banalsite-celsian-cymrite-analcime rock, both in the third unit, and the former material was subjected to the present study. The maximum width of banalsite veinlets is 5 millimeters. They are white in colur but on the weathered surface black spots composed of serandite are found. Its fresh colur is very pale pinkish white.

Under the microscope, banalsite grains have somewhat elongated outline with the trend of elongation parallel to *b*-axis, but the grain boundaries are generally rugged. In the marginal part of thin section rectangular partings are observed. Serandite occurs as minute prisms or the aggregate, and the maximum dimension of grains reaches 2 millimeters across. Celsian is of submicroscopic dimension and smaller in amount. Along the veinlet walls aggregate of albite are developed in places. Figs. 3 and 4 demonstrate aggregates of coarser banalsite grains and of serandite prisms.

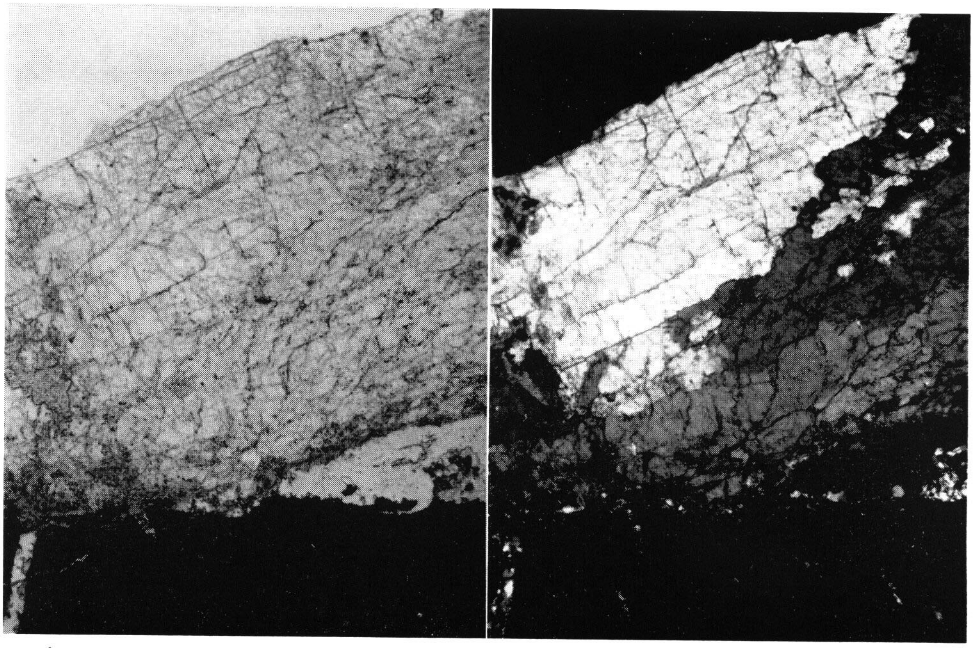

Fig. 3. Photomicrographs of banalsite veinlets. Banalsite occupying the principal part of the veinlets is coarser-grained and with rectangular partings. Black part in the left is the wallrock and wedge-shaped clear part is occupied by aggregate of albite. Left: One polar. Field view: 1.4×1.9 mm. Right: Ditto. Crossed polars.

Banalsite-bearing veinlets crosscut the banding of rocks belonging to the third unit in most cases. The constituents of rocks are fine in grain size that the identification was made by the X-ray powder studies only. The bands are composed of a few millimeter order layers with different shades of whity, brownish, reddish and yellowish tints. Brick red bands are generally composed of clesian, cymrite, hematite with minor piemontite and micaceous material, whereas lighter colored one includes cymrite, albite, analcime and micaceous material in most cases.

X-ray Powder Studies

The X-ray powder pattern of the presnt banalsite has been already published (MATSUBARA, 1985). The unit cell dimensions are: a=8.497(2), b=9.983(2), c=16.756(4) Å. The X-ray powder diffraction pattern of serandite corresponds to that of calcian serandite (MORIKIYO, 1984) as given in Table 1.

