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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

Table 1. Chemical analyses of bellite and $Pb_{10}(CrO_4)_3(SiO_4)_3Cl$; (all values in weight percent)

	1	2	3	4	5
PbO	61.68	70.0	78.21	76.16 - 79.94	80.15
As_2O_3	0.02	14.5	12.41	9.19 - 15.59	nd
P_2O_5	0.04	nd	2.20	1.11 - 3.77	nd
SiO_2	7.59	nd	1.48	0.77 - 2.45	6.42
Cr_2O_3	22.61	2.9	1.71	0.97 - 2.67	10.50
Ga_2O_3	nd	nd	0.11	<0.03 - 0.18	nd
Cl	0.52	2.5	2.22	1.96 - 2.56	4.00
- O = Cl	0.12	0.6	0.50		0.90
Total	92.34	89.3	97.84		100.17

(nd = not determined)

1. From Petterd (1905); additional components reported: V_2O_5 0.11, SO_3 0.05 and Al_2O_3 0.01%.
2. From Tasmania Department of Mines (1970).
3. This paper; average of 56 electron microprobe analyses.
4. This paper; range of values obtained.
5. Synthetic $Pb_{10}(CrO_4)_3(SiO_4)_3Cl$ (from Cesbron and Williams, 1980).

the following elements (standards in brackets): Pb (PbS), As (InAs), Si (forsterite), P (apatite), Cl ($PbCl_2$), Cr (Cr), and Ga (GaP). Ag and Ni were below detectable limits. The averaged values of 56 spot analyses, with range of values obtained for each component, are shown in Table 1. Also included in Table 1 are the analyses reported by Petterd (1905) and the Tasmania Department of Mines (1970), as well as the analysis of $Pb_{10}(CrO_4)_3(SiO_4)_3Cl_2$ synthesised by Cesbron and Williams (1980).

The microprobe analyses show that the bellite consists largely of PbO and As_2O_3, and with persistent, though somewhat variable, amounts of Cr, Cl, Si and P. These elements are evidently accommodated in the crystal structure of the mineral, rather than being due to admixed impurities as has been suggested by some authors. Calculation of correlation coefficients show that there are strong negative correlations between As and P (−0.80), Si (−0.83) and Cr (−0.90), which suggests that P, Si and Cr substitute for As in the crystal structure. This is to be expected considering the tendency of all four elements to adopt tetrahedral coordination. Assuming, then, that these elements substitute for each other in the mimetite structure, the chemical formula derived from the averaged analyses is $Pb_{5.00}As_{1.79}P_{0.44}Si_{0.35}Cr_{0.32}Ga_{0.02}Cl_{0.89}$, or $Pb_{5.00}(As,P,Si,Cr,Ga)_{2.92}Cl_{0.89}$. An unexpected result of the analyses is the Ga content, which has not previously been reported.

Conclusions

This work confirms that bellite is not a valid species, but that it can be regarded as a phosphatian, silicatian, chromatian mimetite. The high Cr values reported by Petterd are puzzling. There are a number of possible explanations. One is that his reported analysis, done by a Mr. J. D. Millen, was grossly in error, but this cannot be checked out because the analytical method has not been reported. Another possibility is that there are misprints in Petterd's (1905) paper; specific errors noted in the paper are a reported analytical total of 99.159% contrasted with the 92.51% given in Table 1, and the fact that chromium was reported as CrO_3, probably an error for Cr_2O_3. A further possibility that must be considered is that the analysed material contained an admixed high-Cr mineral. Crocoite ($PbCrO_4$) has been suggested, and is a logical contaminant because of its similar appearance to bellite, but as pointed out by the authors of the report of the Tasmania Department of Mines (1970), there is too little Pb in Petterd's original analysis to explain the discrepancy by the assumption that the analysed material was simply a mixture of mimetite and crocoite. Furthermore, the two specimens examined in this investigation contain substantial amounts of 'bellite', but no recognizable crocoite, so contamination by the latter is unlikely.

Whatever the explanation for Petterd's analytical results, the name 'bellite' should remain discredited as a species name. It is unfortunate that this name, long fallen into disuse, was used by Cesbron and Williams (1980) with reference to a synthetic product.

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Stellerite from Todhead Point, Grampian Region, Scotland

STELLERITE is a zeolite (named by Morozewicz in 1909) which has the same aluminosilicate framework as stilbite, the first mineral described as a zeolite by Cronstedt (1756) and later named by Haüy (1801). The two minerals differ in their alkali metal and alkaline earth contents. Stilbite has the unit cell formula $NaCa_4(Al_9Si_{27}O_{72}).30\ H_2O$ whilst that of stellerite contains only calcium, i.e. $Ca_4(Al_8Si_{28}0_{72}).28\ H_2O$ (Gottardi and Galli, 1985).

The earliest detailed compilation of zeolite locations in Scotland was that of Heddle (1901) and it contains analyses of two stilbite samples from Todhead Point (Grid Ref. No. 870769) which is on the east coast of Scotland approximately 9 km due south of Stonehaven (Grampian Region). Todhead Point is formed from igneous and sedimentary rocks of Old Red Sandstone (Devonian) age and the zeolites occur in an olivine basalt (Patterson, pers. comm.) as brick red lamellae, up to 1 cm, in amygdales. The basalt crops out immediately below the Todhead lighthouse and also in the adjacent Braidon Bay, north of the lighthouse. When samples collected from Todhead, and thought to be stilbite, were subjected to routine differential thermogravimetric analysis (DTG), using a Mettler TA 3000 instrument, an unusual thermal profile was noted (Fig. 1). Complimentary X-ray powder diffractometry (Philips APD 1700) suggested that the sample contained stellerite and some mordenite. Scanning electron microscopy (Philips 515) confirmed the presence of two distinct crystal morphologies, one stumpy, and one prismatic. The prismatic crystals were virtually sodium free with calcium being the predominant cation present. (EDAX analysis using a Philips 9100 instrument Fig. 2*a*).