HOARDS, HOUNDS AND HELMETS

A Conquest-Period Ritual Site at Hallaton, Leicestershire

Vicki Score

with contributions by

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Summary

This volume presents the results of survey and excavation between 2001 and 2009 on farmland in the parish of Hallaton, Leicestershire, undertaken by Hallaton Field Work Group and University of Leicester Archaeological Services. Following an initial find of over 200 Iron Age and Roman coins in 2000, the excavations revealed a hilltop ritual site with numerous special deposits of metalwork and animal bones, many of them dating to around the time of the Roman invasion in AD 43. The site does not fit easily into the tradition of formal late Iron Age shrines known from southern Britain. It is a large open-air site on the edge of a hill, demarcated by a polygonal boundary ditch with an entrance guarded by ritually bound dogs. The discovery has important implications for understanding the complex social dynamics of the peoples of the East Midlands before, during and just after the Roman conquest. The site provides a new model for helping understand similar deposits of metalwork and coins elsewhere in late Iron Age Europe.

Offerings probably began in the later 1st century BC with the deposition of a group of gold coins, but the most spectacular events took place in the early to mid 1st century AD. At least 16 hoards of Iron Age gold and silver coins, many also containing Roman *denarii*, and unusual deposits of metalwork were carefully placed in specific zones on the site. The latest Roman coin in the hoards was an issue of Claudius dating to AD 41/2 and in all over 5000 Iron Age and Roman coins were recovered from the site. The metal finds included parts of Roman cavalry helmets, a silver bowl and silver and copper alloy ingots. The presence of such rich offerings and the apparent use of the entranceway to restrict access to the interior might suggest use by a few elite individuals. However, the discovery of a mass of pig bone outside the entranceway and the composition of the individual coin hoards strongly suggest that instead the site drew people from all over the region at specific times to participate in communal rituals and feasting.

The release in 2003 of information about the coin hoards and Roman helmet from this rural hilltop captured the imagination of the press, public and archaeologists alike. The real value of the discovery, however, is that, following the initial metal detecting finds, the site was then explored using controlled survey and excavation techniques. Unlike many deposits of Iron Age metalwork or coinage in the landscape, here much has been learnt about the specific archaeological context. Without the added knowledge from follow-up fieldwork, this find too would probably have been interpreted as one large dispersed hoard. The success of the project owes much to the sheer determination of the local fieldworkers. Close co-operation between the finder, landowners, local community, amateur and professional archaeologists and national bodies enabled the site to be excavated without significant damage from illicit metal detecting. The wealth of information retrieved from Hallaton raises questions about the interpretation of similar metalwork deposits that have not benefited from systematic fieldwork and the attentions of a persistent and enthusiastic local fieldwork group.

6 Scientific Analysis of the Objects

Analysis of Silver and Other Metal Objects – *Julia Farley*

A programme of analysis was carried out on two ingots (one silver and one copper alloy), the silver bowl, and a group of silver coins from the site. A variety of techniques were used to reveal information about the composition and structure of the objects, including ICP-OES, XRF and NDA. These techniques are discussed in more detail below. In combination, these analyses reveal information about the alloying processes used to produce different objects, the organisation of production, and the circulation of precious metals in late Iron Age Britain.

The ingots

Samples and methodology

Two of the Hallaton ingots (Chapter 5, Nos 43–44) were analysed using ICP-OES (Inductively coupled plasma-optical emission spectroscopy). Three samples of approximately 20mg were drilled from each ingot using a 0.8mm titanium-coated drill bit. The first 1mm of material was discarded to avoid contamination from surface corrosion. The samples were taken from three different points around the edge of the semi-circular ingot (samples A, B and C), and from points near each apex on the curved underside of the triangular ingot (samples D, E and F).

The ICP-OES analyses were carried out by Lin Marvin from the Department of Geology at the University of Leicester on a Horiba Jobin Yvon Ultima2 spectrometer, following the technique outlined by Gitler and Ponting (2003, 17–18). A 2mg sample dissolved in nitric acid was used to determine the Ag and Cu content, while a 10mg sample dissolved in aqua regia was used to give a quantitative analysis of the minor and trace components. The elements tested for were antimony (Sb), arsenic (As), bismuth (Bi), cobalt (Co), copper (Cu), gold (Au), iron (Fe), lead (Pb), manganese (Mn), nickel (Ni), silver (Ag), tin (Sn), titanium (Ti) and zinc (Zn). The results were obtained using direct metal standards and certified standard solutions.

Results

The accuracy of these results, by comparison with certified standard reference metals and solutions, is approximately 2–3% for major elements and 5–6% for minor and trace elements. The elements recorded in Table 13 as being below detection limits had very low concentrations of <0.05ppm which would equate to concentrations of <0.002%.

These results show that the semi-circular ingot (No. 43) is a tin bronze, approximately 85% copper to 13% tin, with the remainder of the alloy consisting of trace amounts of arsenic, gold, cobalt, iron, nickel, lead, antimony and zinc. The triangular ingot (No. 44) is high in silver (around 83%). The silver is debased with copper (around 15%), and also contains small amounts of gold, cobalt, iron, lead, antimony, tin and zinc.

The samples from each ingot were taken from different and widely spaced points. The close agreement

Table 13 ICP-OES results for samples from the semi-circular ingot (No. 43) and the triangular ingot (No. 44). Titanium was also tested for to assess the level of any sample contamination from the titanium-coated drill bits. Levels of titanium were below detection limits for all samples. (BDL: below detection limits; ND: not detected).

Sample	Concentrations as Weight % (normalised to 100%)												
	Ag	As	Au	Bi	Co	Cu	Fe	Mn	Ni	Pb	Sb	Sn	Zn
Semicircular A	BDL	0.049	0.743	BDL	0.007	86.011	0.344	ND	0.062	0.298	0.086	12.356	0.043
Semicircular B	BDL	0.054	0.773	BDL	0.008	84.697	0.401	ND	0.064	0.315	0.097	13.506	0.085
Semicircular C	BDL	0.049	0.749	BDL	0.007	85.378	0.355	ND	0.063	0.285	0.087	12.990	0.037
Semicircular (average)	BDL	0.051	0.755	BDL	0.008	85.368	0.366	ND	0.063	0.299	0.090	12.947	0.054
Triangular D	82.464	BDL	0.614	BDL	0.003	15.098	0.213	ND	BDL	0.546	0.013	0.980	0.068
Triangular E	82.887	BDL	0.556	BDL	0.003	14.946	0.201	ND	BDL	0.504	0.012	0.850	0.041
Triangular F	83.211	BDL	0.560	BDL	0.003	14.856	0.069	ND	BDL	0.474	0.010	0.789	0.028
Triangular (average)	82.847	BDL	0.577	BDL	0.003	14.969	0.162	ND	BDL	0.509	0.012	0.875	0.046

between the results, both in terms of the major components of the alloy and the trace elements detected, shows a high degree of metallurgical homogeneity within each artefact.

