occurred at lower P and similar or slightly lower T. The low X_{Mg} value in this zincian-staurolite indicates that it formed at medium to low P conditions, as high Mg content stabilizes this mineral at high P and T conditions (Schreyer, 1988).

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Namansilite, NaMn³⁺Si₂O₆: a widespread clinopyroxene?

NAMANSILITE, the manganese analogue of aegirine, jadeite, and kosmochlor, has been named and described by Kalinin *et al.* (1992) from the Irnimiski deposit in the Far East of Siberia. An $Na(Mn^{3+},Fe^{3+})$ clinopyroxene with up to 88.3 mol.% of the Mn (namansilite) end-member had previously been described by Ashley (1986) from a Lower Paleozoic stratiform manganese ore body at the Hoskins mine near Grenfell in the Lachlan Fold Belt of New South Wales, Australia (also mentioned by Eggleton and Ashley, 1989), and the same mineral, referred to as 'Na–Mn-clinopyroxene', has also been described by Basso *et al.* (1989) from Val di Vara in the Northern Apennines, Italy. Here we report namansilite from the Woods mine manganiferous deposit in the Woolomin Formation of the New England Fold Belt, New South Wales. Electron microprobe elemental distribution maps for Na, Mn, Si, and Ca in the new mineral, in association with kozulite, have already been presented by Kawachi (1991).

Occurrence at Woods Mine and physical properties

The Woolomin Formation contains metabasalt, chert, ash-fall tuffs, siliceous sandstone, and

rare volcaniclastic sandstone, in comparatively thin thrust slices (Cawood, 1982) and melange (Cross et al., 1987). It has yielded microfossils of Silurian and Carboniferous age (Ishiga et al., 1988). Included in the formation are numerous small, bedded manganese deposits containing manganese oxides, rhodonite, and other minerals (Kawachi, 1987 and 1991). The Woods mine deposit, 30 km NNE from Tamworth, New South Wales (standard grid reference LL099906, 1:100 000 topo map Bendemeer) is in the contact aureole of the Glencair undifferentiated adamellite intrusions. It has been excavated for ornamental stone and contains a large number of manganese and other minerals including braunite, kozulite, serandite, quartz, aegirine, sugilite, rhodonite, tephroite, barite, and apatite. Analyses of the rhodonite and serandite are given by Kawachi (1987) and of kozulite and sugilite by Kawachi (1991).

Namansilite occurs as aggregates of stout prismatic crystals up to 2 mm long in close association with kozulite forming irregular pods and laminae a few centimetres long. It tends to be moulded around kozulite and may partially replace it. It also occurs as scattered prismatic grains up to 15 μm long in quartz and in serandite and is locally in contact with dark brown manganian aegirine.

Optical properties of namansilite from Woods mine and other localities described in the literature are set out in Table 1. There are clearly some discrepancies between observations in the Table,

more especially in 2V and refractive index β. Our observations are that the mineral is biaxial negative with a small optic axial angle. Dispersion is very weak. The general appearance is very like that of piemontite, as has been pointed out by Ashley (1986). The pleochroism is strikingly similar, but prismatic sections of namansilite are consistently length-fast with $\alpha' \wedge c = 0\text{--}25°$, whereas prismatic sections of piemontite are elongated parallel to b perpendicular to the optic axial plane and may be either length fast or slow with straight extinction. The calculated density is 3.95 g cm^{-3}.

Chemistry

Results of electron microprobe analyses on specimen OU62058 carried out on a JEOL JXA 8600 electron microprobe analyser using wavelength dispersion and ZAF correction are set out in Table 2, together with comparative data from other localities. Standards used are synthetic oxides, synthetic $CaSiO_3$ for Ca, and natural albite and adularia for Na and K respectively.

The Woods, Irnimiski, and Val di Vara namansilites are all close to theoretical end-member composition, whereas for the Hoskins mine mineral, there is substantial solid solution with aegirine, Ashley (1986) reporting an overall range of compositions 11.3–81.7 mol.% aegirine and 15.7–88.3 mol.% namansilite. In some Woods specimens, namansilite is in contact with small grains and aggregates of dark-brown manganian

Table 1 Optical properties of namansilite.