Chemical Compositions

The chemical compositions of banalsite and serandite were obtained by using

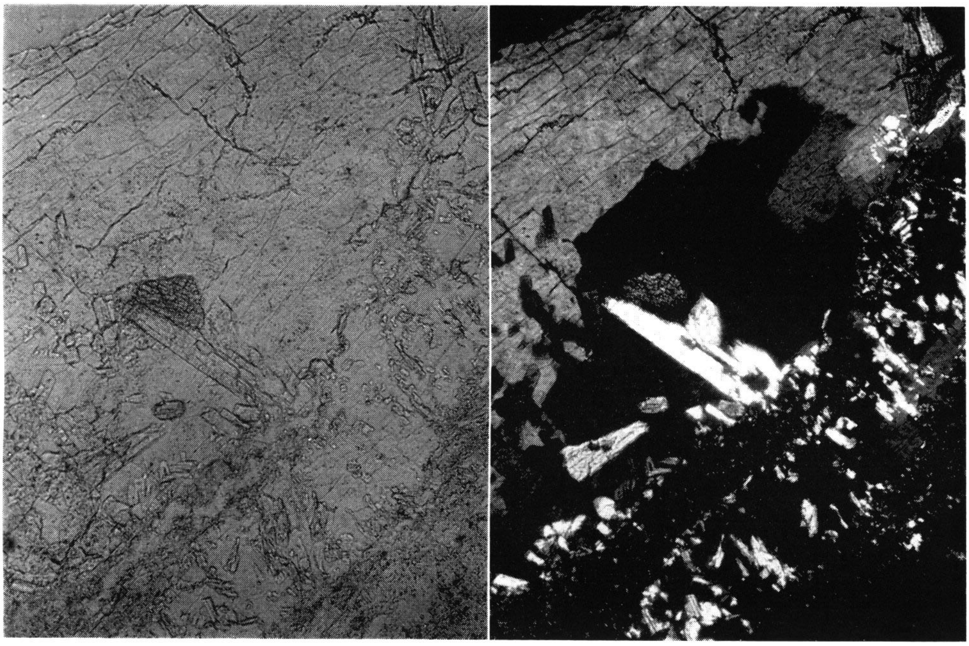

Fig. 4. Photomicrographs of serandite in banalsite veinlets. Prism of serandite (center) is in direct contact with coarser-grained banalsite. Left: One polar. Field view: 0.6 × 0.8 mm. Right: Ditto. Crossed polars.

Table 1. X-ray powder diffraction pattern of serandite

1.		2.		1.		2.	
d(Å)	I	d(Å)	I	d(Å)	I	d(Å)	I
7.55	m	7.60	mw	2.69	w		
6.85	m	6.87	ms	2.64	mw	2.66	mw
5.28	w			2.56	w		
3.79	ms	3.80	ms	2.52	w	2.54	ms
3.41	w	3.42	s	2.39	w		
3.30	w			2.36	w		
3.19	s	3.22	s	2.28	w		
3.08	w			2.225	m	2.24	mw
3.02	s	3.04	s	2.120	m	2.13	mw
2.88	vs	2.86	mw				

(vs=very strong, s=strong, ms=medium strong, m=medium, mw=medium weak, w=weak)
1. Shiromaru mine, Tokyo. Mn:Ca=61:39. FeKα radiation. Camera method (d=114.59 mm).
2. Mitsuishi, Hokkaido. Mn:Ca=56:44. CuKα radiation. Diffractometer method. After Morikiyo (1984).

Link Systems energy-dispersive X-ray spectrometer as given in Tables 2 and 3, respectively. The former one is reproduced from the paper of MATSUBARA (1985). The chemical composition of banalsite is characterized by higher SrO contnt, which is due to substitution for Ba, indicating the presence of continuous solid solutions between banalsite and stronalsite (KOBAYASHI *et al.*, 1987) (HORI *et al.*, 1987).