Interpretation and conclusions

Before analysis both the semi-circular and triangular ingots were believed to be silver. In fact, the two ingots emerged as strikingly different in composition, with the semi-circular ingot containing no silver at all. This highlights the need for scientific analysis to determine the composition of such objects, both for the archaeological information this can provide and also to ensure that correct conservation procedures are followed.

The triangular ingot is known to have been produced (at least in part) by melting down coinage. Two coins are visible half-melted into the flat upper surface, at least one of which appears to be a local *North-Eastern* issue (Chapter 3; Figure 61 above). As discussed below, the composition of the triangular ingot, in particular the silver content, the presence of a variety of trace elements including zinc, and the amounts of lead and tin, suggests that the ingot was produced by recycling a non-selective mixture of *North-Eastern* coins, rather than debasing silver bullion with a copper alloy. The Pb–Sn–Zn ratio and the ratio of silver to copper are both extremely close to the mean values for the *North-Eastern* coins tested in this study.

The bowl

Sample and methodology

A sample of around 20mg was scraped from the edge of the damaged area at the base of the bowl (Chapter 5, No. 30) and analysed using ICP-OES. The analysis was done by Chris Walne at the London Assay Office, on behalf of the Worshipful Company of Goldsmiths. The analyses were carried out on a Perkin Elmer DV 7300 ICP Spectrometer, using a method similar to the one outlined above. Sample sizes used were from 2–4mg for Ag, Cu, Au and Pb and up to 10mg for the trace elements. The elements tested for were Ag, As, Au, Bi, Cd, Co, Cu, Fe, In, Mn, Ni, Pb, Sb, Sn and Zn. The results were obtained using direct metal standards and certified standard solutions. An internal standard of 1ppm Yttrium was also used. We are grateful to Chris for permission to publish these results.

Results

The elements recorded as being below detection limits (iron, nickel, zinc and arsenic) had very low concentrations in the sample of <0.05ppm which would equate to concentrations of <0.002%. The bowl is high in silver (84%), debased mainly with copper (13%) and also containing traces of gold, lead and tin (Table 14).

Interpretation and conclusions

As will be discussed in more detail below, these results are consistent with a production route involving the debasement of a relatively pure silver alloy with copper. Recycling of lower purity silver objects (such as local coinage) would be expected to result in a higher proportion of tin to lead, and also the presence of a wider variety of trace elements (as seen in the triangular ingot).

The silver bullion available to late Iron Age metalworkers (deriving ultimately from the Mediterranean world) was not pure, but contained small quantities of lead, gold and bismuth, generally accounting for around 1–2% of the alloy (Scott 2011, 28–9). These elements derived either from the ore itself, or the extraction process (Craddock 1995, 211–14; Dennis 2006, 54). The total of these elements gives an idea of the bullion content of the silver alloy used to make the bowl, which is around 86%. The silver bullion was debased with a relatively pure copper alloy, containing around 98% copper to 2% tin. The relative purity of the alloys used suggests that this was a carefully undertaken project, probably carried out by an experienced metalworker who intended to produce an alloy with specific qualities. Pure silver is extremely soft, and the addition of around 13% copper would have made the resulting alloy harder and more durable, whilst maintaining its ductility. Roman silversmiths always debased the silver used to produce Roman silver plate with at least 1–5% copper (Strong 1979, 4) to increase the durability of the metal. However, 1st-century Roman silver plate is not generally debased by more than 10% (*ibid.*; Dennis 2006, 119), with much lower levels the norm. Thus, the relatively high copper content of the bowl alloy could support the hypothesis that this object was produced in Britain.

Table 14 ICP-OES results for the bowl (No. 30), analysis carried out by Chris Walne, Senior Assayer at the London Assay Office. (BDL: below detection limits; ND: not detected).

	Concentrations as Weight % (normalised to 100%)														
	Ag	**As**	**Au**	**Bi**	**Cd**	**Co**	**Cu**	**Fe**	**In**	**Mn**	**Ni**	**Pb**	**Sb**	**Sn**	**Zn**
Bowl	84.03	BDL	0.404	ND	ND	ND	12.78	BDL	ND	ND	BDL	1.816	ND	0.292	BDL

The coins

Sample and methodology

Thirty-six coins were tested, including 24 Iron Age British coins from the *North-Eastern* series, representing a variety of uninscribed and inscribed types. Each type sampled was represented by three coins. Two coins of Cunobelin and four Roman *denarii* were also tested. With the exception of one Roman coin, all were from Hallaton. Six replica coins were also tested for comparative purposes. The replicas were made from an alloy of 90% silver and 10% copper, using techniques similar to those thought to have been used in Iron Age Britain. Neil Burridge, the metalworker responsible for producing the replicas, has worked extensively with Philip de Jersey (De Jersey 2009) to investigate Iron Age coin production techniques.

The coins were first tested using WDXRF (wavelength dispersive X-ray fluorescence) to give a preliminary indication of their composition. The WDXRF analyses were carried out with the assistance of Nick Marsh in the Department of Geology at the University of Leicester, on a PANalytical Axios Advanced PW4400 XRF spectrometer. Semi-quantitative analyses were performed on data collected from 2θ scans, covering the energy/wavelength range from Ce Ka to O Ka, Am L lines to V L lines. The samples were analysed under vacuum conditions (<10Pa). Data reduction and semi-quantitative determinations were performed using PANalytical IQ+ software. Since surface preparation was not undertaken, the XRF results cannot be regarded as fully quantitative, and for this reason are not reproduced here, although aspects of the findings will be discussed below.

The NDA (neutron diffraction analysis) was carried out on the GEM instrument at the ISIS research facility in Oxfordshire, with the assistance of the instrument scientist, Winfried Kockelmann. The experiment was run by the author, Sarah Hainsworth and Simon Lawes (from the University of Leicester's Department of Engineering) and Frank Hargrave (from Harborough Museum). The coins were mounted in vanadium pockets and arranged perpendicular to the beam, with the convex side of the coin facing the oncoming beam. The beam was set to the maximum dimensions (20mm wide by 40mm high) to ensure complete (or almost complete) coverage of each coin. Each coin was exposed to the beam for around 1 hour to allow a full analysis of both phase composition and texture. Diffraction patterns were analysed using the public domain programme GSAS, following the approach of Kockelmann *et al.* (2006). Texture patterns were analysed using the public domain programme MAUD (Artioli 2007) to give information concerning manufacturing routes used to produce the coins. This aspect of the analysis will be explored in a subsequent publication.

Results

The XRF analyses gave a semi-quantitative preliminary indication of the elemental composition of the coins. As expected, they were shown to be composed of complex alloys of Ag–Cu. With the exception of the replicas, which were produced using pure Ag and Cu, most of the coins also contained small proportions (almost exclusively <2%, and generally much lower) of Au, Bi, Fe, Pb, Sn and Zn. Notable outliers and patterns in the Pb–Sn–Zn ratios observed will be discussed below.

