Notes and News

A DESCRIPTIVE CLASSIFICATION OF EARLY ANGLO-SAXON COPPER-ALLOY COMPOSITIONS: TOWARDS A GENERAL TYPOLOGY OF EARLY MEDIEVAL COPPER ALLOYS (Fig. 1)

The composition of non-ferrous metals is notoriously varied during the early medieval period. An agreed terminology for alloy types would be of great assistance to all researchers in this field and the means by which such a classification may be achieved are discussed here. In many archaeological reports and discussions, the word 'bronze' is used for almost all copper alloys. In the worlds of art history and the sale room, the use of the same term for many types of copper-alloy objects is similarly regrettable, but firmly entrenched. Although the first phases of copper alloy use did genuinely consist solely of bronzes (copper-arsenic, copper-tin or copper-tin-lead), from the Roman period onwards the availability of zinc-containing copper alloys generated a larger overall range of alloy types. Where chemical analysis has not been performed, the non-judgemental term 'copper alloy' should always be used. Similarly the term 'white metal' should be used for all non-analysed cases instead of 'silver' or 'high-tin bronze'. These terms are generally acceptable, and widely used by archaeological scientists and conservators.

A desire for a universal typology for archaeological alloys is understandable but such definitions are at present premature. Instead, researchers should preferably use alloy-type definitions which are appropriate to the problem in hand, creating them at the time of research, if necessary. For example, a definition of 'bronze' for a Bronze Age dataset may not be appropriate to research in later periods; the type of metal simply may not have been in use. Definitions are also influenced by the extent of our knowledge of contemporary alloys, particularly with respect to the total range and overall balance. Furthermore, the nature of the hypotheses to be tested will influence the style of classification, for example, the perceived need for precision and accuracy within the research. A project concentrating on an artefact form only made from a limited range of copper-tin alloys might nevertheless require sub-division of the chemical dataset (perhaps on the basis of trace elements) to understand the system of artefact production. Finally, the amount and character of the data to be considered are clearly influential; it is especially important to be cautious when a project concerns a small or biased dataset.

One further consideration is highly significant. An alloy typology which suits the purposes of an archaeologist may not please a metallurgist (and vice versa). Type definitions based on an archaeological dataset may be thought too loose or too constricted. Naturally, terms originating from the metallurgical vocabulary will be used in archaeological work on metals, but definitions may not match their sense in strictly metallurgical contexts. Current metallurgical conventions would restrict the term 'copper' to metals with less than 1% of any alloying element, and would employ 'bronze' for all copper-tin alloys with up to 15% tin and less than 4% zinc. Other aspects of classification are not strikingly different to those employed in this paper.[1]

In view of the proposed project-specificity of alloy classifications, clearly all groups formed must be amenable to straightforward comparison with information from other data groups. For this purpose, all definition criteria should be clearly stated and access to the relevant datasets facilitated as much as possible.