	Woods, NSW	Irnimiski[1]	Val di Vara[2]
Absorption tints			
X	pale yellow	lemon yellow	pale yellow orange
Y	brownish red	raspberry red	red-violet
Z	reddish purple	blood red	red-violet
Absorption	Z > Y > X		
α	1.734(4)	1.746(4)	1.750(3)
β	1.85(1)	1.769[3]	1.795(3)
γ	1.87(1)	1.837[3]	1.835(3)
$\gamma - \alpha$	0.13	0.091	0.085
$2V_X$	~15°	15—20°	85(3)°
O. A. P.	(010)	(010)	
$X \wedge c$ in (010)	25°	20°	19°
Dispersion	imperceptible		

[1] Data from Kalinin et al.,(1992)

[2] Data from Basso et al. (1989)

[3] Calculated by Kalinin et al (1992) from α and $(\gamma - \alpha)$. The refractive indices are clearly incompatible with a statement in the text that the mineral is biaxial negative.

Table 2   Electron microprobe analyses of namansilite and manganian aegirine from Woods mine, New South Wales, and of namansilite from other localities.

	Woods, range namansilite	Woods nam	Woods aegirine	Irnimiski nam[1]	Val di Vara nam[2]	Hoskins nam[3]
Number of analyses	5	5	6	6	16	9
SiO_2	51.23 - 52.58	51.69	51.29	52.64	51.32	52.45
Al_2O_3	0.05 - 0.14	0.08	0.07	0.20	0.16	0.07
TiO_2	0.00 - 0.13	0.05	0.28	0.19	0.09	0.11
Fe_2O_3	0.31 - 1.97	1.11	26.60	1.65	0.18	5.41
Mn_2O_3	32.29 - 34.51	33.72	7.05	32.36	35.33	27.70
MgO	0.00 - 0.02	0.01	0.02	0.32	0.02	0.22
CaO	0.00 - 0.02	0.01	1.36	0.07	0.08	0.25
Na_2O	12.57 - 13.33	13.10	12.02	13.81	13.42	13.21
K_2O	b.d.l.	b.d.l.	b.d.l.	0.05	0.02	<0.04
SrO	b.d.l.	b.d.l.	b.d.l.	0.42	-	-
BaO	b.d.l.	b.d.l.	b.d.l.	0.05	-	-
ZrO_2	b.d.l.	b.d.l.	b.d.l.	-	-	-
Total		99.77	98.69·	101.76	100.62	99.42
Atomic proportions for 6 oxygens						
Si		1.987	1.994	1.987	1.965	2.013
Ti		0.001	0.008	0.005	0.003	0.003
Al		0.004	0.003	0.009	0.007	0.003
Fe		0.032	0.778	0.047	0.005	0.156
Mn		0.987	0.209	0.930	1.029	0.809
Mg		0.001	0.001	0.018	0.001	0.013
Ca		0.000	0.057	0.003	0.003	0.010
Na		0.976	0.906	1.011	0.996	0.983
K		-	-	0.002	0.001	0.000
Sr		-	-	0.009	-	-
Ba		-	-	0.001	-	-
Total		3.988	3.956	4.012	4.010	3.991

b.d.l.   Below detection limit.
[1] From Kalinin et al. (1992).   Ti reported as Ti_2O_3
[2] From Basso et al. (1989)
[3] From Ashley (1986).

aegirine. Such aegirine occurs in the same thin section as the namansilite analysed in Table 2, and six spot analyses show compositions ranging from $Ac_{81}Nm_{19}$ to $Ac_{75}Nm_{25}$ (average $Ac_{78}Nm_{22}$, Table 2), whereas the observed range of namansilite compositions is Ac_1Nm_{99} to Ac_6Nm_{94}, average Ac_3Nm_{97}, indicating a wide miscibility gap and much reduced solid solution compared with that reported by Ashley (1986).

The associated kozulite is very close to Mn end-member composition, e.g. SiO_2 49.24%, Al_2O_3 0.02, TiO_2 0.00, FeO* 0.06, MnO* 37.06, MgO 0.03, CaO 0.11, Na_2O 8.91, K_2O 0.03, Cr_2O_3 0.03, Total 95.48 (Kawachi, 1991). The observed kozulite–namansilite relationships thus indicate replacement of the kozulite by a dehydration-oxidation reaction closely analogous to the riebeckite–aegirine reaction (Ernst, 1962).

X-ray study

An X-ray powder diffraction data for Woods namansilite (Table 3) was compiled from replicate charts using Cu-$K\alpha$ radiation with monochromator, using varying quantities of quartz as internal standard. The pattern contains about twice as many indexed lines as the pattern given by Basso et al. (1989) and the less precise pattern of Kalinin et al. (1992). The presence of 220, $I =$ 13, at 3.139 Å, not listed by these earlier authors, is to be noted in particular. Cell dimensions were refined by using 21 lines having $d < 2$ Å and $I > 2$. The resulting unit cell is:

$a = 9.500(1)$, $b = 8.611(1)$, $c = 5.356(1)$,
$\beta = 105.00(1)°$, V = 423.14 Å^3.