Whereas the XRF results give a semi-quantitative analysis of the elements present on the surface of the coins, NDA gives a quantitative analysis of the phases that comprise the bulk of each coin. The NDA results are given in Tables 15 and 16.

Although NDA cannot reveal information about trace elements present at concentrations of below *c.* 0.5%, it has a major advantage over XRF. The XRF results are highly dependent on the elements present near the surface of the coin. Coins with a silver purity of less than around 90% will tend to display surface enrichment of silver to a depth of around 100–200μm (Dennis 2006, 49–53; Gitler and Ponting 2003, 10–16; Butcher and Ponting 2005, 173–4), and thus for these coins XRF will give a higher value for silver than the actual bulk composition. To ensure that XRF results are representative of the alloy mixed in antiquity, it is necessary to prepare the coins by a process of abrasion, and sometimes to average the results of readings from different regions of the coin (Dennis 2006). NDA is a non-destructive technique that measures the total composition of each coin without requiring any sample preparation. The high level of penetration achieved by the neutron beam means that the results reflect the composition of the entire coin, not just the surface, or particular targeted regions.

The raw data in Tables 15 and 16 quantify phases, rather than the elemental composition of the coins. A phase is a homogenous region with uniform physical and chemical properties. It may be composed of a single element, or several. As molten metal cools and solidifies, it may solidify as a single homogenous phase, or as a mixture of phases with different chemical compositions and physical properties. Simple binary alloys of silver and copper generally form a two-phase system, consisting of a silver-rich phase and a copper-rich phase, and these were encountered as the two main phases in all the *North-Eastern* series coins. Small amounts of copper are present in solid solution in the silver-rich phase, and vice-versa. In addition, some coins showed small proportions of

Table 15 Phase results from the neutron diffraction analysis of North-Eastern *series coins from Hallaton. (BDL: below detection limits).*

Category	Type	Analysis Code	Cat. No.	Phase results from NDA					Approx. % Ag to Cu, inc. Cu & Ag from compound phases, normalised to 100%
				Wt% Ag phase	Wt% Cu phase	Wt% Cu_2O phase	Wt% AgCl phase	Wt% CuCl phase	
North-Eastern Series Uninscribed	3a ('Ferriby' unit)	U3A1	3208	95.86	3.83	BDL	BDL	BDL	96
		U3A2	3209	91.90	7.81	BDL	BDL	BDL	92
		U3A3	3243	93.13	6.50	BDL	BDL	BDL	93
	4b ('Ferriby' half unit)	U4B1	2057	89.05	3.78	6.61	BDL	BDL	90
		U4B2	0012	78.90	16.20	4.82	BDL	BDL	79
		U4B3	0571	74.74	19.23	6.01	BDL	BDL	75
	6b ('Kite' unit)	U6B1	1300	74.49	17.84	7.62	BDL	BDL	75
		U6B2	0013	76.86	17.66	5.08	BDL	BDL	78
		U6B3	0014	81.63	13.26	5.07	BDL	BDL	82
North-Eastern Series Inscribed	AVN Type 2 (Unit)	AVN1	0193	73.81	22.18	3.83	BDL	BDL	74
		AVN2	0185	91.54	1.76	4.54	2.15	BDL	94
		AVN3	2372	78.05	18.71	2.90	BDL	BDL	79
	IISVPRASV Type 1 (unit)	ISP1	0252	79.09	19.03	1.88	BDL	BDL	79
		ISP2	0259	80.59	17.18	1.95	BDL	BDL	81
		ISP3	0246	60.24	39.12	0.62	BDL	BDL	60
	VEP Type 3b (unit)	VEP1	2724	79.57	18.49	1.81	BDL	BDL	80
		VEP2	0046	80.58	16.49	2.84	BDL	BDL	81
		VEP3	0048	89.30	5.81	4.43	BDL	BDL	90
	TATISOM Type 1b (unit)	TAT1	0233	90.80	3.69	4.32	BDL	1.09	92
		TAT2	0235	84.82	6.81	7.45	BDL	0.64	86
		TAT3	0237	73.99	23.66	2.32	BDL	BDL	74
	VDC Type 2 (half unit)	VDC1	0425	96.24	1.76	1.89	BDL	BDL	97
		VDC2	3196	85.99	9.90	4.09	BDL	BDL	86
		VDC3	1790	87.52	8.39	4.06	BDL	BDL	88

corrosion phases (Cu_2O, AgCl and CuCl). The minor elements detected in the XRF analyses were not present as separate phases in the coins, suggesting that they also remained in solid solution in the metal, probably as a more complex Ag–Sn–Cu phase.

Since the results for Cu and Ag represent the proportions of these phases, rather than the elements themselves, some care needs to be taken in interpreting the results. Lattice parameter shifts confirmed that these phases do not consist of the pure elements copper and silver. Comparison with the XRF results showed correlations between the degree of the lattice parameter shift and the levels of other elements detected. The patterns observed suggest that the lattice parameter shifts are due to small proportions of copper and gold dissolved in the silver phase, and low levels of silver and tin dissolved in the copper phase. Most important for the results being considered here is the fact that the silver phase will include a small proportion of copper in solid solution, and likewise there will be a small proportion of silver in solid solution in the copper phase.

Levels of solid solution depend on a number of factors, including temperature. The maximum level of solid solution for copper in silver and vice-versa is around 8–9% (at 780°C). At lower temperatures, the mutual solubility of these metals is reduced. When less than 9% copper is present, it is possible for the copper to be entirely dissolved in solid solution in the silver phase. In this case, the alloy will solidify as a single homogenous silver-rich phase. In practice, it is extremely unusual to observe levels of solid solution this high. As the metal cools, some of the copper will normally crystallise out as a dispersion of small copper particles in the silver matrix. XRF testing on *East Anglian* silver coinage carried out by Megan Dennis suggests that the maximum observed level for solid solution of silver in copper and vice versa is generally around 3–4% (Dennis 2006, 49).

Because of the difficulty in establishing the levels of solid solution in each coin, for the purposes of calculating the percentage of silver to copper, the silver and copper phases were treated as if they represented pure Ag and Cu. Comparison with known values and results from other techniques demonstrates that the results given here for percentage of Ag to Cu should be considered accurate to within ±2–3%. The replicas are known to consist of approximately 10% Cu, 90% Ag by weight; the mean % Ag to Cu from the NDA was 89%. XRF results for the coins which displayed only a single homogenous silver phase (the Roman issues and the coins of Cunobelin) showed

Table 16 Phase results from neutron diffraction analysis of the southern British, Roman and replica coins. (BDL: below detection limits).

