Communs geol. Surv. S.W. Africa/Namibia, **3**, (1987) 37-40

ON THE MINERALOGY OF NAMBULITE, A RARE MANGANESE SILICATE FROM NAMIBIA, JAPAN AND BRAZIL

Gabriele I.C. Schneider

ABSTRACT

Nambulite is a rare alkali-bearing hydrous manganese silicate, which occurs in veins associated with manganese ore bodies. It is suggested that the formation of nambulite is related to late hydrothermal activities connected with a contact metamorphic event. The chemistry and structure of nambulite from three known occurrences are similar, but with differences in the alkali content and in the dimension of the unit cell.

1. INTRODUCTION

The manganese silicate nambulite has to date only been described from the Funakozawa Mine in the Kitakami Mountains of north-eastern Japan, where it was first recognized (Yoshii *et al.*, 1972), from the Kombat Mine in the Otavi Mountains of northern Namibia (von Knorring *et al.*, 1978) and from the Figuerinha Mine, Urucum District, Mato Grosso do Sui, Brazil (Schneider and Urban, 1983; Schneider, 1984).

Nambulite is a hydrous lithium-pyroxenoid with a structure similar to that of rhodonite and babingtonite. The ideal formula may be written as $LiNaMn_8Si_{10}O_{28}(OH)_2$ (Yoshii *et al.*, 1972). Nambulite forms coarse prismatic to fibrous crystals which have a vitreous reddish brown colour with an orange tint, it is triclinic and displays perfect (001) and distinct (100) and (010) cleavages.

2. OCCURRENCE

Nambulite occurs in veinlets up to 5 cm thick in the bedded braunite ore of the Funakozawa Mine, Japan. The manganese ore belongs to a formation of probable Jurassic age, consisting mainly of slate and chert, with an association of basaltic volcanic rocks. The manganese mineralization is thought to be primarily related to volcanic activity (Yoshii *et al.*, 1972). The coarse prismatic nambulite crystals reach a size of 8x4x3 mm. Accessory albite, neotocite and rhodochrosite occur in the nambulite veinlets.

At Kombat Mine, Namibia, a hydrothermal vein-system cuts through the layering of manganese ore bodies. The nambulite-bearing veins are up to 10 cm thick (Dunn *et al.*, 1986) and contain prismatic, light red crystals with dimensions of up to 3x4x2 mm, as well as small, fibrous, pink crystals. Larger, deep red crystals of up to 3 cm in length have also been reported (von Knorring *et al.*, 1978). Other gangue minerals occurring with the nambulite are gypsum, brushite, cahnite, barite, calcite, mica, chlorite, kentrolite (von Knorring *et al.*, 1978), manganite, serandite, rhodonite and johninnesite (Dunn *et al.*, 1986). The bornite-chalcopyrite-galena ore of the Kombat Mine is confined to drag-folds at the contact between phyllites of the Kombat Formation and dolomites of the underlying upper Tsumeb Subgroup, both of late Proterozoic age. Associated with the sulphide ores are lenses of iron and manganese minerals. The manganese lenses consist of layered hausmannite and barite (Dunn *et al.*, 1986). The hypogene ore is of epigenetic, hydrothermal origin. An age of 550 to 580 Ma is suggested for this mineralization (Geology Department, Tsumeb Corp. Ltd, 1979).

The nambulite found at the Figuerinha Mine, Brazil, occurs as the major constituent of 3 to 30 mm thick veinlets. It has fibrous, in places radially orientated, crystals with an intense orange colour. The maximum length is 1 cm. Minor amounts of alkali-feldspar, barites and calcite accompany the nambulite. The nambulite veins are hosted by massive braunite ore of the Proterozoic lower Santa Cruz Formation of the Jacadigo Group. The Jacadigo Group consists of a sequence, maximum thickness 550 m, of clastic and chemical sediments deposited in a late Precambrian epicontinental basin. The ore is believed to be of primary sedimentary origin, but the presence of braunite and the metamorphic texture of the ore at the Figuerinha Mine contrast with the sedimentary texture of the cryptomelane ore elsewhere in the Urucum District. It is therefore suggested that contact metamorphism has modified the Figuerinha ore (Schneider, 1984).

TABLE 1: Chemical composition of three nambulite samples (* after Yoshii *et al.*, 1972; ** after von Knorring *et al.*, 1978)

	SiO_2 %	MnO %	FeO %	Na_2O %	K_2O %	Li_2O %	MgO %	CaO %	Al_2O_3 %	H_2O %	TOTAL %
Funakozawa Mine*	49.23	40.67	0.36	2.49	0.04	1.55	1.32	0.81	0.37	1.90	98.74
Kombat Mine**	48.97	40.30	0.15	3.12	-	0.98	2.16	2.87	-	1.70	100.25
Figuerinha Mine	50.37	41.18	0.58	0.99	-	1.00	1.26	1.84	-	nd	97.22

3. CHEMICAL COMPOSITION

The chemical analyses (Table 1) reveal similarities between the major components of nanibulite samples from the three localities. However there is considerable variation in the minor elements present in the different nambulite specimens.