This is essentially identical with the cells determined by Basso et al. (1989):

Table 3   X-ray powder diffraction data for namansilite from Woods mine, New South Wales.

I	d_{obs}(Å)	d_{calc}(Å)	hkl	I	d_{obs}(Å)	d_{calc}(Å)	hkl
66	6.29	6.279	110	15	1.5698	1.5697	440
5	4.588	4.588	200	12	1.5292	1.5304 / 1.5292	402 / 600
8	4.395	4.393	$\bar{1}11$				
45	4.305	4.305	020	4	1.5129	1.5130	$\bar{1}33$
8	3.683	3.684	111	12	1.5006	1.5006	350
13	3.139	3.139	220	3	1.4851	1.4852	$\bar{6}21$
100	2.925	2.924	$\bar{2}21$	3	1.4631	1.4644 / 1.4619	$\bar{3}33$ / $\bar{4}42$
100	2.883	2.882	310				
10	2.830	2.829	$\bar{3}11$	3	1.4411	1.4420 / 1.4391	422 / $\bar{5}13$
2	2.739	2.739	130				
19	2.585	2.586	002	10	1.4250	1.4351	060
3	2.553	2.556 / 2.554	$\bar{1}12$ / $\bar{2}02$	2	1.4107	1.4108 / 1.4094	133 / 233
50	2.499 / 2.495	2.502 / 2.495	$\bar{1}31$ / 221	23	1.3997	1.3998	531
				10	1.3760	1.3762	$\bar{3}52$
2	2.346	2.347	131	3	1.3080	1.3080	621
6	2.291	2.291	311	2	1.3048	1.3049	$\bar{3}14$
10	2.253	2.255	112	7	1.3003	1.3010 / 1.3000	$\bar{5}33$ / $\bar{7}12$
9	2.093	2.093	330				
22	2.072	2.072	$\bar{3}31$	7	1.2961	1.2958	710
15	2.051	2.051	$\bar{4}21$	5	1.2550	1.2549	062
3	2.037	2.038	202	7	1.2318	1.2317	352
15	1.9873	1.9874	041	2	1.2164	1.2166	460
10	1.8943	1.8938	$\bar{2}41$	2	1.1957	1.1959	$\bar{1}71$
5	1.8470	1.8469	$\bar{5}11$	3	1.1775	1.1776	171
5	1.8300	1.8305	331	2	1.1468	1.1469	800
2	1.8074	1.8075	$\bar{4}22$	3	1.1442	1.1446 / 1.1440	$\bar{6}04$ / $\bar{8}21$
3	1.7942	1.7948	510				
4	1.7604	1.7608	241	1	1.0613	1.0615 / 1.0610	$\bar{7}14$ / $\bar{8}23$
5	1.7537	1.7539 / 1.7535	421 / $\bar{1}13$	1	1.0550	1.0552	712
3	1.7265	1.7265	312	13	1.0430	1.0433 / 1.0430	533 / 750
23	1.6929	1.6926	150				
5	1.6549	1.6545	042	3	1.0363	1.0361	$\bar{6}62$
7	1.6389	1.6390	$\bar{2}23$	4	1.0312	1.0320 / 1.0311	821 / $\bar{5}71$
24	1.5791	1.5790	$\bar{5}31$				

$a = 9.500(1)$, $b = 8.610(1)$, $c = 5.353(1)$,
$\beta = 105.06°$

and by Kalinin et al. (1992):

$a = 9.513(4)$, $b = 8.615(3)$, $c = 5.356(7)$,
$\beta = 105.12(1)°$, $V = 423.75$ Å^3.

That for synthetic $NaMnSi_2O_6$ determined by Ohashi et al. (1987) was:

$a = 9.513(1)$, $b = 8.621(1)$, $c = 5.354(1)$,
$\beta = 105.14(1)°$, $V = 423.9$ Å^3.