Category	Type	Analysis Code	Cat. No.	Phase results from NDA					Approx. % Ag to Cu, inc. Cu & Ag from compound phases, normalised to 100%
				Wt% Ag phase	Wt% Cu phase	Wt% Cu_2O phase	Wt% AgCl phase	Wt% CuCl phase	
Roman	RRC 442 (Republican *denarius*, 49 BC)	ROM1	0437	99.76	BDL	BDL	BDL	BDL	100
	RIC 30 (*denarius* of Tiberius, *Lugdunum*, AD 14–37)	ROM2	3341	98.3	BDL	BDL	1.53	BDL	100
	RIC 167a (*denarius* of Augustus, *Lugdunum*, 15–13 BC)	ROM3	1291	99.73	BDL	BDL	BDL	BDL	100
	RRC 458/1 (*denarius* of Caesar, N. Africa, 47–46 BC)	ROM4	N/A	97.85	BDL	BDL	2.01	BDL	100
Non-local British (North Thames region)	Cunobelin (VA 2057)	CBN1	0009	99.42	BDL	BDL	BDL	BDL	100
	Cunobelin (VA 2061)	CBN2	2050	98.92	BDL	BDL	0.61	BDL	100
Replicas		REP1	N/A	86.80	12.82	BDL	BDL	BDL	87
		REP2	N/A	90.05	9.53	BDL	BDL	BDL	90
		REP3	N/A	89.47	9.98	0.50	BDL	BDL	90
		REP4	N/A	87.21	12.27	0.50	BDL	BDL	87
		REP5	N/A	90.01	9.58	BDL	BDL	BDL	90
		REP6	N/A	88.51	11.08	BDL	BDL	BDL	89

concentrations of less than 1.5% Cu, and this was further confirmed by ICP analysis on ROM4. The small quantities of copper present in these coins were not detected by NDA, since at this level all of the copper remains in solid solution in the silver phase. A representative sample of 3 replica and 3 ancient coins were also tested using SEM/EDX (energy dispersive XRF in combination with a scanning electron microscope). A small area at the edge of each coin was ground and polished, removing approximately 1mm of material to reveal the internal structure of the coin. The average (mean) difference between the SEM/EDS and NDA results for normalised % Ag to Cu was just 1.5%, further supporting the accuracy of the NDA values given in Tables 15 and 16.

It should also be noted that the silver phase more accurately reflects 'precious metal' content than pure silver. At low levels, gold will be present in solid solution in the silver, but even if there were enough gold to form a separate phase, the lattice parameters for Ag and Au are too close to be distinguishable by NDA. Nevertheless, this phase is considered as a silver phase here for two reasons. Firstly, all but one of the coins (see below) showed less than 1.2% gold when tested using XRF (at this level the gold would most likely be present in solid solution in the silver, rather than forming a separate phase), so this will not affect the results to any great degree. Secondly, the silver bullion available in late Iron Age Britain contained small quantities of lead, gold and bismuth (Craddock 1995, 211–14; Scott 2011, 28–9). As such, the low levels of gold present should rightly be considered to form part of the silver bullion content of the coins (Dennis 2006, 54).

Interpretation and conclusions

Figure 65 displays the results from the various analyses graphically. A few trends can be noted at once. Overall there seems to have been very little concern to standardise the silver content of particular coin types, with ranges of 10–15% within types the norm. Nevertheless, overall the silver content of most of the coins is relatively high, with only one coin showing less than 74% Ag to Cu. There is also no clear pattern of debasement over time, as has been suggested for other coin series such as the *East Anglian* and *Western* Iron Age coinages (Dennis 2006; Northover 1992). This is clearly demonstrated in Figure 66, which shows the relative purities of the (earlier) uninscribed and (later) inscribed types tested.

The vast majority of *North-Eastern* series silver coins from both periods are 75–95% pure. This actually represents quite a high level of purity, standardisation

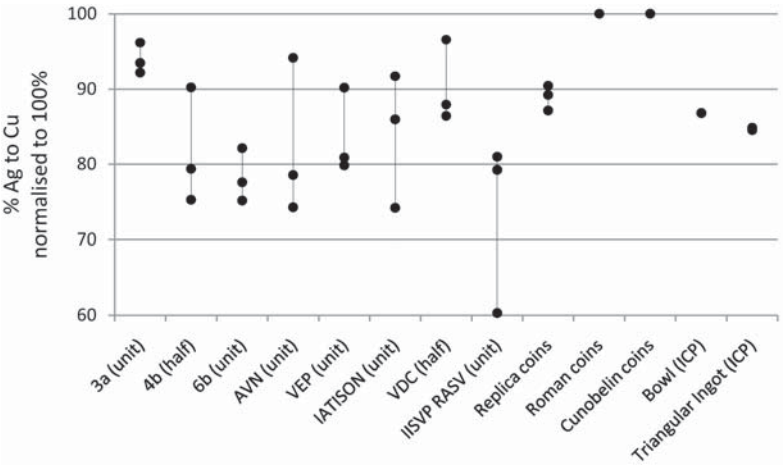

Figure 65 The percentage of silver to copper normalised to 100% for all the silver objects analysed in this study. The NDA results are used for the coins, ICP results are used for the bowl and triangular ingot. Each dot represents a single analysis – except in the case of the replica coins, where the three dots represent the maximum, minimum and median values of the six analyses to give an idea of spread. The three results from the triangular ingot are so close in value that they cannot be distinguished individually.

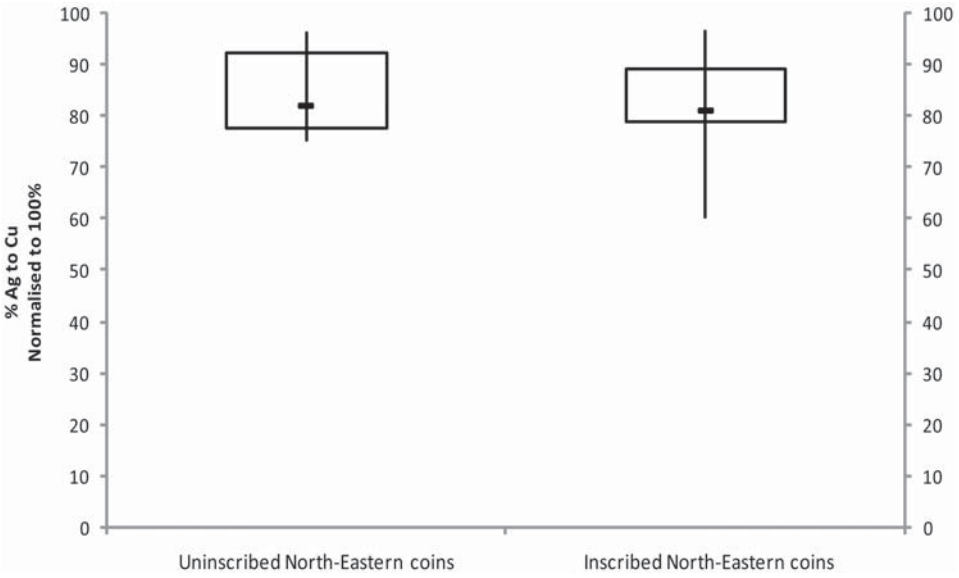

Figure 66 Box and whisker plots showing the silver purity of uninscribed and inscribed North-Eastern *series coins. The short horizontal bars represent the median values, the vertical lines show the spread of the results from minimum to maximum, and the boxes show the interquartile range, i.e. the spread of the central 50% of values.*