The chemical analysis of serandite specifies the material to be a calcian material containing about 31 mole percent of pectolite molecule. It is worthy of note that in the veinlets calcium is preferentially concentrated in serandite, and banaliste and celsian are virtually devoid of calcium. In relation to this evidence, the occurrence of lisetite recently found in eclogite (SMITH *et al.*, 1986) should be taken into consideration. Although the space group is different, it corresponds compositionally to the calcium analogue of banalsite, and its denser packing seems to reflect the geologic condition of formation (ROSSI *et al.*, 1986). In a barium-bearing stronalsite in jadeite rock from Mt. Oosa, Okayama Prefecture, up to 16 mole percent of lisetite molecule is contained (HORI *et al.*, 1987). This suggests that the substitution of calcium for strontium or

Table 2. Chemical composition of banalsite

	1.	2.	3.	4.	5.	6.
SiO_2	37.04	36.68	0.6108	0.6108	1.2209	4.00
Al_2O_3	31.27	30.96	0.3036	0.6073	0.9109	3.97
BaO	19.19	19.00	0.1239	0.1239	0.1239	0.81
SrO	4.03	3.99	0.0385	0.0385	0.0385	0.25
Na_2O	9.46	9.37	0.1512	0.3024	0.1512	1.98
total	100.99	100.00%				

1. Banalsite. Shiromaru mine, Tokyo.
2. Ditto. Recast to 100%.
3. Molecular quotient.
4. Number of metals.
5. Number of oxygen.
6. Number of metals calculated on the basis of total O=16.

Table 3. Chemical composition of serandite

	1.	2.	3.	4.	5.	6.
SiO_2	51.19	51.31	0.8540	0.8540	1.7079	3.00
CaO	12.50	12.53	0.2234	0.2234	0.2234	0.78
MnO	24.78	24.84	0.3502	0.3502	0.3502	1.23
Na_2O	8.73	8.75	0.1412	0.2824	0.1412	0.99
H_2O(calc.)	2.56	2.57	0.1427	0.2854	0.1427	1.00
total	99.76	100.00%				

1. Serandite. Shiromaru mine, Tokyo.
2. Ditto. Recast to 100%.
3. Molecular quotient.
4. Number of metals.
5. Number of oxygens.
6. Number of metals calculated on the basis of O=8.5.

barium in stronalsite-banalsite solid solution reflects the higher pressure of condition of formation. If so, the lack of calcium in the present banalsite is reasonably interpreted from the metamorphic grade around the locality.

Comparative Studies on Banalsite and on Serandite

There are two localities of banalsite to date, the Benallt mine, Carnavonshire (Smith *et al.*, 1944) and Långban, Sweden (Welin, 1968). Both of them are bedded manganese ore deposits metamorphosed under high temperature condition. In the present locality, all the wallrocks and ores of the deposit have no trace of higher grade of metamorphism but of very low grade. Nearby the ore deposit, slate comprises white mica of fine grain size and the estimated grade of metamorphism is prehnite-pumpellyite metagraywacke facies. Therefore, the present banalsite is formed under the metamorphic condition of above grade or lower, proving that the formation of banalsite is possible even under such a lower grade of metamorphic condition. Also, the formation of banalsite is favoured under a silica-poor condition, which is also applicable to the cases of known localities. According to the observation of banalsite specimens therefrom, banalsite veins are developed in massive recrystallized tephroite ore without any silica mineral and silica-saturated manganese silicates at the Benallt mine, whereas in Långban banalsite veinlets are found in gneissose feldspar-biotite rock.

The metamorphic grades around the serandite localites in Japan may involve zeolite facies, as seen in the case of the Ezuri mine, Akita Prefecture (Ogushi *et al.*, 1979). At this locality serandite-quartz veinlets are developed in ferruginous quartz layer overlain by a porphyritic dacite in which stilbite is found. No quantitative chemical analysis is made on serandite from this locality, but the X-ray powder diffraction pattern corresponds to that of end member material. The formation of such serandite under a silica-rich condition is also possible.

Also in Japan serandite is found in metamorphic rocks of higher grades and the compositional range covers from $Ca/(Ca+Mn+Fe+Mg)=0.05$ (Furumiya mine, Ehime Prefecture (Fukuoka & Hirowatari, 1977)) to 0.44 (Mitsuishi, Hokkaido (Morikiyo, 1984)). The metamorphic grade around the former locality is estimated as amphibolite facies seeing from the occurrence of amphibole schist (Yoshimura, 1967), and that around the latter is described as epidote-glaucophane schist facies. In both localities, serandite is accompanied by quartz, proving that serandite can be formed with excess silica under such metamorphic conditions.

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