Origin and prevalence of namansilite

The occurrence of namansilite at the Hoskins mine, New South Wales, is in rocks of upper greenschist facies about 1 km from granitoid intrusives. According to Ashley (1986) there is little evidence of contact metamorphic effects, though the greater extent of namansilite–aegirine solid solution compared with that at Woods may indicate that the temperature at Hoskins has been the higher. The Val di Vara occurrence is said to be in rocks of prehnite–pumpellyite facies, though the association with amphiboles (Basso et al., 1989) suggests that the grade of metamorphism may be slightly higher than typical prehnite–pumpellyite facies. The Irnimiski namansilite (Dzhavody section) is found only in veins up to 3 mm thick in braunite ore, in close association with taikanite, a new NaBaMn-silicate, pectolite, Mn-amphiboles, Mn-bearing orthoclase, Mn-phlogopite and other minerals; the veins are believed by Kalinin et al. (1992) to be the result of hydrothermal solutions related to small adjacent basaltoid intrusions.

All occurrences appear to be the products of relatively low-grade metamorphism of stratabound, highly oxidized, manganiferous sediments, now containing braunite and other minerals with Mn in the trivalent state. Barite and other Ba minerals are reported from all the occurrences. Such manganiferous metasediments are not rare, especially in the thick, relatively deepwater marine sequences of accretionary prisms and subduction zones. However, the requirement of high soda (Na in excess of available Al where feldspar is stable) is a constraint on the formation of namansilite and indicates more exceptional geochemical conditions. The presence of pectolite or its Mn analogue, serandite, in the four known occurrences is further evidence of availability of Na.

The fact that namansilite is so easily confused for piemontite, and that four quite independent and widely separated occurrences have been reported within a few years, suggest that this mineral may be less rare than its recent recognition might suggest.

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'Bellite' revisited

THE name bellite was introduced by W. F. Petterd (1905) for a 'chromo-arsenate of lead' from the Magnet mine, Russell County, Tasmania. The mineral was described as occurring as delicate tufts and velvet-like coated surfaces thickly lining and clustering in drusy cavities in somewhat soft iron-manganese gossan, as well as bright red to crimson hexagonal crystals up to three millimetres in length. A chemical analysis reported by Pettered is shown in Table 1.

In the seventh edition of *Dana's System of Mineralogy* (Palache *et al.*, 1951) bellite is regarded as being 'identical with or near mimetite', based on an examination which showed that the interfacial angles of crystals were close to those of mimetite, and chemical tests that indicated little or no Cr. The reported chemical analysis was regarded as being erroneous or representing a mixture.

A partial micro-analysis of bellite by the Tasmania Department of Mines (1970), shown in Table 1, gave a greatly reduced Cr content and higher Pb, As and Cl contents; the authors concluded that this new analysis is consistent with a mixture consisting of mimetite and crocoite close to 10:1.

Bellite was therefore generally regarded as a discredited species until it was given a new lease of life by Cesbron and Williams (1980) who synthesised a compound corresponding to the chemical formula $Pb_{10}(CrO_4)_3(SiO_4)_3Cl_2$, and called it bellite. The authors presented crystallographic and chemical data for this compound; their analysis is shown in Table 1.

Because of the confusion in the literature on bellite, it was decided to reinvestigate material from the type locality.

New data

Two specimens of bellite from the Petterd Collection of minerals were kindly provided by N. R. Kemp, Curator of Geology of the Tasmanian Museum and Art Gallery, 40 Macquarie Street, Hobart, Tasmania. The specimens, numbered X978 and X979, and labelled 'Bellite (phosphatian mimetite)' were reportedly from Magnet, Tasmania. Although we cannot be absolutely sure that these specimens represent 'type' material, their presence in Petterd's collection is strongly indicative.

The specimens consist largely of porous iron oxides and hydroxides, with an encrustation of yellow to reddish-orange prismatic crystals up to about 0.5 mm long and 0.1 mm wide. Under the scanning-electron microscope (SEM) the crystals are seen to consist of well-developed hexagonal prisms terminated by basal pinacoids, sometimes with the addition of pyramidal facets, typical of mimetite. Qualitative energy-dispersive spectra show that the principal chemical components are Pb and As, with relatively minor amounts of Cr, Si, P and Ga. The orange crystals contain more Cr than the yellow ones. No crocoite was observed.

X-ray powder diffraction patterns of the bellite are virtually identical to published data for mimetite, and it is therefore assumed that the mineral has the mimetite crystal structure.

A cluster of reddish-orange crystals from specimen no. X978, which contains larger crystals than X979, was embedded in epoxy resin, sectioned, and polished. The crystals were analysed by a Camebax SX-50 electron microprobe at an accelerating voltage of 20 kV and specimen current of 30 nA. The analyses were carried out to detect