and continuity in alloy composition compared to issues from other parts of Britain such as East Anglia and Western England (Dennis 2006; Northover 1992). The comparison will be explored further below, when silver sources are considered. Figure 66 seems to suggest that uninscribed coins were less standardised than inscribed coins, but in fact this masks the fact that the alloys represented in the uninscribed coins are not evenly distributed over the 75–95% silver range. Figure 67 shows the frequency of different alloy compositions for both inscribed and uninscribed coins.

Broadly speaking, there appear to be two different alloy groups, or 'favoured' alloy compositions for the uninscribed *North-Eastern* series: one very high in silver, around 90–100%, and the other debased to around 20–25% with a copper alloy. This is not apparent for the later inscribed coins, where alloy compositions are more evenly distributed between 75–95% Ag to Cu. However, for both groups, there is a

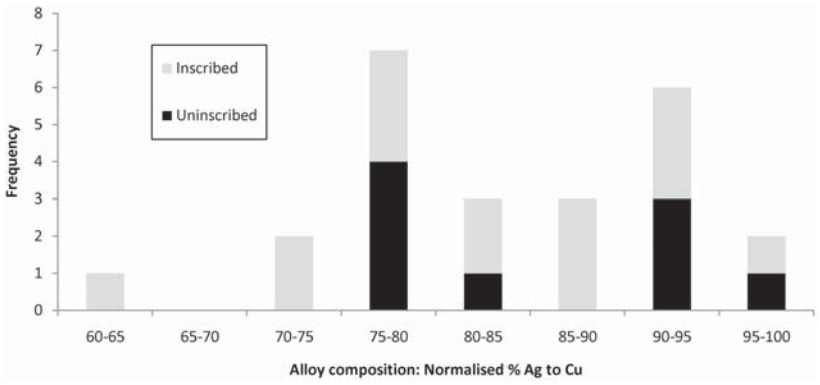

Figure 67 The relative frequency of different alloy compositions for North-Eastern *series coins tested.*

Figure 68 The **IISVPRASV** *coins tested.*

floor of debasement at around 75% Ag, below which those responsible for mixing the alloys seem to have been unwilling to go.

Importantly, coins of the same type were made out of both high- and low-purity silver alloys. It would not have been possible to tell, just by looking at the general design or inscription on a coin, what its fineness was. This seems to support the assertion that the *North-Eastern* silver series was not issued to a standardised bullion content. Perhaps a high degree of standardisation was not considered necessary; high purity certainly does not seem to have been essential for assuring the value of the coins.

A few coin types are worth commenting on in more specific detail. The 3a uninscribed coins are the earliest of the coins tested. They are also the type most consistently high in silver, and the most standardised, with the lowest variation in silver purity. This could suggest that the earliest silver coinage was not debased with copper to any large degree, and indeed may simply have been produced by recycling a high-purity silver alloy. Possible silver sources will be considered below. This is the strongest evidence for greater debasement of later coins compared to earlier types, but there are problems with such an interpretation. The associated 4b half units, presumably produced at around the same time, do not show the same high levels of purity and standardisation. The difference in purity between the 3a coins and later issues is also small, and some inscribed types (e.g. **VOLISIOS DVMNOCOVEROS**) show a comparable level of purity and standardisation.

The **IISVPRASV** type is considered to be a late issue, most likely minted after the Roman conquest (Chapter 3), and certainly stands out in this analysis. Two of the **IISVPRASV** coins tested (Figure 68, ISP1 and ISP2) are very similar in design, and show comparable alloy compositions of around 80% Ag to Cu. The other issue, ISP3, could not be more different. The design is more crudely executed, and the coin is the most unusual of all the coins tested in terms of its composition. NDA revealed ISP3 to have by far the lowest silver content at just 60%, and it also showed an unusual composition in the XRF analysis, with over 10% Au. The next highest Au value was just 1.1%. The poor quality die engraving and unusual alloy composition suggests a botched or hurried batch of coins. This perhaps suggests that some of the **IISVPRASV** issues may have been made to very different standards, and using a different alloying process, than earlier types.

The **AVN**, **VEP** and **TATISOM** issues, which Leins suggests may have been broadly contemporaneous (Chapter 3), show fairly similar compositional ranges. However, one other group of inscribed coins does stand out. The **VOLISIOS DVMNOCOVEROS** coins have a consistently high silver content, comparable to the earliest uninscribed coins, although only a small

sample of each type has been tested. **VOLISIOS** coins are also unusual in other respects. They show a different style of engraving, an absence of die-links to other groups, and a consistently northern geographical distribution, quite different to that of the other inscribed coin types. Taken together, these factors could suggest that the **VOLISIOS** coins were the product of a separate northern mint. Fragments of coin mould have been found at Scotton in North Lincolnshire (Collis 1971, 75; Whitwell 1982, 15; North Lincolnshire Museum: SNAC 14), which would support the hypothesis that some coins were being produced much further north than the better known probable centres of production at Old Sleaford (Elsdon 1997) and Leicester (Clay and Mellor 1985).

The NDA results alone are sufficient to highlight general patterns and some of the interesting features of the different issues, but comparing these results with the XRF data can give us a further insight into both the types of alloys used and the processes by which the coins were made. Whilst the XRF results are unreliable measures of silver content because of the problem of surface enrichment in all but the highest purity coins, they provide useful information about the relative proportions of other elements. Most importantly, they reveal the ratio between the lead, tin and zinc components of the alloys, as shown in Figure 69.