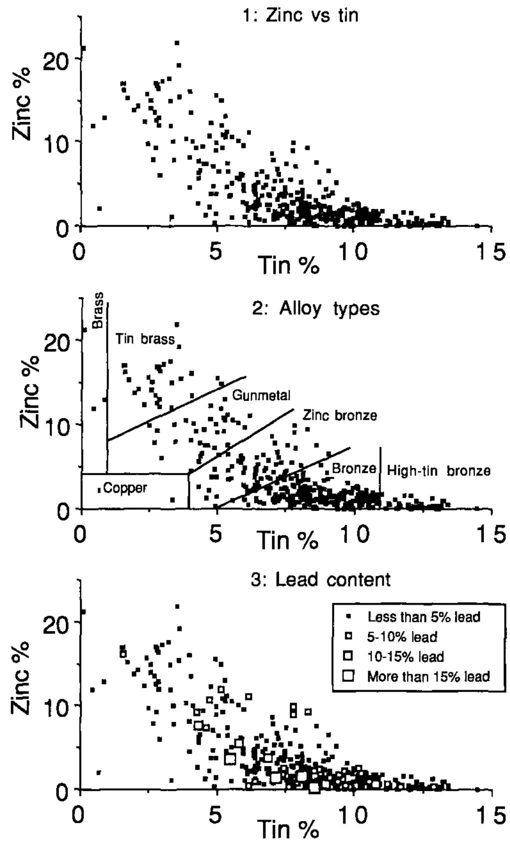

FIG. 1
1. Binary plot of zinc against tin
2. Alloy types 3. Lead content

A dataset of 360 analyses from a single type of early Anglo-Saxon artefact — the cruciform brooch — is used here to illustrate the formation of an alloy classification.[2] The study of early medieval copper alloys is in its infancy and so this work may be useful in several respects. Since cruciform brooches were cast and not subsequently worked to any degree the metallurgical constraints of the form are very tolerant — a broad range of bronzes or brasses are equally appropriate. Hence the range and balance of alloy types used in this dataset are more likely to be related to the general availability of copper alloy resources than would the range and balance of similar datasets including data from sheet metal or other worked metal artefacts. Conversely, this dataset provides little scope for speculation about the capacity for alloy design.

The alloying elements in this case are copper, tin, zinc and lead. Each of these elements is normally present at levels above 1 % in each of the artefacts analysed, the exceptions being in a small number of cases where high levels of either zinc or tin are seen.[3] Several other elements (see below) are also present in the metal, but at levels too low to have had a significant effect on the alloying characteristics.

Initial approaches to the alloying data were through a binary plot of zinc against tin (Fig. 1.1). This shows a continuum of datapoints, within which there are areas of denser concentration. Zinc and tin are strongly negatively correlated. Clearly, to design an alloy typology for this dataset purely in terms of hard and fast percentages would be inappropriate. Any sub-division of the dataset must take into account both the zinc-tin correlation and the non-uniformity of datapoint distribution. In this case, the author selected several constraining lines by eye.[4] These lines mark natural divisions within the data and most lie perpendicular to the axis of the distribution. For exceptional cases where the datapoints deviate from the general trend (at high or low values of zinc and/or tin) rather more abitrary divisions were introduced. The small number of samples means that these latter definitions are the most likely to be prone to alteration, after further analyses. All the delimiting lines can be expressed in mathematical terms, either by their gradient and intercept values (Table 1) or by elemental concentrations (see below and Fig. 1.2).

The following alloy types were defined:

Bronze — copper alloyed with tin, with only small amounts of zinc present. A small number of bronzes were noted for their high tin and low zinc contents; those with tin contents of over 11% were given the type high-tin bronze.
Zinc bronze — copper alloyed with tin, with significant amounts of zinc present.
Gunmetal — an alloy containing copper, tin and zinc.
Tin brass — copper alloyed with zinc, with more than 1% tin present.
Brass — an alloy containing copper and zinc, with only small amounts of tin present (less than 1%).[5]
Copper — an alloy with very little tin or zinc present (less than 4% of either element).
Upper concentration limits need not be given for each element since this particular dataset has reasonably clear 'edges' to its distinction. This type of restriction may prove necessary in future research.

TABLE 1

POSITION OF DELIMITING LINES IN THE COPPER-ALLOY CLASSIFICATION (WHERE NOT PERPENDICULAR TO THE X AND Y AXES)

Line forming division between	*and*	*Gradient*	*Intercept*
Tin brass	Gunmetal	1.25	7.75
Gunmetal	Zinc bronze	1.55	−2.5
Zinc bronze	Bronze	1.0	−5.0

The proportion of lead present also has to be considered because lead has highly significant effects on the properties of copper alloys. In this dataset, lead is generally present at less than 5%, but there are many instances of higher levels of concentration. However, a plot with the concentration of lead represented (Fig. 1.3) demonstrates little significant patterning. The majority of high lead values are found in the bronze and zinc bronze categories, this merely reflects the overall prevalence of these alloy types in the dataset.

Alloys with large amounts of lead (in this case, 5% is suggested as a lower limit) may be classified as leaded bronzes, leaded zinc bronzes etc. 'Quaternary copper alloy' is the logical term for metals with copper, tin, zinc and lead all present at high levels (leaded gunmetal is an alternative); six examples exist in this dataset. The term 'ternary alloy' should be avoided where possible, since it could refer to any combination of the alloying elements.