The analyses show that nambulite from the Funakozawa Mine is relatively rich in lithium and sodium and poor in calcium, with medium contents for iron and magnesium compared to both other localities, and is the only sample with a detectable amount of potassium. The specimen from Kombat is extremely low in iron but is rich in magnesium, calcium and sodium, and is poorer in lithium than the sample from Funakozawa Mine. Nambulite from Figuarinha Mine has a very high iron content, medium values of magnesium and calcium, and very little sodium. The Figuerinha and Kombat nambulites contain the same amount of lithium.

4. X-RAY DIFFRACTION STUDY

X-ray powder data from the three nambulite specimens show good correlation of d-spacing values, but variations in the intensity of the X-ray reflections do occur (Table 2). The cell dimensions of nambulite are listed in Table 3.

In general, the cell dimensions are very similar, differing in the range of only two to three hundredth of an Å.

There is almost no variation in the direction of the c-axis. Measurements differ for the a- and b-directions, with by far the largest variation for the latter. Nambulite from the Funakozawa Mine has the largest unit cell,

TABLE 2: X-ray powder data of nambulite from three localities (* after Yoshii *et al.*, 1972).

h k l	Funakozawa*		Figuerinha		Kombat	
	d[Å]	I	d[Å]	I	d[Å]	I
-1 1 0	7.11	25	7.09	40	7.07	44
0 0 1	6.70	25	6.67	31	6.65	39
0 2 0	5.62	10				
-1 0 1	5.21	15	5.19	24	5.18	4
1-1 1	4.75	15			4.74	20
0 2 1,-1 2 1, 1-2 1	4.13	10				
1 2 0	3.92	10			4.11	3
-1 3 0			3.81	14	3.78	5
-2 2 0	3.56	20				
1 2-1	3.54	35	3.54	34	3.54	34
1 3-1, 0 0 2, 2 0-1	3.35	40	3.34	50	3.34	29
0-1 2	3.27	10				
-1 0 2, 0 3 1	3.17	65	3.17	98		
0 1 2	3.14	45	3.14	100	3.15	44
-1 1 2	3.09	55	3.09	33		
2-2 1	3.07	60			3.07	53
2 0 1	3.05	10	3.05	98		
1 1-2	3.01	30	3.01	83		
0-2 2	2.97	80				
1-1 2	2.96	100	2.96	88	2.96	100
-1 4 0, 1 0 2	2.92	70	2.92	88	2.92	25
1-2 2	2.81	10	2.82	13	2.81	3
1 1 2, 2 2 0	2.71	35	2.71	60	2.70	16
-1 4 1			2.64	36		
2 2-1	2.62	40	2.61	38		
-2 0 2			2.60	19	2.60	24
-2 2 2,-3 2 0,-3 1 0	2.51	15	2.52	23		
-1 3 2	2.49	30	2.49	58	2.49	21
1 2 2	2.41	10	2.42	42	2.41	7
-3 3 0	2.38	5				
2-2 2	2.37	10			2.37	6
-3 3 1			2.28	13	2.29	2
1-5 1, 2 3-1, 0 5 0	2.25	15				
2-3 2, 1-4 2, 0-4 2	2.24	20	2.24	13		
0-1 3	2.22	30	2.22	52		
3-3 1, 3 0 1,-1 0 3	2.20	45			2.21	14
-3-1 1, 0-5 1,-3 4 0	2.18	10	2.19	41	2.19	28
-1 4 2			2.16	10	2.17	5
1 3 2	2.11	10	2.11	14	2.11	4
0 4 2,-2 4 2,1 0 3	2.07	10	2.07	9	2.07	3
1 4-2, 1 2-3,-1-4 2	2.04	10	2.04	9	2.05	6
-2 1 3, 2 3-2,-2 0 3,-3 3 2	2.00	15	1.99	10	1.99	4
-4 1 0			1.88	25	1.88	3
2-61	1.85	35			1.85	7
0-4 3, 2 0 3, 4 0 0	1.81	5			1.82	5
-3-3 1			1.79	9	1.79	3
4-2 1			1.78	11		
1-6 2			1.73	16	1.73	2
4-4 1, 2 5 0, 2 3-3	1.70	25	1.70	26		
-3 6 1, 2-4 3, 1 6 0	1.69	25			1.69	13
3-5 2,3 1-3	1.675	20				
0 0 4,-4 0 2, 3 3-2	1.670	35			1.67	24
1 5 2, 0-2 4	1.63	10			1.63	3

and the sample from Kombat Mine has the smallest cell parameters.The variations in the crystal lattice of the three nambulite specimens are due to different amounts of cations in the structure. Sodium is partially replaced by potassium in the sample from Funakozawa Mine. Manganese is replaced to varying degrees by calcium, magnesium and iron in all three samples. The relatively large unit cell of the sample from the Funakozawa Mine is probably related to the replacement of sodium (Ø 0.97 Å) by potassium (Ø 1.45 Å). Nambulite from the Figuerinha Mine has the highest iron content, which indicates replacement of manganese (Ø 0.80 Å) by the smaller iron (Ø 0.74 Å). The low sodium content of this sample may be due to the fact that not all sodium positions in the structure are occupied. Nambulite from the Kombat Mine, which has the smallest unit cell, shows high replacement of manganese (Ø 0.80 Å) by magnesium (Ø 0.66 Å).