Two distinct clusters are clearly present in Figure 69, one comprising a group of alloys where lead predominates in the Pb–Sn–Zn ratio, and the other displaying a higher proportion of tin. There is no correlation with silver purity; there are high- and low-purity silver coins in each group. This makes it unlikely that the two groups represent different silver sources. There is also no correlation with coin type; no type is exclusively restricted to one particular cluster. Repeated recycling would have blurred the distinction between the two groups, tending towards the centre of the diagram or at least (given that use of alloys containing zinc appears to be reasonably limited) towards a more even mixture of lead and tin. The 'x' symbol marks the mean composition of all the *North-Eastern* coins tested (except VDC1, which was excluded due to its unusually high Zn value of almost 10%, almost certainly a distortion due to the small size of the sample). The triangular ingot can also give a good idea of the alloy that might be expected from general recycling. It was certainly produced at least in part from recycled *North-Eastern* series coins; at least

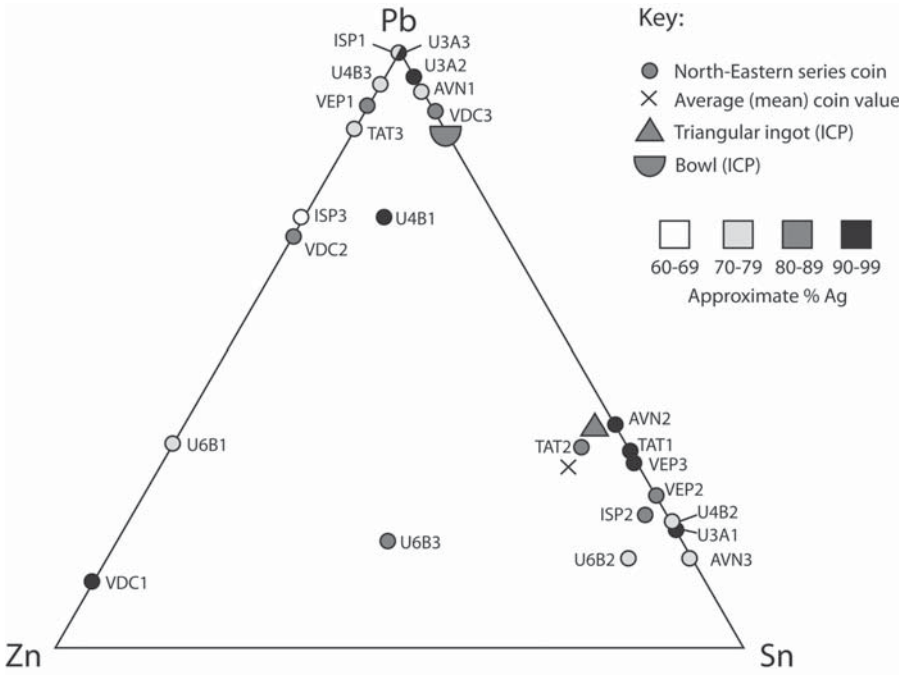

Figure 69 Ternary diagram showing the relative proportions of Pb, Sn and Zn for each North-Eastern *series coin from the XRF data, as well as the ICP results for the bowl and triangular ingot. The Roman coins and the two coins of Cunobelin were not included since the levels of Pb, Sn and Zn were too low for the XRF data to be reliable; only Pb was detected in any of these coins. ICP analysis on ROM4 confirmed that levels of Sn and Zn in this coin were below 0.08%. One particular outlier, VDC1, was a broken half unit, and as such presented only a very small surface for XRF analysis, thus the unusually high level of zinc recorded for this particular coin may be misleading. Because of questions over their reliability, the VDC1 results were omitted from calculation of the average (mean) Pb–Sn–Zn ratio.*

one can be seen half-melted into the top surface. At 84.7% silver to copper, its composition is consistent with what might be expected from combining a random selection of high- and low-purity *North-Eastern* series coins: the mean for all the *North-Eastern* coins tested in this study was 83.5% silver to copper. The triangular ingot also has a Pb–Sn–Zn composition extremely close to the mean.

The calculated mean for the coins and the measured value from the triangular ingot thus give us an idea of the composition that might be expected from non-selective recycling of *North-Eastern* series silver coins. The alloys of some of the coins tested (e.g. TAT2) could have resulted from such a recycling process. It is unlikely, however, that the alloys with the highest levels of Sn, or those in the high-lead Pb–Sn–Zn ratio cluster (including the bowl), could have been the result of indiscriminate recycling. Nor would such recycling explain the existence of high-purity silver alloys. The most likely explanation for the observed pattern is that the majority of the objects tested in this study were produced by debasing a high-purity silver alloy with a copper alloy.

For all coins, lead levels were below 1.3% of the total alloy composition as determined by XRF. This is low enough to be attributed to the presence of residual quantities of lead in the silver bullion used to make the coins (Scott 2011, 28–9), and does not necessarily imply the addition of any lead during the alloying process. The same may be true for the bowl, which contains 1.8% lead. Thus objects in the high-lead ratio cluster may have been debased with relatively pure copper. In rare instances, brass (an alloy of copper and zinc), appears to have been used as the debasing alloy, but the majority of the coins show higher levels of tin and were most likely debased with an alloy of copper and tin.

Figure 70 plots the percentage of tin to copper against the overall proportion of copper for the locally produced silver objects tested in this study. The distribution once again demonstrates the use of several different debasing alloys in the *North-Eastern* series silver coinage. Whilst it is possible that coins containing less than 10% copper were produced directly from a high-purity silver alloy, most coins appear to have been additionally debased to some degree. The group of coins containing very little tin were most likely debased with pure copper or an alloy of copper and zinc. Coins with 5–13% tin to copper (U4B2, U6B2, U6B3, AVN2, TAT1, TAT2, VEP2) may have been debased with bronze, whereas the four coins with the highest tin content (U3A1, AVN3, ISP2, VEP3) were debased with a high-tin copper alloy such as potin. Again, there is no correlation between the debasing alloy selected and coin type or silver purity.

Figure 70 also shows that the triangular ingot once again corresponds closely to the mean value for the *North-Eastern* silver coins, supporting the hypothesis that it was produced through non-selective recycling of local coinage. The unusual Sn–Cu ratio for the bowl reinforces the argument put forward earlier that the alloy used to produce this object was carefully manufactured for particular properties, rather than being the result of a casual debasing process, as appears to have been the case with the *North-Eastern* series coins.

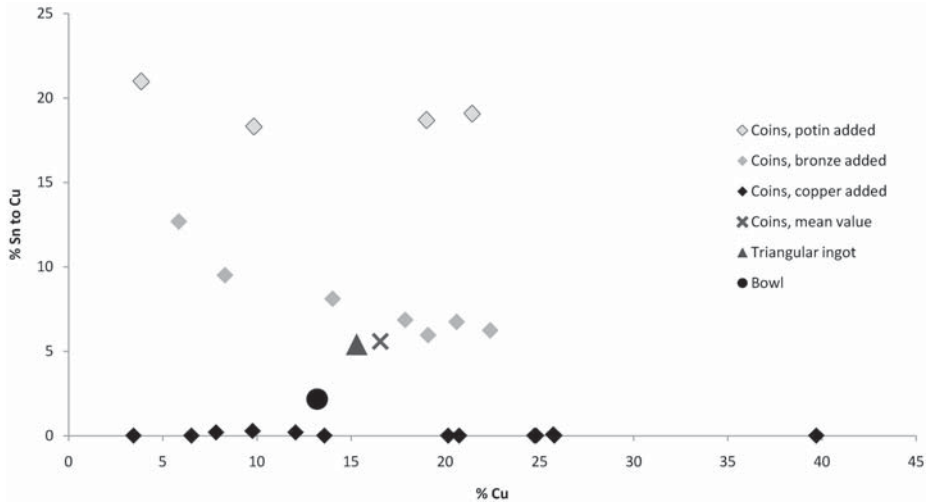

Figure 70 The % Sn to Cu plotted against % Cu for the North-Eastern *series coins tested. This shows the presence of three different groupings: alloys containing little or no Sn, alloys with 6–13% Sn to Cu, and alloys with a higher Sn content, around 20% Sn to Cu. (In order to give the most accurate results, Sn values from the XRF analyses were compared with Cu values from the NDA). ICP values for the bowl and the triangular ingot are also included.*