The above constitutes an alloy classification; it does not concern itself with information about trace element concentration. Several elements are frequently present in these alloys at concentrations between 0.001% and 1%; iron, nickel, arsenic, cobalt, bismuth, gold, silver, antimony, sulphur. This type of data certainly presents some interesting possibilities, but it must be used with an awareness of the difficulties of interpretation. Trace element concentrations in artefacts represent the final result of a series of high-temperature episodes (refining, smelting, alloying and recycling) on the balance of trace elements present in the freshly-mined ore.[6]

One cannot here embark on a thorough review of the position of this alloy classification within early medieval copper alloys generally, in view of the magnitude of the subject. However, this dataset may be usefully compared with data from cruciform brooches from other areas,[7] with other Anglo-Saxon artefacts[8] or with contemporary material from the Continent and Scandinavia.[9] Evidence so far collated indicates significant regional and chronological variations, in both the types of alloys present and the frequency of alloy type usage. It seems likely that future research will require different alloy classifications or a modification of the present one, particularly in the areas of high-zinc and high-tin copper alloys.

This note represents only a preliminary outline, and forms a working classification for this archaeological dataset. The simple method of selecting constraints is open to criticism, but it does at least provide a sub-division of the dataset which is comprehensible. I await the opinions of other interested parties.

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NOTES

[1] Information from Peter Northover, Dept of Materials, University of Oxford.

[2] The data was compiled for research on early medieval copper-alloy technology (C. Mortimer, *Some aspects of early medieval copper-alloy technology, as illustrated by a study of the Anglian cruciform brooch*, unpubl. D.Phil. thesis, Oxford University, 1990). Analyses performed by atomic absorption and electron micro-probe analysis. Thanks are due to Helen Hatcher (Research Laboratory for Archaeology, Oxford), Peter Northover and Chris Salter (Department of Material Sciences, Oxford) and many curators for access to collections here and abroad.

[3] Amongst alloys with high zinc levels, very low concentrations of tin are found (and vice versa).

[4] More complex procedures, such as cluster analysis did not seem necessary.

[5] This classification does not provide detailed information on brasses, as there were few high-zinc alloys in the dataset.

[6] Mortimer, op. cit. in note 1, 362–71.

[7] For the analyses of 135 other cruciform brooches from Scandinavia and the Continent see Mortimer, op. cit. in note 1, 390–96.

[8] See for example, R. Brownsword. T. Ciuffini and R. Carey, 'Metallurgical analyses of Anglo-Saxon jewellery from the Avon Valley', *West Midland Archaeology* 29 (1986), 101–12; the unpublished paper by P. Northover, 'Analysis of cast saucer brooches from the Upper Thames'; C. Mortimer, M. Pollard and C. Scull, 'X-ray fluorescence analysis of some Anglo-Saxon copper alloy finds from Watchfield, Oxon', *Journal of Historical Metallurgy* 20.1 (1986), 36–42.

[9] For example, in Sweden the metalworking debris at Helgö (K. Lamm, 'The Manufacture of Jewellery during the Migration Period at Helgö, Sweden', *Journal of Historical Metallurgy* 7.2 (1973), 1–7) and brooches from Öland (B. Arrhenius, 'Die technischen voraussetzungen für die Entwicklung der Germanischen Tierornamentik', *Frühmittelalterliche Studien* 9 (1975), 93–109), in Denmark various brooches (U. Näsman, 'Metal supply in Eketorp', *Early Medieval Studies* 6 (1973), 97–103) and in France pioneering analyses on Merovingian artefacts (E. Salin, *La Civilisation Merovingienne* (1957), vol. 3, 169 ff.). Research is also currently underway on Roman imports to Denmark (H. Bollingberg, National Museum, Copenhagen) and on French material (C. Mortimer).

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A TREWHIDDLE-STYLE HOOKED TAG FROM HIGH WYCOMBE, BUCKINGHAMSHIRE (Fig. 2, Pl. II, A)

A fine example of a decorated late Saxon silver hooked tag was discovered with a metal detector by Mr W. Parkin at High Wycombe in 1989. There were no associated finds, nor are any known in the immediate area. The find was made on land belonging to Sir Francis Dashwood and, following a coroner's decision not to hold an inquest, was purchased by Buckinghamshire County Museum at Aylesbury.[1]

The circular disc of the piece has two protruding stitch loops and a complete hook with an overall length of 44 mm. The disc, diameter 21 mm, is defined by a band of 35 beads at the periphery and contains a circle divided axially into four equal segments. Within each segment is a single stylized animal with head facing over its shoulder; three of these proceed anticlockwise around the disc, whilst the remaining animal faces the other way. Inspection under a binocular microscope reveals slight traces of a crystalline substance, which is likely to be niello, at a few points in the recessed areas. Along the arm of the hook is a simple trapezoidal incised shape reflecting the taper of the hook. The rear of the plate is plain. The