5. GENETIC ASPECTS

Ito (1972) studied the synthesis of hydrous Li-pyroxenoids under a wide range of experimental conditions. Narita *et al*. (1975) stated that due to the difference in size of sodium and lithium, the distribution of these two elements in the nambulite structure is random. Therefore a wide range of $(Li,Na)_2Mn_8Si_{10}O_{28}(OH)_2$ solid solutions could be expected. However, a phase with Li: Na = 1:1, as in nambulite, failed to crystallize under the conditions used in Ito's (*op. cit.*) study. The maximum substitution of lithium by sodium is reported as 30% at 720°C and 2 kbar.

Natural nambulite occurs in vein systems in rocks that have been subjected to metamorphism and metasomatism. The volcanogenic - sedimentary manganese orebodies in the Kitakami Mountainland of Japan were contact-metamorphosed by late Cretaceous granitic intrusives (Roy, 1976). A contact-metamorphic event was proposed for the braunite ore body of the Figuerinha Mine in Brazil on mineralogical and textural grounds (Schneider, 1984). The mineral assemblage of the Kombat manganese ore, with hausmannite as the main manganese mineral, points to a moderate grade of metamorphism thought to be related to the second Damaran tectono-thermal event, associated with widespread intrusions of granitoids (Innes and Chaplin, 1986).

The occurrence of cross-cutting vein systems in ores from all three localities proves the presence of a late stage hydrothermal activity in connection with the metamorphism. It is therefore suggested that nambulite forms under low temperature and pressure conditions in hydrothermal systems related to contact metamorphism. No external supply of elements is necessary, since all components for the formation of nambulite can be derived from the surrounding ore.

6. ACKNOWLEDGEMENTS

My colleague Mr. M. Diehl is thanked for carrying out microprobe analysis of two nambulite samples at the University of Cape Town. Thanks are also due to Dr. H.-J. Lauenstein, who provided a sample of nambulite from the Kombat Mine.

7. REFERENCES

Dunn, P.J., Peacor, D.R., Su, S.-C., Nelen, JA and von Knorring, O. 1986. Johninnesite, a new sodium manganese arsenosilicate from the Kombat Mine, Namibia. *Mineralog. Mag.*, **50**, 667-670.

Geology Department, Tsumeb Corporation Ltd. 1979. *The Kombat/Asis West Mine*. Unpublished internal report.

Innes, J. and Chaplin, R.C. 1986. Ore Bodies of the Kombat Mine, South West Africa/Namibia 1789-1805. *In*: Anhaeusser, C.R. and Maske, S., Eds., *Mineral deposits of southern Africa*. Spec. Pub. Geol. Soc. S. Afr., 2335 pp.

Ito, J. 1972. Synthesis and crystal chemistry of Li-hydropyroxenoids. *Mineralog. J.*, **7**, **No.1**, 45-65.

Narita, H., Koto, K., Morimoto, N. and Yoshii, M. 1975. The crystal structure of nambulite $(Li,Na)Mn_4Si_5O_{14}(OH)$. *Acta cryst.*, **B31**, 2422-2426.

Roy, S. 1976. Ancient manganese deposits, 395-470. *In*: Wolf, K.H., Ed., *Handbook of strata-bound and stratiform ore deposits*. **7**, Elsevier, Amsterdam, 656 pp.

Schneider, G. and Urban, H. 1983. Ein neues Vorkommen von Nambulit, ein seltenes Lithium- und Natriumhaltiges Mangansilikat vom Urucum-Distrikt, Brasilien. *Fortschr. Miner*., **61 Beih. 1**, 195-196.

Schneider, G. 1984. Zur Mineralogie und Lagerstattenbildung der Mangan- und Eisenerzvorkommen des Urucum-Distriktes (Mato Grosso do Sui, Brasilien). *Frankfürter Geowiss. Arb*., **Serie C, 1**, 205 pp.

TABLE 3: Cell dimensions of nambulite from three different localities (* after Yoshii *et al.*, 1972; ** after von Knorring *et al.*, 1978).

	Funakozawa*	Kombat**	Figuerinha
a	7.621 Å	7.603 Å	7.603 Å
b	11.761 Å	11.729 Å	11.741 Å
c	6.761 Å	6.730 Å	6.730 Å
α	92°46’	92°38’	92°49’
β	95°05’	94°48’	94°59’
γ	106°52’	106°33’	106°43’

Von Knorring, 0., Sahama, Th.G. and Törnroos, R. 1978. Second find of nambulite. *Neues Jb. Miner. Mh*., **1978/8**, 346-348.

Yoshii, M., Aoki, Y. and Maeda, K. 1972. Nambulite, a new lithium- and sodium-bearing manganese silicate from the Funakozawa mine, northeastern Japan. *Mineralog. J.*, **7**, 29-44.