Whilst some of the alloy mixes represented here could be the result of more general recycling, the presence of two distinct Pb–Sn–Zn clusters in Figure 69, and the varying levels of tin to copper seen in Figure 70 support the model of a process involving the debasing of a high-purity silver alloy. Megan Dennis has come to the same conclusion concerning the production of *East Anglian* Iron Age coins (2006, 59–63). There does not seem to have been any particular criterion for selecting the debasing alloy, since every coin type tested is represented in more than one region of the Pb–Sn–Zn ternary diagram.

A model of production involving the debasing of a high-purity silver alloy with a copper alloy substantially narrows the potential sources of the silver being used in the Iron Age East Midlands. There is little evidence for the refining of debased silver in Iron Age Britain. Cupellation hearths (identical to later Roman examples from Wroxeter and Silchester) were uncovered at Hengistbury Head in association with a block of copper-silver alloy (Gowland 1915, 72; Northover 1987; Salter and Northover 1992) but, whilst these may be evidence of late Iron Age silver refining on the South coast, it is possible that this material dates to the Roman period (Dennis 2006, 18), and there is certainly no evidence of comparable technology in the East Midlands or neighbouring regions. Even if the technology and skills to refine debased silver were available, it seems highly unlikely that such a process was used to produce *North-Eastern* series silver coinage, given the general variation in silver content even within issues. With silver purity not a key issue in determining the value of coinage, there would be little point in expending valuable time, energy and resources on the difficult process of purifying a silver alloy only to then debase it by an unspecified amount with a non-standard copper alloy. This suggests that some of the silver sourced by the

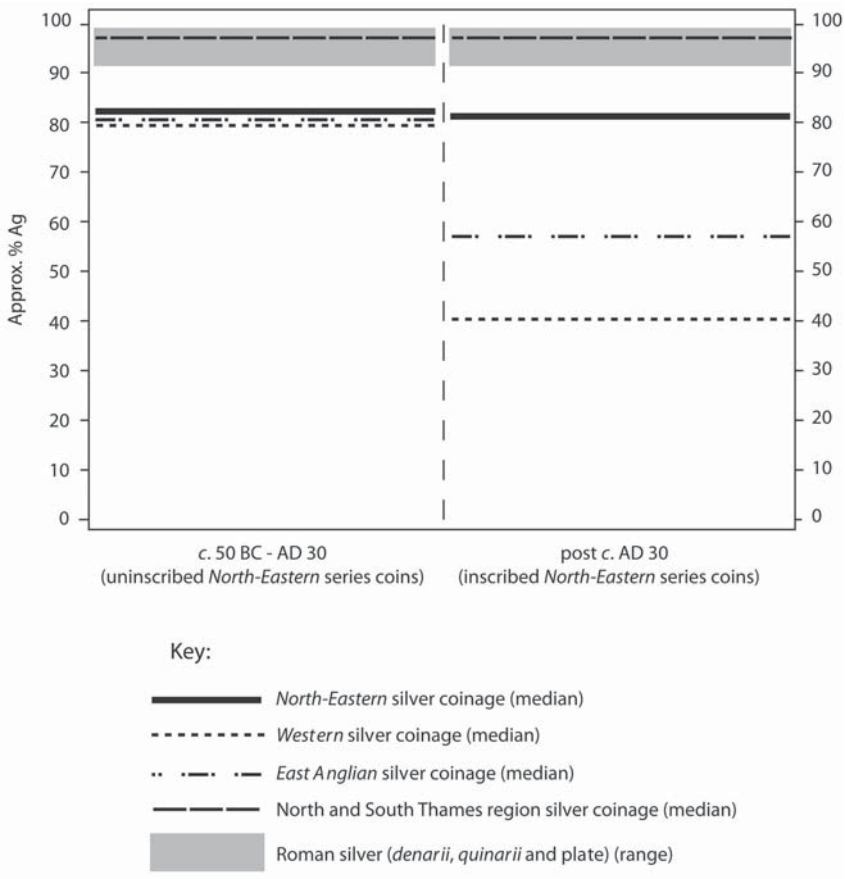

Figure 71 Silver purity of uninscribed and inscribed North-Eastern *silver coinage compared to the purity of contemporary silver sources potentially available to Iron Age communities in the East Midlands. (NB: coins from other regions are considered on the basis of their probable date of issue, not the presence or absence of inscriptions, since the change to inscribed coinage occurred at different times in different regions). The values given here are approximate, and represent a summary of the data presented by Dennis (2006), including her own analyses of East Anglian silver coins, and unpublished analyses of other regional series by Peter Northover and Oxford Materials Characterisation. Other sources include Northover (1992); Cowell et al. (1987); Hobbs (1996); Strong (1979); Butcher and Ponting (2005) and Riha and Stern (1982).*

East Midlands mints must have been over 95% pure. Since there is little or no evidence for local silver extraction from British ores either in the East Midlands, or in Iron Age Britain as a whole (Bayley *et. al.* 2008, 41), this silver must ultimately have been imported. There are a number of channels through which imported silver could have reached Iron Age communities in the East Midlands.

Figure 71 shows the relative purities of the silver sources potentially available to Iron Age communities in the East Midlands. Considering percentage of silver alone, some of the uninscribed issues (although not high-purity types such as 3a) could have been made from recycled *East Anglian* or *Western* issues. However, this would not explain the existence of discrete Pb–Sn–Zn clusters within this period, even between coins of similar purity: general recycling would not tend to produce such grouping. Instead, it is likely that even in this early period *North-Eastern* coins were being produced via the dilution of a high-purity silver alloy. This certainly must have been the case in the later inscribed coinage period, when there is no clear source of a 75–95% silver alloy. Each batch of coins produced in this way would have had a unique Pb–Sn–Zn signature depending on the debasing alloy. This is exactly the pattern observed. Some recycling of *North-Eastern* (and probably a few non-local) issues is almost certain to have taken place, but most of the alloys observed cannot be explained in this way.

High-purity silver alloys (such as that used to produce Roman plate), or even refined silver bullion (around 98% pure, containing traces of gold, lead and bismuth), could have been obtained from a number of different sources. Gallic contacts are unlikely, since silver this fine would have had to have been imported from central or eastern Gaul (Dennis 2006, 109–16). Silver objects from these regions are not found in the East Midlands (and indeed are very rare in Britain as a whole), so it seems unlikely that Gallic silver was being imported in large quantities in the Iron Age. It is more probable that refined silver was entering the East Midlands either through southern British contacts or through direct interaction with the Roman world.

Summary

The silver objects considered in this study show strikingly different alloy compositions. The bowl was produced from an alloy consisting of around 86% silver bullion, debased with a copper alloy containing around 2% tin. The unusual composition of the bowl compared to the other silver objects tested, and the relative absence of impurities, suggest that the alloy was produced specifically for the manufacture of this object. The alloy design and the production of the bowl were most likely carried out by a skilled metalworker with experience of working with silver. The relatively high copper content supports the hypothesis that the bowl was manufactured in Britain, or at least outside the Roman world.

The composition of the triangular ingot was very different to the bowl alloy, but similar in all respects to the mean for the *North-Eastern* series silver coins tested, supporting the suggestion that this object was produced largely through the recycling of local coinage. Nevertheless, whilst some melting down of coinage clearly took place, most of the coin alloys cannot be explained as the result of recycling. Clustering in the Pb–Sn–Zn ratios seen in the compositions of the coins suggests that most batches of alloy were produced not by recycling previous *North-Eastern* issues, but by debasing a relatively pure silver alloy with either pure copper, tin bronze or, in rare instances, brass. The debasing alloy does not appear to have been selected based on any particular criterion other than convenience; there is no correlation with coin type or level of debasement. The high-purity silver used to produce the coins must have been sourced (at least in part) through southern contacts – either directly from the Roman world, or from British groups in the North and South Thames regions.

The *North-Eastern* series silver coins tested show relatively high levels of purity throughout the late Iron Age. With the exception of one late **IISVPRASV** issue, all coins exhibited a silver content of 74–96%. Whilst it is possible that very high-purity early issues such as 3a were produced from imported silver bullion debased very little or not at all, most other types appear to have commonly been debased by up to around 20% with a copper alloy. There is no evidence of an ongoing process of increasing debasement, as seen in the *East Anglian* and *Western* coin series.

Within the purity range outlined above, there appears to be little attempt at standardisation in the bullion content of the *North-Eastern* silver series. The coins may have been issued in batches of similar purity (the 3a, **IISVPRASV**, **VEP** and **VOLISIOS** coins show pairs of coins with comparable silver contents), but even coins of the same type frequently display very varied levels of silver purity, with ranges of 10–15% the norm. The level of standardisation is comparable to (or higher than) that seen in the *East Anglian* and *Western* series, but much lower than the consistently high-purity coinage issued in the North and South Thames regions (Northover 1992; Dennis 2006) where production is likely to have been more centralised and closely controlled.

Aside from the earliest uninscribed coins tested, the only group which stands out in terms of composition are the relatively high-purity **VOLISIOS** half units. In

combination with other differences, including their consistently northern distribution, this could support the suggestion that these coins were produced by a separate, more northerly mint. However, a larger sample and a more comprehensive programme of analysis would be needed to confirm or deny this hypothesis.

VP-SEM-EDX Analysis of the Glass Eyes – *Andrew S. Meek*

Small fragments of blue glass from the 'eyes' (Chapter 5, No. 68; Figure 62) were submitted to the British Museum Research Laboratory for scientific analysis to discover more about their origin.

Equipment and methodology

Quantitative analysis was carried out using a Hitachi S3700 variable pressure-scanning electron microscope – energy dispersive X-ray spectroscopy (VP-SEM-EDX): low vacuum 200 Pa, 20 kV accelerating voltage, 0–10 kV spectral range, 2.30 nA probe current, 180 seconds; results being calibrated using mineral and metal standards.

An unprepared fragment of Corning A glass standard was analysed under identical conditions and used as an external standard, to establish the accuracy of the results. Detection limits were calculated using a spectrum synthesis programme on Oxford Instruments INCA Analyser software. An average of two analyses of the Corning A standard can be found in Table 17, along with the published values for this standard. The analysis of any unprepared samples under low-vacuum conditions will suffer from problems of accuracy due to the interaction of the electron beam with air in the chamber.

Overall the acquired results can be considered relatively accurate. However, for cobalt oxide (CoO) and chlorine (Cl) any measured result must be regarded as an over-estimate of the actual level present in the sample. They should therefore be considered as semi-quantitative and are labelled as such in Table 18. The precision is presented in this table as a standard deviation value. These values are very low for most oxides measured. However, the quantities are significant, greater than 20% of average measured value, for phosphorous oxide (P_2O_5) and CoO. Therefore P_2O_5 must be added to the list of results that can only be considered semi-quantitative.

Due to the volatility of sodium, it may be lost from a glass surface during analysis under a high voltage electron beam such as that used here. Also, sodium is commonly leached from ancient glass surfaces during burial. Therefore the quantity of sodium oxide (Na_2O) reported for an unprepared ancient glass surface may be considerably lower than is actually present in the bulk glass. The reported Na_2O value should, therefore, be considered an under-estimate of the average Na_2O content of the glass analysed.

Results and discussion

The analytical data reported in Table 18 show that this is a soda–lime–silica glass. The levels of Na_2O are slightly lower than most Roman glasses, but this is probably an effect of the use of surface analysis. The

Table 17 Published values, non-normalised measured values (average of two analyses), accuracy and precision values for Corning A glass standard minimum detection level for the methodology used.

		Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	Cl	K_2O	CaO	MnO	FeO	CoO	CuO	Sb_2O_3
Corning A	Expected (weight %)	14.52	2.81	1.01	66.56	0.12	0.10	2.93	5.30	1.18	1.09	0.15	1.22	1.72
	Measured (weight %)	14.75	2.70	0.85	67.59	0.12	0.14	2.93	5.20	1.10	1.09	0.21	1.34	1.69
	Accuracy (% difference)	1.58	3.91	15.84	1.55	0	40.00	0	1.89	6.78	0	40.00	9.84	1.74
	Precision (st. dev.)	0.16	0.03	0.06	0.73	0.04	0.02	0.05	0.01	0.06	0.04	0.05	0.03	0.23
	Detection level (weight %)	0.18	0.06	0.06	0.42	0.06	0.06	0.09	0.12	0.09	0.09	0.09	0.12	0.12

*Table 18 Non-normalised SEM-EDX results for the blue glass from Hallaton. Results are the average of two area analyses. (nd=not detected). * These results should be considered semi-quantitative.*

	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5*	Cl*	K_2O	CaO	MnO	FeO	CoO*	CuO	Sb_2O_3	Total
Blue glass (weight %)	13.69	0.89	3.40	67.96	0.47	0.83	1.15	6.01	0.80	1.21	0.12	0.32	nd	96.79

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